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The Viking Age settlement pattern of Langholt, North Iceland: Results of the Skagafjörður Archaeological Settlement Survey

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An archaeological survey of the Viking Age settlement pattern in the Langholt region of North Iceland suggests that being early in this sequence conferred tremendous advantages to the settlers of this previously uninhabited landscape. Many of the farms established during the settlement of Iceland (which began about A.D. 870) are in use today. However, accessing the Viking Age landscape is difficult. In Langholt the earliest layers of most farmsteads are buried under a thousand years of occupational debris, while the abandoned sites have been covered by extensive soil deposition. Here we report on our coring and test excavation results that outline Viking Age farmstead location, establishment date, and maximum size by the end of the Viking Age. There is a strong correlation between farmstead size and establishment date. This correlation suggests that during the rapid settlement of Iceland, the farmsteads established by earlier settlers were wealthier and that wealth endured.

Keywords: coring, volcanic tephra, Norse, farm mound, medieval archaeology, first-mover advantage

Introduction

The fundamental contradiction of the Viking Age—that the last great migration of post Roman Europe could also be an important catalyst of state formation—has long been studied (Pirenne 1925; Randsborg 1980; Hodges 1982; Hodges and Whitehouse 1983; Jones 1991, 1993; Hedeager 1994; Bagge 2010; Hodges 2012). The distribution and redistribution of wealth figure prominently in theories about the push and pull of Viking Age expansion and migration (Barrett 2007, 2008, 2010). Uninhabited Iceland, with its remarkable archaeology punctuated by volcanic tephra horizons, was an important part of the western Viking Age migrations. Based on our archaeological settlement survey, this paper outlines farmstead location, size, and establishment date in Skagafjörður, North Iceland. We argue that farmstead size is a proxy for wealth and that the settlement pattern describes the distribution of wealth. The results suggest that, in this region, farmsteads established earlier in the migration were wealthier than those established later. This correlation, and the advantages that were associated with being early, have implications for the understanding of the process of mass-migration events.

Despite Iceland's inhospitable name and location, just south of the Arctic Circle, the island is relatively temperate due to the North Atlantic Drift of the Gulf Stream (FIG. 1). This volcanic island on the mid-Atlantic ridge was first settled in the late 9th century A.D. as part of the broader Viking Age expansion of Norse peoples out of Scandinavia (McGovern *et al.* 1988; McGovern 1990; Bigelow 1991; Morris and Rackham 1992; Fitzhugh and Ward 2000; Barrett 2003; Dugmore *et al.* 2005; Jesch 2015). The stories of the settlers and their descendants are recounted in a substantial indigenous body of prose literature, generally referred to as Icelandic family sagas (Hreinsson 1997) as well as other historical works. While the family sagas single out some farmers and chieftains as being wealthy and powerful, what that wealth or power was, where it came from, or how it was maintained has been the subject of much debate (Durrenberger 1988; Miller 1990; Þorláksson 1992; Vésteinsson 2000; Byock 2001; McGovern *et al.* 2007).

According to most interpretations of the sagas, Viking Age society in Iceland had no formal system of elite finance and limited territoriality (Sölvason 1991; Jakobsson 2009). Farmers could pledge their

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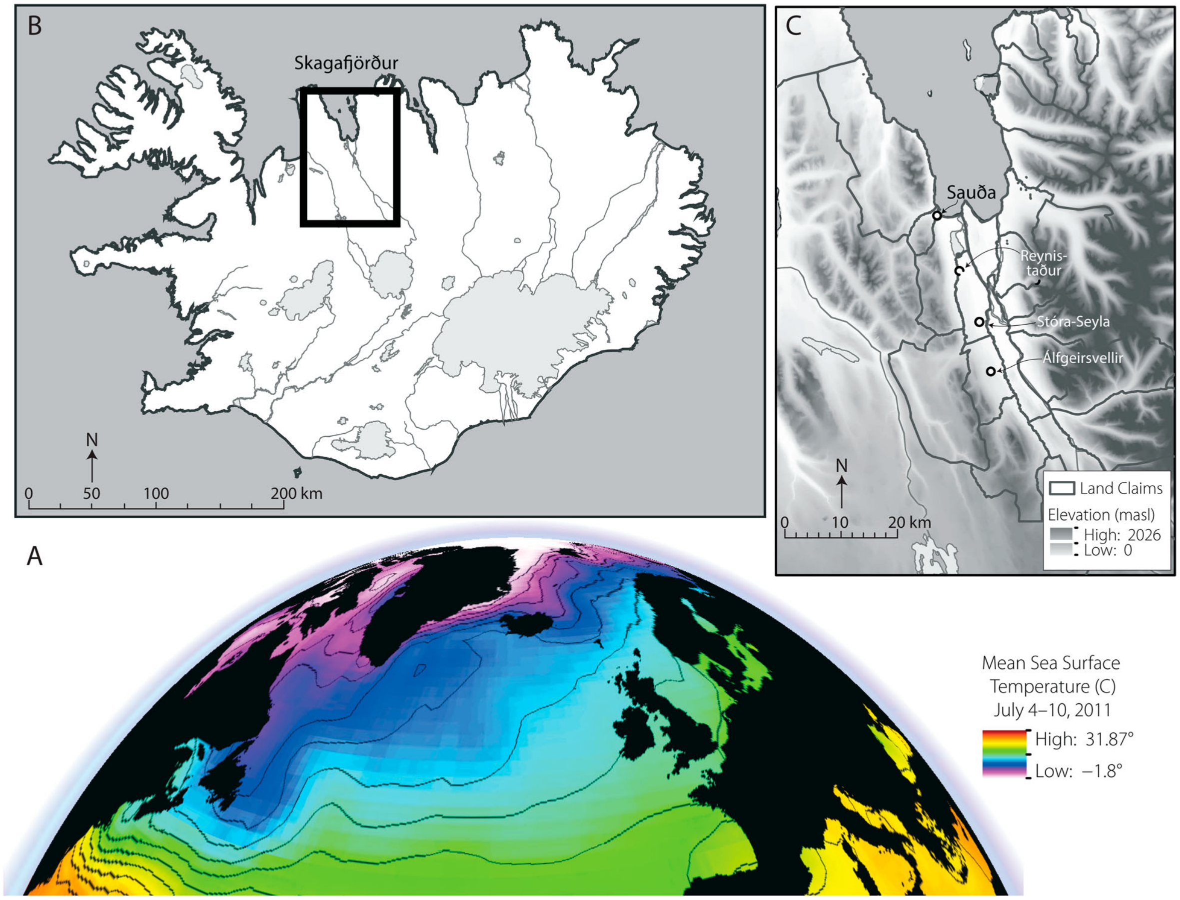

Figure 1 A) Iceland and North Atlantic surface temperatures; B) Iceland with glaciers in gray and Skagafjörður outlined; C) Early land claim boundaries in Skagafjörður. The survey area includes both Reynistaður and Stóra-Seyla.

allegiance to any chief within their quarter of the island (Jakobsson 2012). Despite the absence of a manifest system of elite finance or source of wealth differentiation, the chiefly society thrived for almost 400 years (Sigurðsson 1999). Soon after the settlement began, about A.D. 870, wealth and power started to be consolidated. As early as A.D. 1030, paramount chiefs and powerful large landowners began to emerge, becoming common after A.D. 1180 (Smith 1995; Byock 2001). In the 12th century, chiefly families began consolidating power by monopolizing political authority over geographic regions. By the early 13th century most of the island was under the control of just five or six families (Karlsson 2000) and in A.D. 1262 the king of Norway gained control over the entire island. At the end of the Late Middle Ages (A.D. 1500), wealth and power was profoundly stratified with the clergy and a few secular landlords controlling many farms and large productive manors (Júlíusson 2010). While the sources of wealth that resulted in the highly stratified medieval Icelandic society were no doubt protean, we argue that the socioeconomic inequalities among farmsteads and farming households were rooted in the initial sequence of farm establishment on the island.

The settlement of Iceland is recounted in two texts: the *Book of the Icelanders* and the *Book of Settlements*, written in the 12th and 13th centuries (Thorgilsson and Hermannsson 1966; Pálsson and Edwards 1972). Both sources suggest that colonists initially settled Iceland around A.D. 870 and came primarily from Norway and the northern British Isles, which has been confirmed by DNA studies (Helgason *et al.* 2001; Helgason *et al.* 2009; Price *et al.* 2009). The more detailed *Book of Settlements* describes the initial land claims of approximately 400 principal settlers, including chiefs, who claimed large regions. The texts describe how many of the earliest settlers gave or sold partitions of their land claims to their children, later settlers, or individuals who were part of their settlement entourage, which included workers, relatives, and slaves (Smith 1995; Kunz 2008). According to these accounts (Pálsson and Edwards 1972), mass emigration to the island ended in A.D. 930 when the land was "fully settled" (cf., Gestsdóttir and Price 2006).

The archaeological record is broadly consistent with the dates given in the texts (McGovern *et al.* 2007; Vesteinsson and McGovern 2012). Iceland's earliest sites are coincident with the eruption of the Vatnaöldur fissure crater dated to A.D. 871±2 (Nordahl 1988; Grönvold *et al.* 1995; Larsen *et al.* 2002; Vésteinsson *et al.* 2002; Roberts *et al.* 2003; Thordarson and Larsen 2007) and the general pattern shows a widespread and rapid colonization of the island around this time (Einarsson 1994; Vésteinsson 1998; Dugmore *et al.* 2000; Vésteinsson *et al.* 2002; Dugmore *et al.* 2005; Sveinbjarnardóttir *et al.* 2006; Lawson *et al.* 2007; Bolender *et al.* 2011; Vesteinsson and McGovern 2012). Thus, it is tempting to use the details in the texts to infer the settlement pattern during that time. However, modern scholars approach the detailed descriptions of individual settlers and their land claims with caution, noting that the oral histories underlying these later accounts were by no means secure and that the later Icelanders had political reasons for tracing certain families back to the early colonization and to various prominent family lines in Scandinavia (Friðriksson 1994; Friðriksson and Vésteinsson 2003). More importantly, the texts only account for a fraction of the farms established in Iceland, which had increased to over 4,560 by A.D. 1096 (Thorgilsson and Hermannsson 1966; Byock 2001: 254).

The results of the settlement pattern study of Langholt, in the Skagafjörður valley of North Iceland, are based on archaeological evidence from a regional study of Viking Age farmsteads. We combine synchronic and diachronic settlement measures to chronicle the rapid occupation of this previously uninhabited landscape. The data set consists of site location, site size at the end of the study period (A.D. 1104), and site establishment date. We find a strong and persistent correlation between site size and site establishment date. This correlation, along with the site location data, indicates that farmsteads established earlier were larger, and in all likelihood wealthier, than farmsteads established later and that these differences endured long after the initial settlement. That is, there seems to be tremendous advantages to being first into this uninhabited landscape. At present we can only speculate on the reasons for the first-mover advantage (e.g., Glazer 1985; Lieberman and Montgomery 1988, 1998); however, the existence of these advantages may help to explain the rapid expansion of Norse activity and settlement that is a distinct characteristic of the Viking Age.

The Viking Age Landscape of Iceland

Viking Age farms, like medieval and pre-modern farms in Iceland, were dispersed throughout the habitable coastal and lowland areas as well as interior valleys. Until the modern era, Iceland had no urban settlements and effectively only one type of permanent domestic site: the farm. These farms consisted of a central concentration of turf structures, the immediately surrounding infields, the outfields, pastures, and other resource locations that were utilized by specific farmers (Amorosi *et al.* 1998; Urbańczyk 1999). Farms were the central part in a production system based on transhumant pastoralism in which livestock was moved to highland pastures in the summer while grass was grown to produce winter fodder (Friðriksson 1972). The Norse infield-outfield system allowed the household to be largely self-sufficient (Eggertsson 1992; Roesdahl 1998; Christiansen 2002; Thurston 2007), which probably accounts for the persistent dispersed settlement pattern (cf., Drennan 1988)—although there may have been some specialized production and exchange (Smith 2005; McGovern *et al.* 2007).

Comprised of dispersed infrastructure, lands, and resource rights, the farm is difficult to identify archaeologically and for this reason we distinguish between the farm and the farmstead, which is the primary survey target. The farmstead is the central concentration of farm buildings, including the central domestic longhouse, barns, and other ancillary structures (Ólafsson and Ágústsson 2004; Vésteinsson 2004; Milek 2006; Lucas 2009). Longhouses and other farmstead buildings were constructed with a driftwood frame surrounded with substantial turf walls (Mook and Bertelsen 2007; van Hoof and van Dijken 2008; Stefánsson 2013), with rocks used infrequently in the north of Iceland (Sigurðardóttir 2002; Steinberg 2004; Sigurðardóttir 2008). Turf is the root mass cut from the upper portion of a bog which, once dried, becomes a light, flexible, and durable building material with good insulating properties (Myhre *et al.* 1982).

The other major archaeological feature of a farmstead is the associated household midden (Zutter 1999). Middens consist primarily of fireplace ash from burning peat, dung, and wood (Simpson *et al.* 2003; Vésteinsson and Simpson 2004). The middens can also include bird, fish, and mammal bones; charred and uncharred seeds, turf from buildings; and various scattered artifacts (Amorosi *et al.* 1994). Sometimes middens fill earlier semi-subterranean structures (Simpson *et al.* 1999; Lucas 2009). Viking Age Icelandic middens can extend as a thin sheet across the farmstead or as a high pile near the dwelling structures or as some combination. Because of the rapid and nearly continuous deposition of household ash, tephra layers (described below) useful for dating, are often well preserved in middens.

Archaeologically, farmsteads can be characterized by their concentrated layers of charcoal, turf, and peat ash. Because the Viking Age distribution of cultural layers seems to mirror the concentrated footprint of early modern Icelandic farmsteads that are well known from the ethnohistorical record (cf., Urbańczyk 1999; Ólafsson and Ágústsson 2004; Sigurðardóttir 2008; Stefánsson 2013), it is reasonable to assume that the older Viking Age farmsteads were also relatively concentrated. Farmsteads frequently had outbuildings scattered throughout and at the edges of the homefields that surrounded the core domestic buildings (Albrethsen and Keller 1986; Sveinbjarnardóttir 1992; Júlíusson 2000; Berson 2002; Vésteinsson 2004, 2010). In the pre-modern period there were also productive activities that took place well away from the main farmstead, most commonly at shielings (Sveinbjarnardóttir 1991; Lucas 2008; Brown, Simpson, *et al.* 2012; Vickers and Sveinbjarnardottir 2013). Centrally concentrated farmsteads represent the main, but not necessarily the sole, dimension of farm productivity.

The location of most farmsteads has been relatively stable since they were first established and many farm names seem to have been given during the Viking Age (Nicolaisen 1969; Sigmundsson 2005; Jesch 2015: 45) and continue to be used to the present. Today, modern farm buildings are often built on top of much older farmsteads that have formed farm mounds up to 5 m high primarily composed of midden and the debris of previous turf structures (Davidson *et al.* 1986; Snæsdóttir 1991; Buckland *et al.* 1994; Trigg *et al.* 2009; Vésteinsson 2010). In the less fertile highlands, farm abandonment was relatively common, beginning as early as the 10th and 11th centuries (Rafnsson 1990; Sveinbjarnardóttir 1992; Einarsson 1994; Vesteinsson and McGovern 2012). In the more fertile lowlands, farm abandonment appears to have been very rare (but see Lárusdóttir 2006) but it is not uncommon for farmsteads to be relocated during the Viking Age (Bolender *et al.* 2011). In lowland areas, these relatively short-lived earlier iterations of the farmsteads did not form farm mounds (cf., Johnston 2004; Sweely 2005) and are therefore often buried by later aeolian accumulations (Steinberg 2003, 2004). The relative paucity and aceramic nature of the surviving material culture from Viking Age Iceland, compounded by the large-scale absence of plowing and arable agriculture, makes these abandoned and buried farmsteads nearly impossible to identify using traditional surface survey (Smith and Parsons 1989).

Skagafjörður

According to the *Book of Settlements*, Skagafjörður (FIG. 1C), the valley in north central Iceland where we have completed this settlement survey, was claimed by 22 named colonists (Pálsson and Edwards 1972). The lowlands have received substantial aeolian sediment and a series of discrete datable volcanic tephra layers. This sediment and sequence of tephra layers mean that the earliest sites, once identified, can be well preserved and easily dated.

The 30 to 90 cm of aeolian material that was deposited in lowland Skagafjörður over the last 1140 years accumulated most rapidly from ca. A.D. 870–1100, during the first two centuries of settlement (Guðbergsson 1975, 1994, 1996; Catlin 2011). The soil of the central highlands of the island eroded rapidly after settlement (Óskarsson *et al.* 2004; Arnalds 2010), and the coastal lowlands received some of that sediment (Arnalds 1987; Arnalds 2004). Most soils in Iceland are andisols and are derived from weathered basalts and redeposited volcanic tephra (Jóhannesson 1960; Arnalds *et al.* 1995). Andisols are friable when dry and therefore are subject to substantial erosion, particularly in long frontiers (Arnalds 1990; Dugmore and Buckland 1991; Fridriksson 1995). Furthermore, because of its friable nature, clay from andisols cannot be made into pottery.

The tephra layers from the frequent Icelandic volcanic eruptions are commonly embedded in aeolian sediments and cultural deposits. In Skagafjörður the tephras are mostly thin—less than 1 cm thick—and have distinct colors, compositions, and sequences that can be matched with dated volcanic system eruptions (Þórarinsson 1970). Tephra falls are also incorporated into wetland areas where turf was cut for building material and therefore can be used to establish a terminus post quem (TPQ) for the construction of turf buildings (Milek and Roberts 2013). Tephra layers can often be used to refine radiocarbon dates by eliminating sections of the calibration curve which is especially effective when there are multiple intercepts (FIG. 2).

Skagafjörður has an early tephra sequence that allows for a fine-grained chronology of the changes in early settlement patterns (Larsen *et al.* 2002). While tephra deposition can vary over small distances (Davies *et al.* 2010) the basic tephra sequence is found throughout Skagafjörður and allows for a common dating system among farms and farmsteads, including sheet middens and relict field systems (Þórarinsson 1977). The dates of the historic eruptions coincidently roughly correspond to several major events (FIG. 2) including the original settlement of the island about A.D. 870, the end of mass migration to the island in 930, the conversion to Christianity in 1000, the establishment of the tithe law in 1097, the incorporation of Iceland into the Norwegian state in 1262, and the beginnings of the Little Ice Age in 1300.

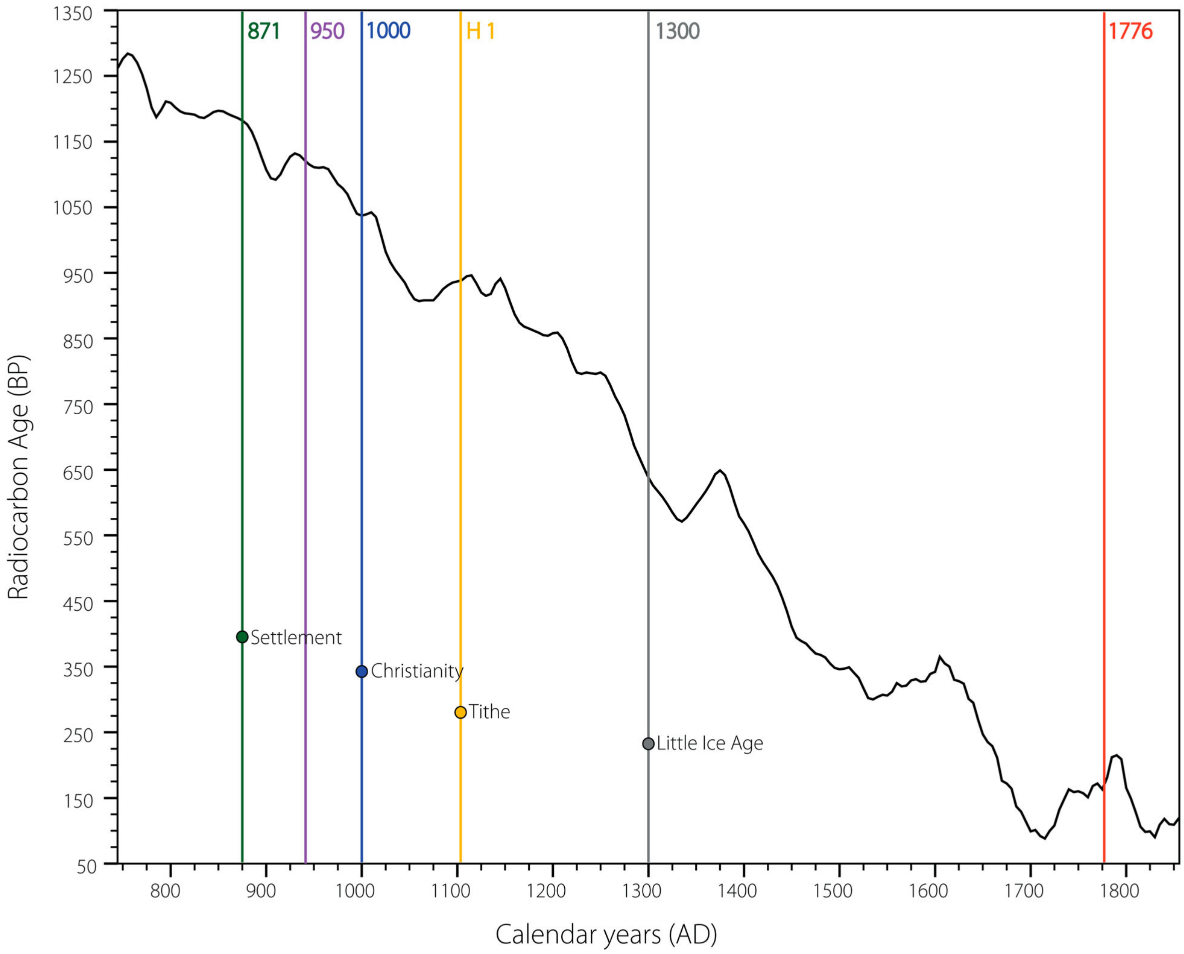

Figure 2 Tephra sequence with the radiocarbon calibration curve (from Reimer *et al.* 2009).

Prehistoric tephras in Skagafjörður are Hekla 4 (H4) from about 2300 B.C. (Eiriksson *et al.* 2000) and Hekla 3 (H3) from about 950 B.C. (Dugmore *et al.* 1995). These two tephras are either yellow or white and are the thickest (generally 2–3 cm) of all the tephra layers in Skagafjörður. There is sometimes so little sediment deposition over the 1350 years between these two tephras that in dry land environments, the two layers often seem to be one.

There is a group of three tephras in Skagafjörður from the time of initial settlement (Sigurgeirsson 1998) that are referred to as the Landnám tephra sequence. The earliest tephra in this sequence is a dark black layer probably from the Katla volcano, but is not well dated (Wastegard *et al.* 2003). This is followed by the "Landnám" or settlement tephra layer from the Veiðivötn fissure swarm associated with the Torfajökull and Bárðarbunga volcanos (Larsen 1984). The layer is so-named for its association with the earliest settlements in Iceland (Dugmore and Newton 2012). In general, this layer consists of two distinct tephras—an olive-green tephra overlying a white tephra. However, in Skagafjörður, only the green portion is present (cf., Hallsdóttir 1987). The Landnám tephra layer is dated to A.D. 871 ± 2, and is found from Greenland (Grönvold *et al.* 1995; Zielinski *et al.* 1997 [who also arrive at an A.D. 877 ± 4 date]) to Scotland (Cage *et al.* 2011). The third tephra of the sequence is a blue-green un-sourced and undated layer from the mid-10th century. There are several potential candidates for this layer, including the large A.D. 934 ± 2 eruption of Eldgjá (Hammer *et al.* 1980; Thordarson *et al.* 2001; Fei and Zhou 2006) or an A.D. 933 ± 6 green tephra identified in the Lake Mývatn area from Veiðivötn, termed V-Sv (Sigurgeirsson *et al.* 2013). Because this third tephra is poorly understood, and it may not be either of these candidates, it will be referred to as a mid-10th century tephra with a tentative date of A.D. 950.

A dark tephra has been identified in a few locations around Skagafjörður (Ólafsson 1985; Boygle 1999), which approximately dates to A.D. 1000 and whose source has not been determined but likely to be either from Grímsvötn or Veiðivötn. The white or yellow layer from Hekla that fell in A.D. 1104 (H1) is the most consistent and thickest historic tephra in Skagafjörður (Thórarinsson 1967; Eiriksson *et al.*

2000) and is readily identifiable in both natural and cultural stratigraphic sequences. The H1 tephra was used as a consistent cross-site gauge of farmstead size at the end of the study period. The majority of farmsteads in the survey area were established before the H1 tephra fell. Two additional tephra layers in Skagafjörður resulted from the eruption of Hekla in A.D. 1300, and again in A.D. 1766. These tephras vary from gray-blue to dark black depending on location and soil moisture (Larsen 1984; Sveinbjarnardóttir 1992; Larsen *et al.* 1999; Larsen *et al.* 2001; Larsen *et al.* 2002). The historic tephra layers in Skagafjörður are not so thick that they significantly affected animal grazing or plant life when they fell (Caseldine and Hatton 1994; Simpson *et al.* 2004). These tephra layers form the basic archaeological temporal sequence of the settlement pattern study.

Skagafjörður Archaeological Settlement Survey

The Skagafjörður Archaeological Settlement Survey (SASS) has intensively investigated the region around Langholt (which means long hill). On Langholt, SASS has instituted a multistage protocol that exploits the tephra layers and subsurface preservation provided by the aeolian sediment. The protocol starts at the regional level and progressively works from the region, to the site, to specific activity areas. By integrating coring, extensive geophysics, test excavations, intensive geophysics, and traditional excavation into a series of stages, we have gone some ways toward overcoming the archaeological survey biases that Iceland in general (Smith and Parsons 1989), and Skagafjörður specifically, presents. This paper focuses on the results of coring and test excavation. Coring and test excavation yielded three basic archaeological measures of the Viking Age settlement pattern: farmstead location, farmstead size at the end of the Viking Age, and farmstead establishment date.

Langholt is on the western flanks of the central Skagafjörður valley bottom and is bordered on the east by the small freshwater stream Húseyjarkvísl (which feeds into the large glacial river Héraðsvötn) and on the west by the freshwater stream Sæmundará. Langholt is a tongue of Upper Tertiary basic and intermediate extrusive basalts (Feuillet *et al.* 2012) overlain by morainic glacial till. It is about 8 km long, 2 km wide, and has a top elevation of 150 masl. The land is fertile by Icelandic standards (Jóhannesson 1960) because of substantial aeolian soil deposition. Langholt is historically identified as a single initial land claim by one of the original settlers of Iceland and the archaeological survey includes all of that claim, and part of a claim to the north (FIG. 1). Today the area is still intensively occupied and many of the farms remain in commercial operation. In the survey area there are 17 visible farm mounds most of which have Viking Age occupational layers.

The long-term depositional processes that result from multi-generational rebuilding and episodes of abandonment and reoccupation of farmsteads do not necessarily create a smooth or regular farmstead footprint. The Viking Age cultural deposits (archaeologically identified as those under the H1 tephra) can be deeply buried under later occupational debris. The earliest cultural deposits of a farm mound can be in the center of the farmstead extent, but just as often, the deepest part is off to one side. At the edge of a visible farm mound the cultural layers under an in situ H1 tephra can be 20 or 30 cm thick but completely taper-out just 5 m further out from the farm mound's center. At abandoned farmsteads, without any post Viking Age occupation, the deepest part is usually the ash midden pile.

The early substantial soil deposition, the paucity of surface artifacts, and contemporary field smoothing (with little plowing) has often eliminated telltale signs of buried turf buildings from relocated and abandoned farmsteads in areas like Langholt. This means that the subsurface of all areas with substantial soil deposition must be examined for evidence of possible early settlement in order to establish a reliable settlement pattern sequence.

Farmstead Location

Obtaining a complete inventory of sites and their locations is the most basic aspect of a settlement pattern (Willey 1953; Parsons 1972). For many farms in Skagafjörður the Viking Age farmstead is at the bottom of a visible farm mound but to obtain the complete sequence, abandoned and relocated farmsteads must be identified as well. Because not all Viking Age sites are visible on the surface, over 4000 hand cores were taken to identify any possible buried sites. The cores covered all the fertile areas of Langholt, both around modern farmsteads and in the interstitial areas. The coring data have allowed the identification and measurement of stratigraphic sequences of aeolian soil, tephra, and cultural deposits across the Langholt region.

Coring has long been used to resolve the location, size and stratigraphic sequence of buried and complex sites (Stein 1986; Schuldenrein 1991; Stein 1991). Coring has been used less frequently as a primary reconnaissance technique where archaeologists have generally favored field walking (e.g., Hey and Lacey 2001; Banning *et al.* 2006), or shovel test pits (e.g., Lovis 1976; Shott 1985; Krakker *et al.* 1986; Nance and Ball 1986; Shott 1989), or phosphate testing (e.g., Thurston 2001; Holliday and Gartner 2007) in areas of low visibility. In lowland Iceland, coring has been used to identify sites and to investigate a wide range of environmental and social parameters (Bolender 2006; Carter 2010; Catlin 2011).

Hand coring in areas of Iceland that have received aeolian sediment and tephra layers is remarkably productive. Coring allows for a rapid assessment of where buried farmsteads are and are not. Drained bogs and wetland areas that were larger than a hectare and obvious in air photos were not surveyed. Areas of denuded glacial deposits (Arnalds *et al.* 1987) or eroded frost hummocks (Van Vliet-Lanoe *et al.* 1998; Grab 2005) were walked and cored as soil allowed. The elimination of large areas from intensive subsurface reconnaissance is an important first stage in targeting buried features, as the entire landscape is too large to investigate intensively. Not only can cultural deposits (charcoal, ash, midden, floor, and turf) be identified in small hand cores, but in most instances, those cultural deposits can be dated based on the tephra layers recovered in the soil core.

The coring methodology is straightforward and extensive. We have used Oakfield peat samplers (a model no longer manufactured), an Eijkelkamp meter-long single-gouge auger for harder or dryer soils, and most frequently, a JMC Backsaver soil sampler push probe with an 18-inch long 1.25-inch wide sampling tube. Comparisons between cores and excavated stratigraphy indicate relatively minor compression of sequences in the cores in aeolian soil and cultural deposits. (However, waterlogged bog deposits may escape recovery in the core and peaty layers may expand when removed from the surrounding matrix).

In areas with sufficient soil accumulation to completely bury abandoned farmsteads, coring intervals varied from 10 m to 100 m depending on the geological conditions, with most cores spaced every 50 m. At this density it would be expected to find a little less than 40% of sites smaller than 1000 sq m (e.g., Krakker *et al.* 1986). Therefore, where soils were at all well drained, or cores contained a hint of human activity, the density was reduced to 25 m, providing a high probability (>95%) of encountering small (600 sq m) sites. Wherever possible, cores probed down to the prehistoric tephra layers (e.g., H3 or H4) ensuring that the entire potential period of occupation was sampled. All tephra layers, soil horizons, and inclusions (cultural and otherwise) were recorded. When cultural material was identified (e.g., charcoal, ash, midden, floor, or turf not belonging to natural in situ bog deposits) additional cores were taken, filling in the intermediate areas in the survey grid to more precisely determine the nature, extent, and dates of the deposit.

Over 4000 cores (of which about 300 were part of the farm mound midden test pit program) were taken as part of the regional coring survey that covered about 600 ha (FIG. 3). The survey identified two large Viking Age sites (>3000 sq m): Stóra-Seyla and Glaumbær that were later relocated (Bolender *et al.* 2011) and two small (<1500 sq m) Viking Age sites on modern farms with already known Viking Age components: Marbæli 2 and Torfgarður 2. Both small sites were abandoned before the A.D. 1104 tephra fall. All four of these locations presented no surface expression. Stóra-Seyla and Glaumbær were intensively investigated with geophysics and large aerial excavations (Bolender *et al.* 2011; Damiata *et al.* 2013). Depending on how one counts, this brings the total of Viking Age farmsteads in Langholt to between 17 and 20 (TABLE 1) with between 12% and 20% of them having no surface sign.

Farmstead size

Viking Age farmsteads vary in extent. The same coring program described above—designed to identify buried sites—was also the primary tool for measuring a farmstead's size. Farmstead size was determined by calculating the area of continuous spread of building debris, midden, and other cultural layers that occurs under the H1 tephra layer. This defining perimeter denotes the maximum site expanse possibly reached before A.D. 1104.

Icelandic Viking Age farmstead remains are generally concentrated, distinct, and correspond to modern named farms. The 17 historically identified farms surveyed had distinct and concentrated areas of pre-A.D. 1104 cultural material that correspond to the locations of the modern farms on which they were found. However, six of these farms had multiple distinct areas of pre-A.D. 1104 cultural deposits with measurable interstitial space between them. Within these historically defined farms, it was not clear if the multiple distinct areas of pre-A.D. 1104 cultural deposits should be combined as a single farmstead or if the distinct deposits should be separated out into smaller farmsteads.

Within the Langholt survey area, the closest historically known independent farms are only 300 m apart. The average distance between historically identified farms is 900 m (SD 300 m). There were no areas of pre-A.D. 1104 cultural material that extended across boundaries between two historically known farms. Given this distribution of known cultural areas, two different rules for grouping areas of archaeological cultural material under the A.D. 1104 tephra were employed. The modern farm rule simply combined all areas within the property boundaries of a given historically identified farm and used the earliest establishment date for that entity. The 100 m rule separates areas of cultural material under the A.D. 1104 tephra into different farmsteads if there is at least 100 m of interstitial space surrounding a cultural area. These farmsteads were assigned independent establishment

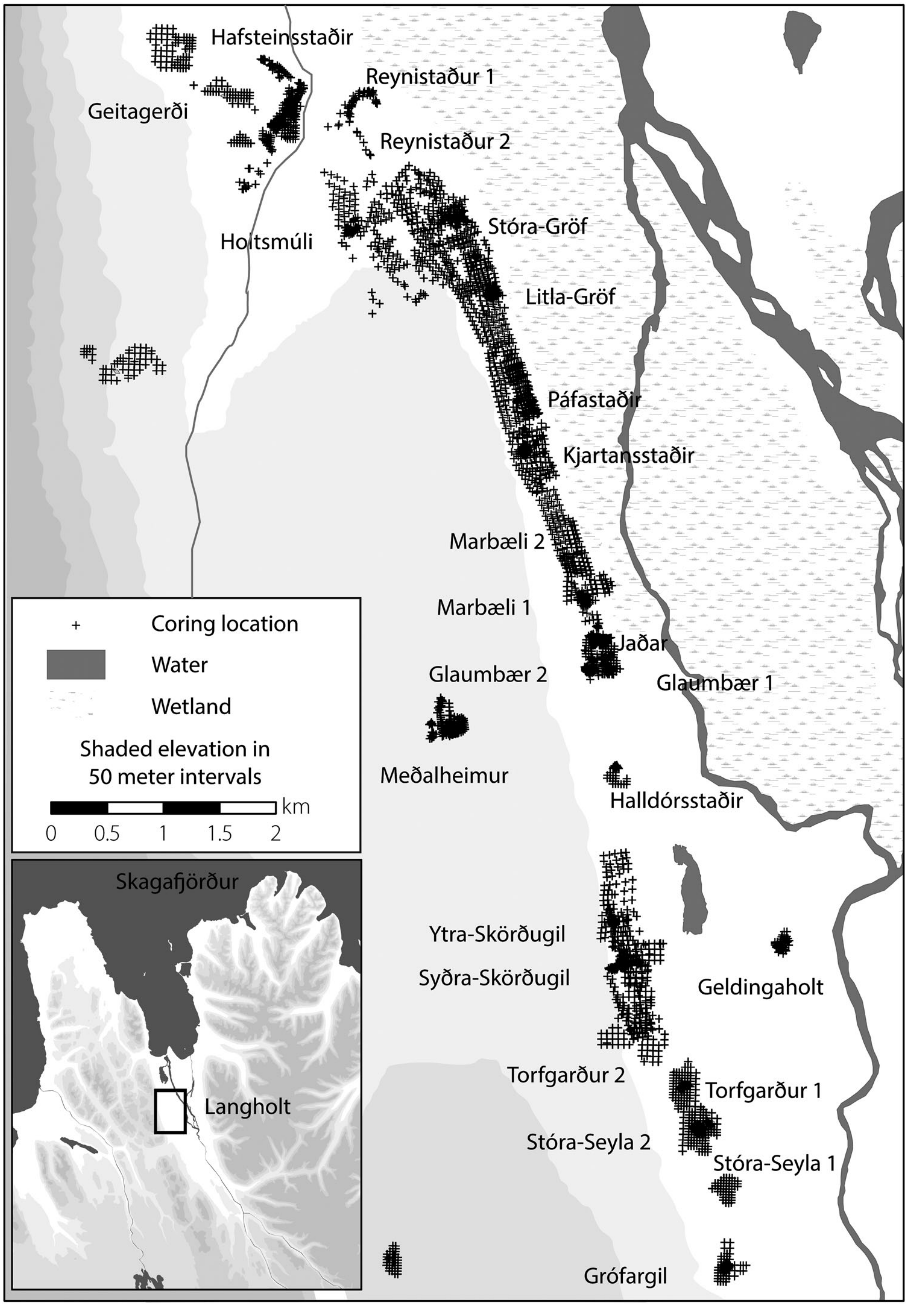

Figure 3 Langholt coring locations.

dates based on their individual sequences (TABLE 1). Using these two rules, a farmstead's perimeter was determined by the results of the plotted cores taken around a site (FIG. 4).

The results of cores were divided into three simple categories: "yes," "no," and "maybe" based on the presence of cultural material below the H1 tephra layer. "Yes" cores presented cultural deposits below the H1 (or an earlier) tephra. "Maybe" cores indicated early cultural deposits, as determined by depth or association with another tephra such as the 1766 or 1300 tephra, but without the presence of a clearly defined H1 tephra layer. The absence of the H1 in a context of a cultural deposit is mostly because it was not preserved or the core did not penetrate deeply enough to encounter it (i.e., refusal within more recent deposits). A "no" core resulted when no cultural layers were present in the core or where there was no cultural layer below the H1. Almost all "no" cores had the H1, or some other tephra that allowed for the assessment of this important negative evidence. In several cases, "maybe" results in the center of deep farm mounds represent, in all likelihood, deeply buried cultural deposits where the H1 was out of reach of the core. Most importantly, "no" results close to ambiguous or positive results could be due

Table 1 Farmstead data.

Farm	Tephra Date Range (A.D.) TPQ	TAQ	Oldest ^{14}C Date BP±	Extreme 2σ Range (A.D.)	Laboratory Number	Establishment Point Date Estimate (A.D.)	Years Since 872 A.D.	Duration: Years Until 1104 A.D.	Area by 1104 A.D. (sq m)	1880 Census People	1883–1896 Farm Inventory Averages Cattle	Sheep
Reynistaður	871	950	1205 ± 20	769–886	UCIAMS 62807	879	7	225	8340	24	6.6	221.1
Reynistaður 1	871	950	1205 ± 20	769–886	"	879	7	225	7573			
Reynistaður 2	871	1000	1189 ± 32	719–950	AA 46687	911	39	193	767			
Stóra-Seyla	871	950	1130 ± 15	879–982	UCIAMS 87104	914	42	190	7179	19	5.9	108
Stóra-Seyla 2*	1000	1104				1100	228	4	2766			
Meðalheimur	871	950	1160 ± 20	775–961	UCIAMS 49534	917	45	187	4691			
Marbæli	871	950	1070 ± 20	893–1019	UCIAMS 49331	922	50	182	8329	10	5.1	130.5
Marbæli 1	871	950	1070 ± 20	893–1019	"	922	50	182	7209			
Marbæli 2	1000	1104				1052	180	52	1120			
Hafsteinsstaðir	871	950	1158 ± 44	769–985	AA 55485	929	57	175	3022	13	3.7	133.4
Stóra-Gröf	871	1000	1130 ± 15	886–972	UCIAMS 77359	929	57	175	3564	14	5.1	184
Syðra-Skörðugil	871	1000	1125 ± 20	885–980	UCIAMS 49533	933	61	171	4161	9	3.1	54.3
Litla-Gróf	871	1000	1115 ± 15	891–978	UCIAMS 87103	935	63	169	4593	10	2.7	96.7
Glaumbær	871	1000	1115 ± 20	890–982	UCIAMS 105200	936	64	168	7111	19	6.9	247.5
Glaumbær 2*	871	1104				988	116	116	3597			
Torfgarður	871	1000			UCIAMS 77364	936	64	168	2979	8	1.6	23.3
Torfgarður 1	871	1000				936	64	168	2064			
Torfgarður 2	1000	1104				1052	180	52	915			
Kjartansstaðir	950	1000	1080 ± 15	893–1019	UCIAMS 77360	975	103	129	3326	18	4.5	62.5
Geldingaholt	871	1000	1045 ± 20	1024–872	UCIAMS 49330	986	114	118	4154	20	8.9	251.4
Holtsmúli	871	1000	1020 ± 15	990–1027	UCIAMS 77365	995	123	109	2745	8	2.6	107.6
Páfastaðir	1000	1104				1052	138	94	2455	13	4.5	118.7
Halldórsstaðir	1000	1104				1052	180	52	1537	7	1.8	28
Grófargil	1000	1104	982 ± 45	895–1160	AA 55486	1052	180	52	603	12	2.9	69.7
Ytra-Skörðugil	1000	1104				1052	180	52	587	7	2.4	36.3

* Relocated Farms. Not used in charts or statistics. Indented entries are used instead of the modern farm entry for 100 m rule calculations.

to post depositional disturbance, and thus their weight was discounted.

The pattern of cultural material recovered in the cores was used to define the perimeter of the pre-A.D. 1104 farmstead. The perimeter was plotted half way between a "yes" and "no" core, or on a "maybe" core between a "yes" and "no" core. The continuous area within the perimeter was calculated to produce the maximum possible area of a farmstead by A.D. 1104 (in sq m). If there were multiple contiguous areas (either within a modern farm or within the 100 m rule) they were combined. The 50 × 50 m coring density, described above, was sufficient to obtain a rough idea of the perimeter. When augmented with additional intermediate cores, a farmstead's extent by 1104 can be determined within approximately 15 m in any given direction, and usually within a shorter distance. In the survey, farmstead area was defined from as few as 4 cores and as many as 100. In some instances the Viking Age boundary of a farmstead was under contemporary buildings, defined by natural topography, or too deeply buried to access with hand cores. Natural boundaries (e.g., steep hillsides, rivers, streams, and wetland edges) were used as borders whenever possible (e.g., rivers at Reynistaður or marshy areas at Halldórsstaðir in FIG. 4). In such areas, Viking Age farmstead boundaries were estimated as closely and conservatively as possible.

Farmstead establishment date

The establishment date of a farmstead is the final critical metric for the settlement pattern study. The establishment dates were determined from tephra dates, sometimes in combination with AMS radiocarbon dates, obtained from carefully targeted excavations in the oldest part of a farmstead's midden.

Household middens are ideal targets for obtaining the establishment date of a farmstead. Substantial concentrations of ash and bone are indicative of domestic occupation and their presence can distinguish farmsteads from isolated outbuildings and other non-domestic site types. The ash and other household garbage was not universally spread on fields, but often built up into a mound (e.g., Davidson *et al.* 1986) and a small portion of the ash spread over living floors (Milek 2006). Middens were often concentrated adjacent to a side entrance

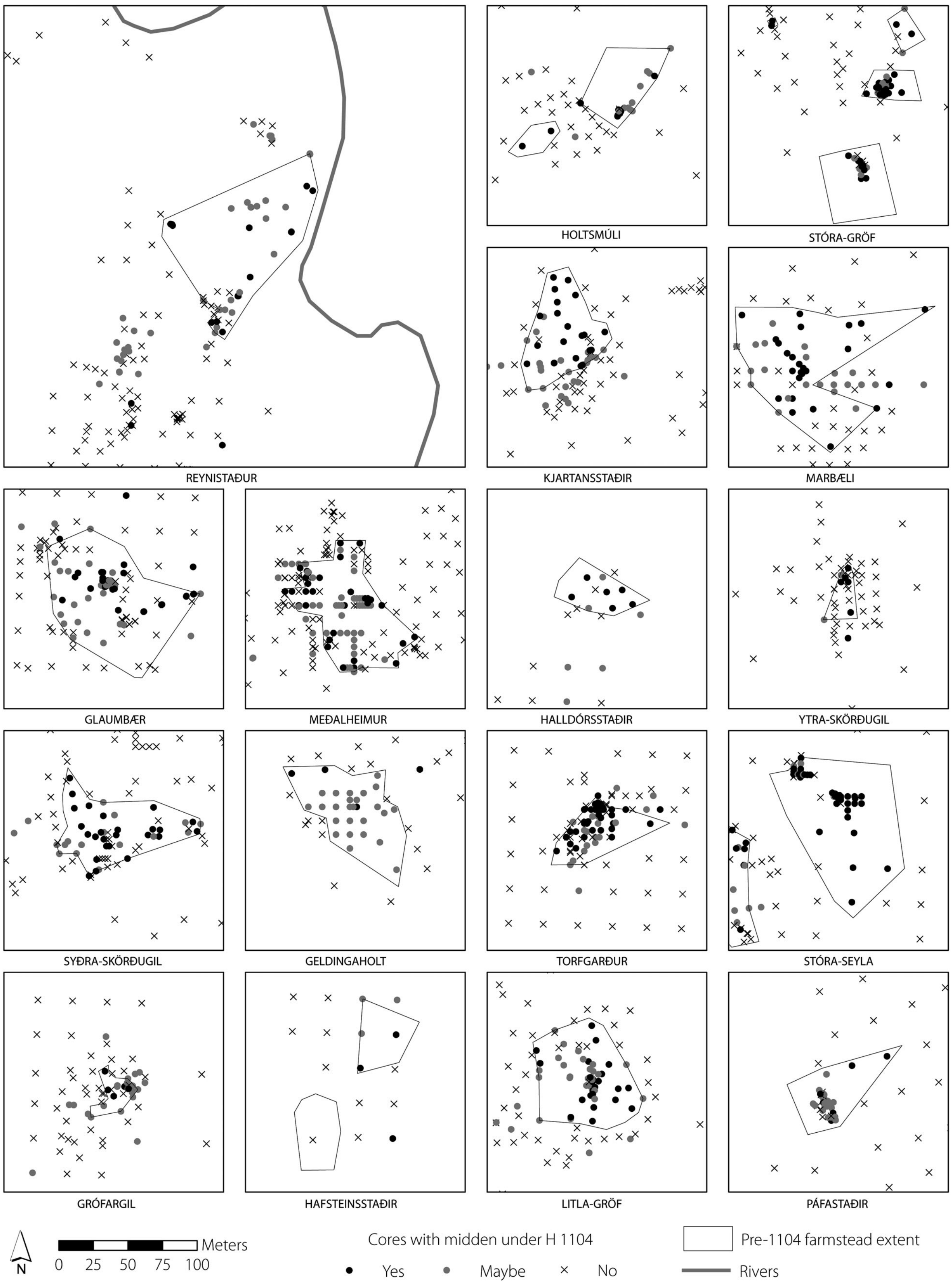

Figure 4 Site perimeters based on coring results. These do not include the substantial excavations at Reynistaður, Stóra-Seyla, Glaumbær, and Marbæli. Not shown are the very small sites of Reynistaður 2, Marbæli 2, and Torfgarður 2 or the relocated farmsteads at Stóra-Seyla or Glaumbær.

or kitchen door (Snæsdóttir 1991; Buckland *et al.* 1994; Vésteinsson 2010). In other regions, Viking Age middens frequently were dispersed like a sheet around the farmstead area but this does not appear to be typical of the Viking Age farmsteads in the Langholt area, most of which have concentrated, stratified midden deposits from the Viking Age. In all of these midden formations, the ash tends to build up rapidly due to the tremendous volume of waste from the burning of peat, dung, and wood (Simpson *et al.* 2003; Vésteinsson and Simpson 2004). Midden deposition seems to be relatively continuous and thus provided an excellent environment for the rapid burial and preservation of tephra layers. Middens can be sampled without unduly damaging the complex stratigraphic relationships in structures.

Two of the farmsteads with an isolated Viking Age occupation (Glaumbær and Stóra-Seyla) were surveyed using geophysical methods to identify structures and their overall layout, as these sites had no surface sign. Usually an initial reconnaissance survey was conducted with electromagnetics (EM) to identify and delineate buried turf structures and middens, followed by ground penetrating radar (GPR), and electrical resistivity to produce detailed maps of structures and site stratigraphy. All three methods can be used to identify ash middens in Icelandic soils. Ash middens usually present themselves as having relatively lower resistivity, higher EM in-phase response, and as strong GPR reflectors compared to their surroundings (these characteristics do vary from site to site). Once a midden was identified using geophysical methods, it was densely cored (1–5 m spacing) to identify areas where early tephras were present and associated with peat ash deposits. The oldest and deepest part of the midden was then excavated to confirm the stratigraphy and to recover artifacts, faunal material, and soil samples for paleoethnobotany (Trigg *et al.* 2009). Midden excavations ranged in size from 1×2 to 3×3 m trenches.

For farmsteads with long-term occupations that developed into large farm mounds, the middens are readily identifiable from surface remains. The problem is that there is so much peat ash that the earliest midden and tephra layers may be 3–5 m below the surface. At these mounded farmsteads the majority of the peat ash midden has usually been deposited since the 1766 tephra (hence the peat ash midden's visibility) and excavating through this overburden is difficult and in some cases unsafe. Therefore, we generally targeted edges of the midden with early deposits and preserved tephra layers. These areas were cored densely at a 1–3 m spacing. Small excavations (1×1 or 1×2 m) then targeted the oldest midden layers.

Farmstead establishment dates were determined from tephrochronology and AMS radiocarbon dates from charred botanical samples or domestic animal bones that were recovered from the earliest midden deposits. A farmstead establishment tephra-date range was determined by the relationship of the lowest peat ash deposit to the surrounding tephra layers (TABLE 1). The bottom tephra is a TPQ, while the tephra above the lowest midden deposit is a terminus ante quem (TAQ) establishment date. Point-date estimates for farmstead establishment were derived from the midpoint of the bracketing tephra layers. In many cases flotation or excavation yielded material for AMS dating from that earliest context. Of the 22 farmsteads that were investigated, 10 have associated AMS dates. If either of the extremes of the 2σ range were narrower than the bracketing tephras, that extreme of the 2σ range was used instead to estimate the midpoint. That is, the point-date for a farmstead's establishment is the average or midpoint of either the bracketing tephra or the extreme 2σ range, whichever was narrower.

Using a point-date estimate instead of a date range allows for a detailed comparison of rates of change (Stein *et al.* 2003); however establishing point date estimates from a date range is not without issues (Blaauw 2010). There are potentially better methods of establishing point-dates than taking the midpoint, especially when using radiocarbon ranges. However, more robust methods for establishing midpoints from radiocarbon dates (Telford *et al.* 2004; Michczynski 2007) can be even more problematic for calendrical date ranges where there is a wiggle or flat part of the calibration curve, of which there are two major occurrences during the period in question (FIG. 2). Thus, the radiocarbon 2σ extreme constrained bracketing tephra midpoint described above seems most efficacious for a farmstead establishment point-date estimate (TABLE 1).

In the survey area only six modern farmsteads were established after the Viking Age. Using the modern farm rule, only one farm established during the Viking Age was abandoned in pre-modern times (Meðalheimur) and using the 100 m rule, four farms were abandoned (Meðalheimur, Reynistaður 2, Marbæli 2, and Torfgarður 2).

Results of the Skagafjörður Archaeological Settlement Survey

Using this protocol we have surveyed 22 modern farm properties in Skagafjörður (TABLE 1) (FIG. 3). On these modern farms, we identified 17–20 Viking Age farmstead locations, outlined their maximum possible extent during the Viking Age, and determined when they were initially established.

The initial settlement of Iceland and subsequent division of land claims was a rapid process. In the survey region, a majority of farms were established within 150 years following the initial settlement (FIG. 5). Using only the TAQ tephra dates, the Langholt survey area was settled at a pace that varied between farmsteads being established about every six years (50 years/8 farmsteads) to about one every 26 years (104 years/4 farmsteads, TABLE 1). While it is difficult

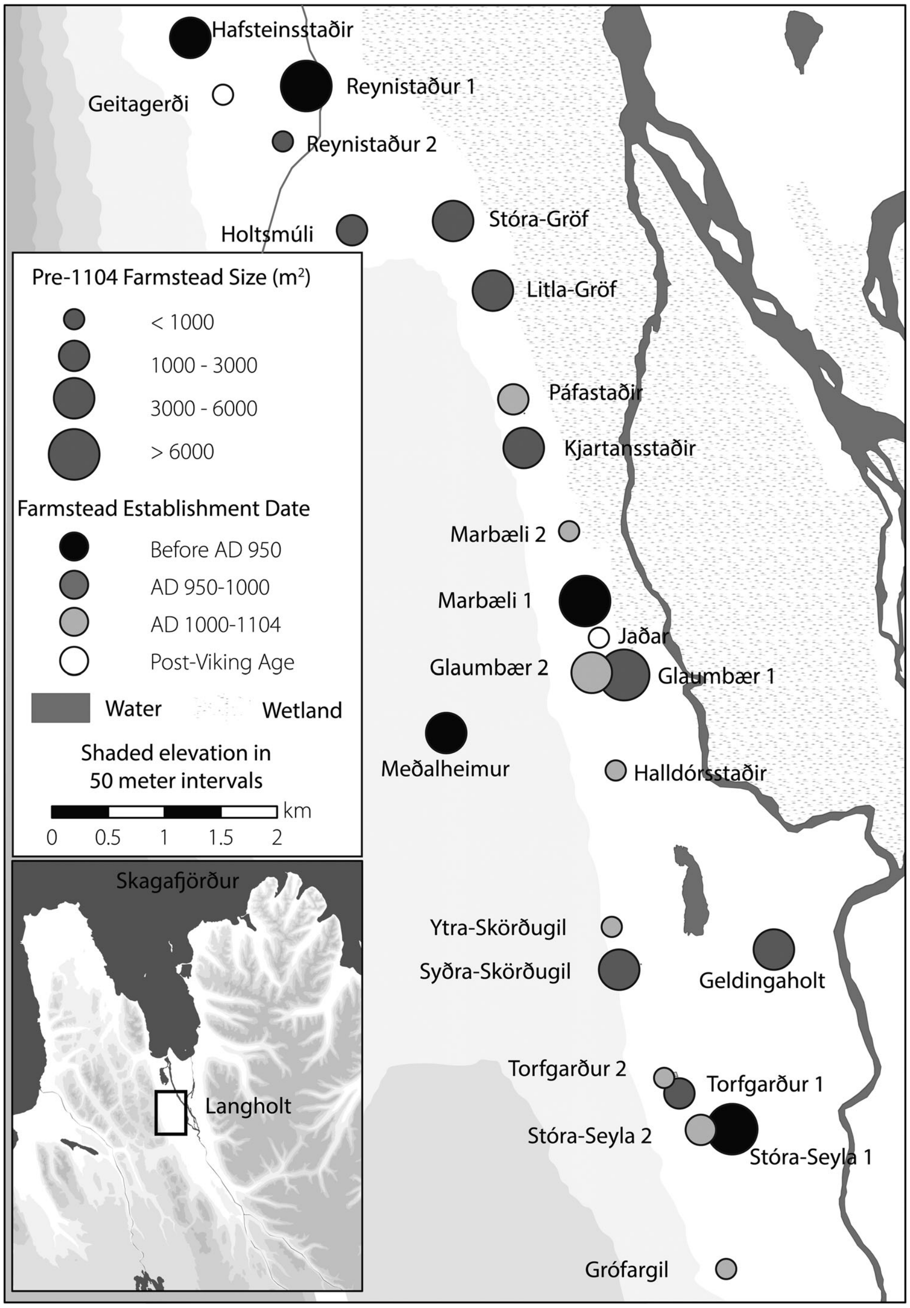

Figure 5 Langholt settlement sequence.

to put these rates into context, using the TAQ tephra dates, it seems that the 50 years between the A.D. 950 and 1000 tephras saw the greatest number of farmsteads established.

The farmstead establishment point-date estimates suggest that the period of most rapid settlement took place between A.D. 900 and 950 (FIG. 6A). While this period may be earlier than the tephra TAQ dates suggest, the maximum rate (6.25 farms/50 years) is about the same. The linear regression is very strong and highly significant ($R = 0.965$, $R^2 = 0.867$). The settlement order–date regression line (FIG. 6A) implies that, on average, every 11 years a new farmstead was established in Langholt during the study period. For this data set, the linear regression curve is the strongest line (besides the quadratic and cubic curves) suggesting a relatively even settlement process. That is, the log or exponential regression is weaker than the linear regression and suggests that the overall settlement rate does not speed up or slow down through time, but it might peak in the middle of the study's time period.

The differences in size, as measured by combined areas of cultural debris under the A.D. 1104 tephra that resulted from the settlement order is relatively small. In Langholt the mean Viking Age farmstead,

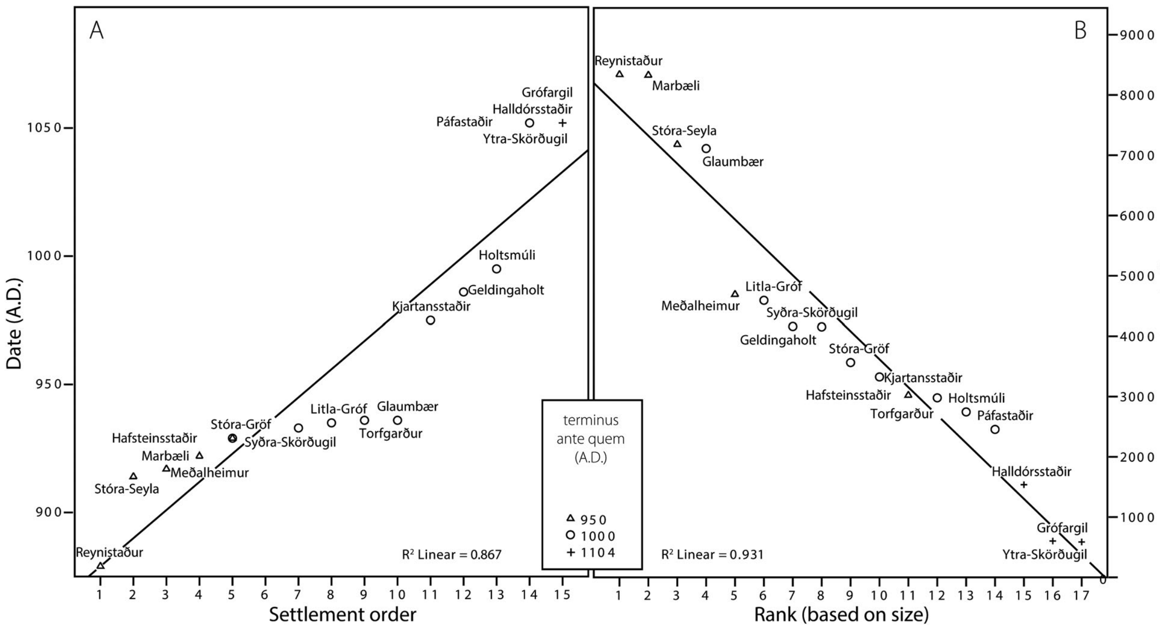

Figure 6 A) Linear relationship between date (A.D.) and settlement order; B) Linear relationship between area (sq m) and rank based on size.

using the modern farm rule (n = 17), is about 4081 sq m (SD 2424) (about 64 m across), with the 100 m rule (n = 20), the mean farm size is 3469 sq m (SD 2350). Farmstead area ranges from 587 sq m (about 24 m across) to 8340 sq m (91 m across) by A.D. 1104. The rank size relationship (FIG. 6B) is strongly linear, not log-log, as one would expect in a complex stratified society (Johnson 1982; Aubán *et al.* 2013). The stronger linear relationship for the rank-size relationship holds true for both the modern farm rule and the 100 m rule (TABLE 2). The Gini coefficient for farmsteads grouped by modern farm is 30% suggesting substantial equality in the overall distribution of farmstead sizes (Mulder *et al.* 2009; Brown, Watson *et al.* 2012).

Table 2 Correlation coefficients for area and rank and area and duration using both modern farms and the 100 m rule.

Correlation	R	R^2	Sig	Coefficient
Modern Farm Boundaries (N = 17)				
Area & Rank	0.965	0.931	.000	463 (sq m decrease per additional size rank)
LN(Area) & LN(Rank)	0.811	0.657	.000	0.80 (8% decrease in area per 10% additional size rank)
Area & Duration	0.815	0.664	.000	36.7 (sq m increase per additional year)
LN(Area) & LN(Duration)	0.899	0.809	.000	1.45 (14.5% increase in area per 10% additional duration)
100 m rule (N = 20)				
Area & Rank	0.974	0.948	.000	387 (sq m decrease per additional rank)
LN(Area) & LN(Rank)	0.857	0.734	.000	0.89 (8.9% decrease in area per 10% additional rank)
Duration & Area	0.721	0.52	.000	29.1 (sq m per additional year)
LN(Duration) & LN(Area)	0.758	0.574	.000	1.19 (11.9% increase in area per 10% additional duration)

While the settlement rate and the resulting farmstead site size hierarchy are both relatively even, the remarkable correlation between farmstead size and establishment date suggests that the result of the settlement process was profoundly uneven. Farmsteads established early are significantly larger by A.D. 1104 than farmsteads established later. The average size of a farmstead with a tephra TAQ of A.D. 950 (modern = 6312 sq m, 100 m rule 5934 sq m) is significantly larger ($p < 0.05$) than farmsteads with an A.D. 1000 TAQ establishment date (modern = 3899 sq m, 100 m rule = 3653 sq m). The difference between farms with a TAQ establishment date of 1104 (modern = 909 sq m, 100 m rule = 1137 sq m) and those with an A.D. 1000 TAQ is even more significant (FIG. 7).

The farmstead establishment point-date estimates when regressed linearly against the maximum farmstead area by A.D. 1104 yield an R of 0.815 that explains about 66% (R^2) of the variance. The modern farm rule correlation coefficient suggests that for each additional year later a farmstead is established, it will be about 37 sq m smaller. These numbers are slightly less strong and lower for farmsteads

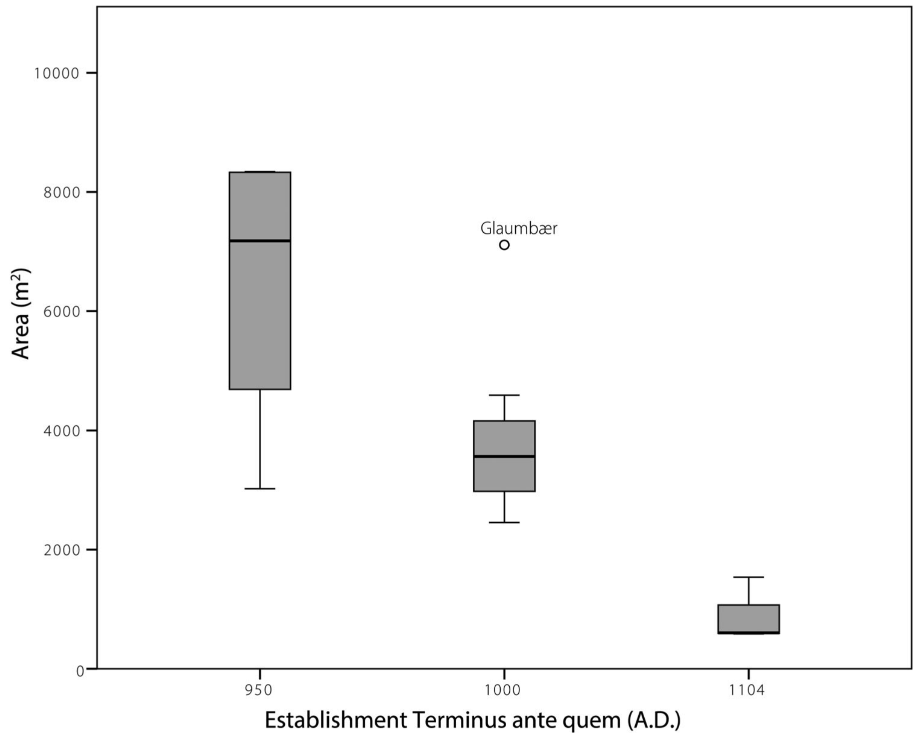

Figure 7 Boxplot of area (sq m) by TAQ. The middle bold line in the box is the median, the box itself is the interquartile range, and the t-bar is 1.5 × interquartile range (or the minimum/maximum value, whichever is lower).

defined using the 100 m rule, but nonetheless still very significant (TABLE 2).

More significantly, the natural logarithm (ln) of area against the natural logarithm of duration has a stronger correlation (0.899) than the linear regression (TABLE 2) in the modern farm rule. The coefficient (1.45) suggests a very dynamic relationship, not simply a linear one as described above. This ln-ln relationship suggests that establishing a farm 10% earlier is predicted to yield a farm that is almost 15% larger (FIG. 8) in A.D. 1104. The ln-ln regression for farmsteads grouped using the 100 m rule is not quite as strong or dynamic, but again it is stronger than the corresponding linear relationship (TABLE 2).

Not only are more recently established farmsteads dynamically smaller, but the establishment date and farmstead area by A.D. 1104 are positively correlated with early-modern farm productivity metrics—such as the number of cattle, sheep, and agricultural yields—and census data (Office of Governor General 1880). For the farms established during the Viking Age that are still in existence in the 1880's (n = 16) (88%), many of the categories of data averaged from the Farmers' Association records from 1883–1896 (Sveitabók, Seyluhreppur 1861–1901 Héraðsskjalasafn Skagfirðinga and Skýrslubók hreppstjórans í Staðahreppi, 1883–1918, Héraðsskjalasafn Skagfirðinga) are strongly correlated with the archaeological data collected during this survey. Using averages derived from multiple years helps smooth annual variations in farmstead production as well as changes in household demographics. Farmers' Association data may be less subject to misrepresentation than tax assessor's records (cf., Vésteinsson 2000; Edvardsson *et al.* 2004; Edvardsson 2010). While some of the strongly correlated Farmers' Association categories are complex (e.g., tax and production measures) the average number of cattle against farmstead area in A.D. 1104 serves to illustrate the relationship. The farmstead area by A.D. 1104 is correlated with the average number of cattle on the same early-modern farm ($R = 0.627$, $R^2 = 0.393$) (FIG. 9A). Using the 1880 census, the average number of people on an early modern farm with an A.D. 1104 TAQ (8.7) is significantly smaller ($p < 0.1$) than those with an A.D. 1000 TAQ (13.2) or an A.D. 950 TAQ (16.5, see FIG. 9B). While these correlations may be stronger due to a survival bias (e.g., Jung and Shiller 2005), we do not believe that the correlation can be due to such a bias, given that only two farms are not in the later tax records. The correlations suggest that the results of earlier establishment dates and larger size in A.D. 1104 are important and long lasting.

Discussion

For chiefly societies, elite residences are often larger than other domestic sites (Johnson and Earle 2000: 273). However, in archaeological contexts the duration

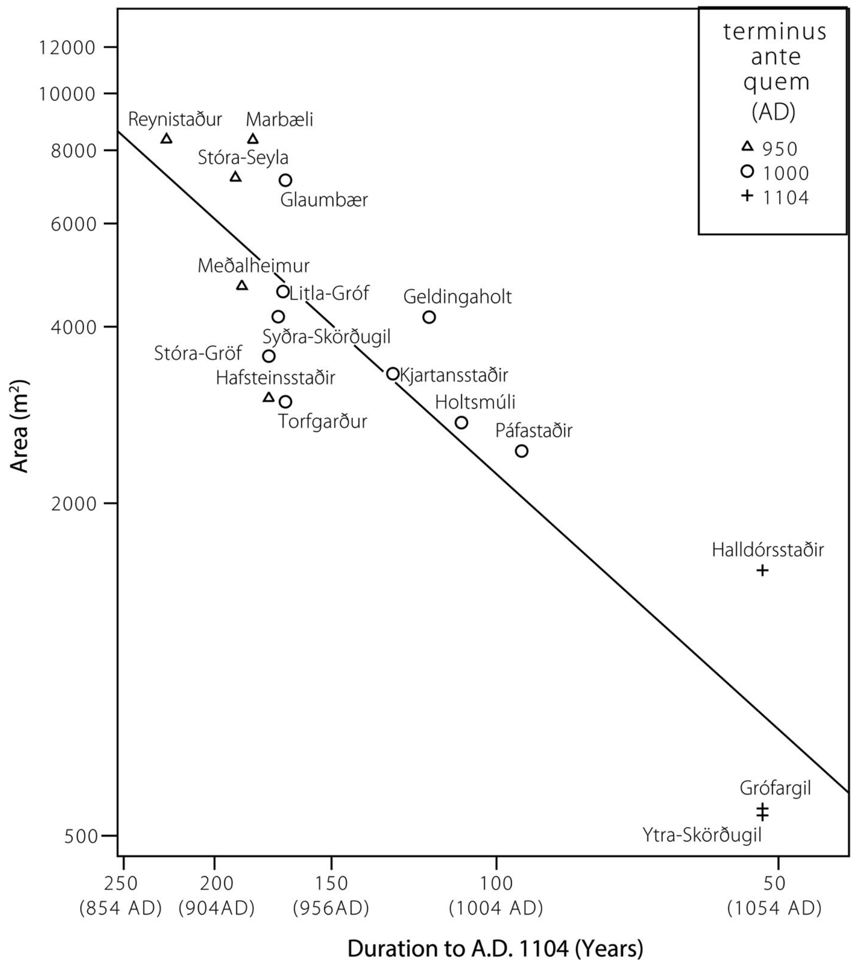

Figure 8 Farmstead area in A.D. 1104 versus the establishment point date estimate of Viking Age farmsteads (both scales are logarithmic).

of site occupation may confound site size as a metric for site status as deposits may extend with time. Distinguishing the two processes that contribute to site size is critical to the interpretation of the Langholt settlement pattern. For chiefly monumental construction, site duration has been used to determine the level of chiefly control (e.g., Kolb 1994; DeMarrais *et al.* 1996; Earle 1997). Monumental sites that were built rapidly in just a few phases are usually viewed as an indication of chiefly power and influence while sites that were repeatedly built over a longer time period do not carry such interpretations (Blitz and Livingood 2004; Clark and Martinsson-Wallin 2007; Thompson and Andrus 2011). However, the cultural deposits of a Viking Age farmstead are subject to a series of different calculations from those of monumental construction. All things being equal, it would be easy to assume that the relationship between the sequence of farm establishment and farmstead size before A.D. 1104 is purely a function of occupational duration. The earlier a site is established, the longer it has to become larger. Farm mounds do accumulate and grow with time but this does not appear to explain the differences in farmstead area. Rather farmstead extent may better be explained by the wealth of the farm.

Size and duration

That duration may be correlated with site size may seem mundane, but it does suggest substantial occupant and farmstead coherence over the Viking Age and points to stable and well-defined institutions of property rights. While the relationship between farmstead and household is complicated (e.g., Netting *et al.* 1984; Wilk and Ashmore 1988; Wilk 1989), the relationship is even more convoluted in Iceland by potentially unstable property rights during the Viking Age (Durrenberger 1998; Eggertsson 1998). Nonetheless, these correlations, along with other work (Durrenberger 1988; Eggertsson 1992; Gilman 1998; Bolender *et al.* 2008), indicate that property rights were stable enough during the Viking Age in Iceland to justify treating farmsteads as coherent long-term entities in which property was passed down through, and in part was the basis for, family lines (Bolender 2007).

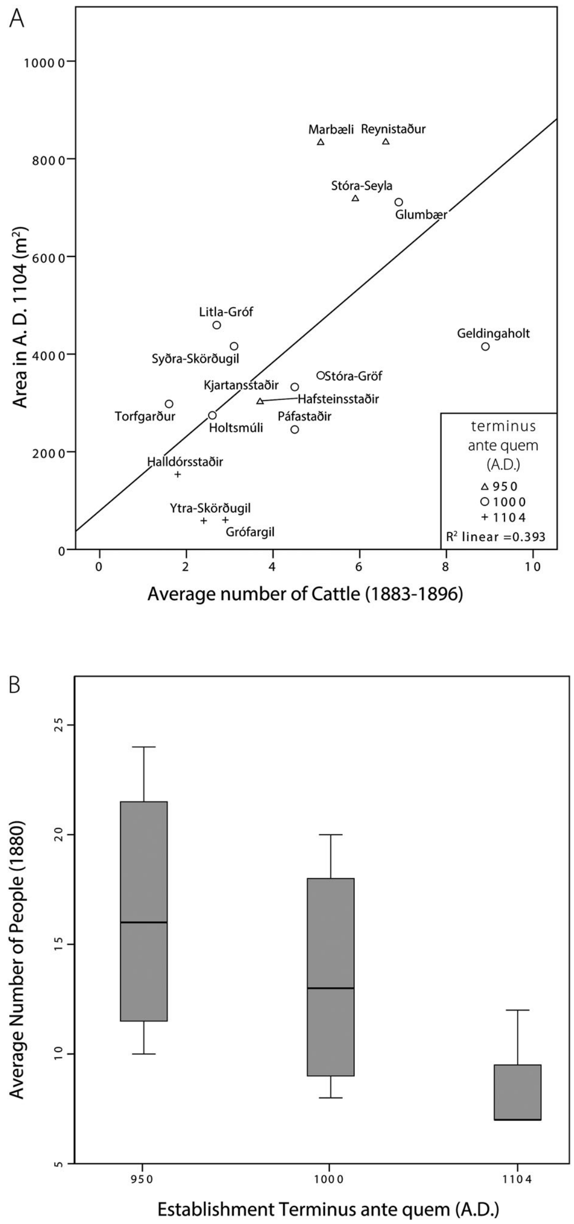

Figure 9 A) Farmstead area in A.D. 1104 versus average cattle count (1883–1896 Farmers' Association); B) Boxplot of average number of people on a farm in 1880 by TAQ. The middle bold line in the box is the median, the box itself is the interquartile range, and the t-bar is 1.5 × interquartile range (or the minimum/maximum value).

The establishment date of a farmstead (TABLE 2) and the measures of agricultural productivity in the 1880–1890's are synchronic measures, while the maximum farmstead size by A.D. 1104 is the sum of a series (cf., Smith 1992). If the maximum farmstead size was attained at a single moment in time, then it is also a synchronic measure, but it is more probably a sum total or series measure. Combining and correlating synchronic and series data sets must be associated with a detailed and exact chronology (Smith 1987a) which probably exists for Langholt.

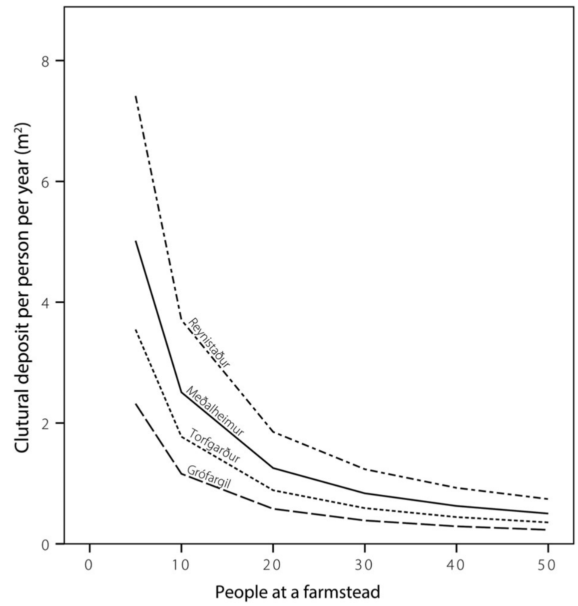

Figure 10 Farmstead population—deposit curves based on equation 1 and data from Table 1, of the relationship between number of farmstead inhabitants and area of cultural deposit per person year for four Viking Age farms.

As a series measure, site size is a function of the length of time that a site was occupied, the area of cultural debris each person deposits, and the number of people at a site.

$$\mathbf{S} = \mathbf{t}\frac{s_n}{p_n}\frac{p}{t_n}$$

where S = total area of cultural debris (s_n is the area of cultural debris deposited in 1 year), t = time in years (t_n is 1 year), and p is the number of farmstead inhabitants, (p_n is one person). By using the maximum farmstead size in A.D. 1104 (S) and duration a site was occupied (t) and suggesting a range of farmstead populations—Vesteinsson and McGovern (2012), find an average of 6.1 people per farm—a curve for four of the farmsteads in the survey region has been created (FIG. 10). The s_n/p_n against p/t_n curves suggest that, except for a condition of very few inhabitants at the smaller farmsteads, both the area of cultural deposit per person per year and the number of farmstead inhabitants in any given year are probably higher at the largest farmsteads.

Not included in the farmstead size equation is the nature of the spread of cultural material over and around a site. This depositional behavior is poorly understood for Viking Age farmsteads. Small differences in cultural and taphonomic patterns could produce large differences in farmstead size as measured two dimensionally (cf., Barrett et al. 2001; Shahack-Gross 2011). Earlier farmsteads might spread out more than later farmsteads because they have an abundance of land. However, in a rural settlement pattern, it would seem unlikely that these initial differences would persist and correlate with premodern agricultural indicators.

It is true that for the two farms that relocated, the newly relocated farmstead areas are smaller in 1104 than their earlier incarnations (TABLE 1—entries with *). For example, the relocated farmstead at Stóra-Seyla, which was occupied for only a few years before the A.D. 1104 tephra fell, is less than 30% that of the initial site (Bolender *et al.* 2011) but still quite substantial. The expansion rate for those early years must have been in the 100's of square meters per year (e.g., 2766 sq m/4 years = 692 sq m/year). The relocated farm at Glaumbær 2 also expanded rapidly after relocation, with an average growth rate of almost 72 sq m/year (3579 sq m/52 years). So it is possible for sites to expand rapidly towards the end of the study period, in a short time, but they generally do not.

There are additional indications that occupational duration is not sufficient to account for the nature of the correlation between establishment date and farmstead size in A.D. 1104. Most obviously, there may be confounding variables that are more important to understanding the relationship between farmstead size and establishment date. This idea is reinforced by the observation that establishment date is also correlated with productivity and census measures from the 1880 to the 1890's. It is unlikely that productive measures in early modern Iceland should be simply correlated with duration of settlement before A.D. 1104.

The accumulated extent of debris associated with the farmstead does appear to increase over time but the change in area appears to be minimal and probably does not account for the variation seen in pre-A.D. 1104 farmsteads. For example, at Torfgarður—the only farmstead for which we currently have this data —the size in A.D. 1104 is 2979 sq m (TABLE 1) and its total post-Viking Age (from A.D. 1104 to 1964) size is only 5043 sq m. The post A.D. 1104 growth rate of area would be about 2.6 sq m per year, much lower than the calculated pre A.D. 1104 growth rate of 17.7 sq m/year for Torfgarður (2979 sq m/168 years, TABLE 1) or the overall average pre A.D. 1104 growth rates of between 29.1 (100 m rule) and 36.7 sq m/year (modern farm rule). Nonetheless, farmsteads may continually increase in height (or depth) with time (Davidson *et al.* 1986; Mook and Bertelsen 2007; Vésteinsson 2010). What little data we have, point to the idea that farmstead area may first expand rapidly and then become relatively static.

Wealth, although a complex concept (Smith 1987b), is a good candidate for the confounding factor in the correlation between site size in A.D. 1104 and duration. Duration is the length of time a site was continuously occupied (Stein *et al.* 2003). If the maximum site size is related to duration, site size can be understood as a proxy for a site's past activity. Wealth is the total stock of assets that could yield goods and services (Douglas and Isherwood 1996: 30). If wealth is an important confounding factor it is because farmstead size and duration are both related to the resources of the occupants: the earlier a site was occupied, the better off its occupants.

The number of farmstead inhabitants and the amount of cultural material spread per person may be related to wealth. While not a hard and fast rule, in general, wealthier sites tend to have a larger number of inhabitants (Netting 1982; Wilk 1983; Netting *et al.* 1984; Demmer *et al.* 2002; Schmitt and Lupo 2008). In complex societies, sites with wealthier occupants not only have more people, but also have larger and more complex architecture, even accounting for the greater number of occupants (e.g., Ames 2001; Nash 2009; Carballo 2011). The rate at which each person contributes to the cultural deposits around the site is probably related to the wealth of the occupants. For example, much of the content of the Viking Age middens that make up the bulk of farm mounds are fuel residues (Snæsdóttir 1991; Simpson *et al.* 2003; Vésteinsson 2004; Vésteinsson and Simpson 2004; Trigg *et al.* 2009; Vésteinsson 2010) and we suggest that combined production and consumption activities of people on wealthier farms will produce more wood, peat, and dung ash per year and per person than on poorer farms (cf., Abrams 1994).

Pre- and post-settlement wealth

Wealth as a confounding factor of farmstead size and establishment date could operate in two different temporal sequences. The occupants' wealth could derive from a correlation with immigration order in which earlier settlers tended to be wealthier (e.g., chiefs from Norway emigrated first). That is, wealth disparities already existed before settlement and are played out on the newly established landscape. On the other hand, the correlation of occupants' wealth with establishment date and site size could derive from the advantages of arriving first and choosing the best land or being able to establish ownership claims over other resources. That is, better land produced larger sites and settlement establishment date is correlated with ownership of better land or larger estates. In this case, wealth disparities would be created through the dynamics of the settlement process (cf., Edwards 2012).

The Langholt data does not allow for a detailed discussion of the relative contribution of pre- and post-settlement sources of wealth, and these are not mutually exclusive. In other areas settled as part of the Viking Age western migration, the sources and the timing of changes in wealth distribution are somewhat ambiguous. In Viking Age Greenland, where dating is more difficult but where the Norse sites are more apparent on the surface and therefore their size easier to estimate, McGovern (1985) has noted that larger hall size is positively correlated with a whole host of economic indicators including sheep pen area; larger pastures; cattle to caprine ratio; and hay storage area (McGovern 1992). Christensen (1990), employing some of the same data and building on early scholarship (Nørlund 1934; Roussell and Degerbøl 1941), suggests that settlement order plays a strong role in Norse Greenland, with the chiefs arriving earlier and taking the good areas. Later, lower status arrivals or later native generations had to occupy less favorable locations. On the other hand, in Orkney (Barrett *et al.* 2000), with the intensive studies at Quoygrew, it appears that wealth, while multifaceted, was derived primarily from trade and piracy, broadly associated with farmsteads that were established early (pre-Viking Age). These earlier farmsteads were also associated with later intensification and specialization, first in fishing for export (Barrett and Richards 2004; Barrett 2007) and then in agriculture (Barrett *et al.* 2004; Simpson *et al.* 2005; Milner *et al.* 2007). This general sequence suggests that location and endowments may be important factors in the later distribution of wealth. These case studies, like the Skagafjörður data, show a similar relationship between farmstead size and establishment order, but only hint at whether the wealth differences derived from already existing socioeconomic differences or if they developed after Viking Age settlement.

If the differential distribution of wealth is primarily post settlement, it makes Viking Age Iceland a wonderful laboratory. It may be either that environmental differences gave rise to Ricardian economic land rent as early settlers claimed the best land, or that early immigrants gained significant political control over later settlers, likely through access to land, which could have been translated into durable inequalities (cf., McAnany 1995). Unlike many settlement hierarchies, all the sites in the study area consist of the same basic type: the household farmstead. Interestingly, this is basically the scenario that Ricardo (1817) imagined as the bases of his law of rent. This law is one of the foundations of political economy (Samuelson 1978) and the results presented here are exactly what Ricardo predicted. He imagined that the differences in wealth must come from differences in natural endowments as a landscape filled in and more marginal land was put into production. But Langholt is superficially environmentally homogeneous, so one consequence of an infilling may be that, following the initial land claims, later farmsteads had to be established on land that at least nominally belonged to an already established larger farm property. This scenario suggests that the post-settlement creation of later small farms may be an outcome of complex, social and power relationships and not only based on natural endowments. Either way, the advantages to being early into an uninhabited landscape were profound and enduring.

Conclusions

The SASS project has produced basic measures of farmstead location, establishment date, and maximum size in a previously uninhabited landscape. Together, these basic variables reveal the dynamic process of land claim, farmstead establishment, and land division, which creates a distinct but subtle settlement hierarchy that is probably based on differences in wealth.

The dynamics of the settlement pattern are clear. The distributional pattern indicates that farmsteads were initially widely dispersed and that interstitial areas were later filled in, while the order of establishment is closely tied to farmstead size with the largest ones established earlier in the settlement sequence. The initial settlement pattern has been remarkably stable with many farmsteads remaining in roughly the same location as originally established during the Viking Age (Bolender *et al*. 2011). That farmstead size and establishment date roughly correlate with early modern productivity metrics suggests that these differences are long lasting. We argue that most of the factors that go into farmstead size are related to wealth and that farmstead size distribution is a good proxy for farmstead wealth distribution. Most interestingly, duration and maximum farmstead size in A.D. 1104 are logarithmically related, and this suggests that the very earliest sites that were established enjoyed substantial advantages well above a linear relationship. While the data presented here do not explain the mechanism which creates this wealth differential, the correlation provides a basis for understanding some of the dynamism of the Viking Age.

In chiefly societies a settlement hierarchy often develops when the largest sites serve some functional purpose, such as central places in redistribution networks (Peebles and Kus 1977; Cohen and Service 1978; Earle 2002). In Viking Age Langholt, the settlement hierarchy is, on the surface, relatively even. While there is clearly a settlement hierarchy, creating tiers out of the relatively smooth continuum of dates and site sizes identified in Langholt is difficult. The settlement pattern may be, as Gilman (1995) proposes for Germanic societies, based on exploitation, rather than production, and therefore a tiered settlement hierarchy should not be apparent until long after social stratification has been institutionalized. Tiered settlement aside; the order of farmstead establishment may be the critical variable in creating a durable settlement hierarchy.

While the Langholt data is ambiguous about the causes of the advantages of being first, the results are unmistakable: there are real and long lasting advantages for the farmsteads established earlier in the migration sequence. If the advantages to early settlers seen in the Icelandic settlement pattern were also present in other places where Viking Age Norse expansion took place, it might explain the rapid expansion out of Scandinavia that characterized the Viking Age in general. The causes underlying these first-mover advantages are well beyond the scope of this paper (see Lieberman and Montgomery 1988, 1998). Whatever the cases or causes, if the Viking Age settlers knew that the advantages to being first were so substantial, then that would go a long way toward explaining the rapid colonization of the island and the character of the subsequent medieval manorial state.

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