Report of the
Skagafjörður Archaeological Settlement Survey

2005

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Funded by
United States National Science Foundation

With the institutional assistance of
Hólaskóli
Byggðasafn Skagfirðinga Glaumbæ
Sveitarfélagið Skagafjörður
Árskóli Sauðárkróki

Permit issued by
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Table of contents

Note to Readers

This an interim report on the majority of the activities of the Skagafjörður Archaeological Settlement Survey (SASS) during the summer of 2005. As it is an interim report, it is incomplete and unpolished. This report has several substantial and important omissions. The report on the substantial excavation at Glaumbaer, by Douglass Bolender can also be found at http://www.fiskecenter.umb.edu/SASS.htm. The Glaumbaer excavation is only touched on this document.

Acknowledgments

Also participating in this work were Bill Brennan (State University of New York, emeritus), Yasushi Nishimura (Nara National Cultural Properties Research Institute) and Kent Schneider (U.S. Forest Service). We thank them for their work and council. Howell Roberts and Adolf Friðriksson of FSÍ arranged for the work at the Althing and Adolf Friðriksson also helped with the work as Ytra Garðsholm.

We wish to thank Icelandair, which provided reduced airfare for much of the crew. Kaffi Krokur, which fed us quite well. The Sveitarfélagið Skagafjörður and Árskóli Sauðárkróki provided housing and lab space for the crew. Byggðasafn Skagfirðinga Glaumbæ provided substantial logistical support. Hólaskóli privoded space to write up results.

This material is based upon work supported by the National Science Foundation under Grant No. 0453892 “Chiefdom to Manor: Using Ground Penetrating Radar on Viking Age and Medieval Archaeological Sites in Skagafjordur, Iceland” John Steinberg (Principal Investigator), E. Paul Durrenberger, Dean Goodman & Brian Damiata (Co-Principal Investigators). Previous support has come from Grants No. 0107413 & 9908836.

Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation or any of the other instutions, orginizations, or people that supported this work.

Introduction

For work in Iceland, we have been awarded three NSF grants: High Risk Exploratory Research: Political Economy of Free State Iceland - Regional Archaeology in the Mosfell Valley (BCS #9908836 August 1, 1999 - July 31, 2001, $19,970), Chiefdom to Manor: An archaeological settlement survey of Viking Age and Medieval Skagafjordur, Iceland (BCS #0107413, July 1, 2001 - January 31, 2004, $99,984 which had the addition of an REU supplement to study the organic content of turf walls) and Chiefdom to Manor: Using Ground Penetrating Radar on Viking Age and Medieval Archaeological Sites in Skagafjordur, Iceland (BCS # 0453892 March 1, 2005 - August 31, 2006). Publications resulting from these grants include: Bolender 1999, 2006; Carter 2003; Steinberg 2003, 2004, 2006; Steinberg and Bolender 2004; Steinberg and Byock 1999 and a series of reports. Other publications are currently in press and preparation. These projects follow a straightforward research design in which survey methods were tested, developed, and applied to the anthropological problems of Viking Age settlement patterns in Northern Iceland. This report describes the 2005 archaeological fieldwork in Skagafjörður, Northern Iceland, designed to test the effectiveness of Ground Penetrating Radar (GPR-Slice) images for guiding the excavation of well-preserved but deeply buried turf long-houses of the Viking Age.

Iceland was uninhabited until AD 874, when chieftains and wealthy farmers, along with their household retinues, began to arrive in their open boats. Accounts of the settlement and of the resulting chiefly society are given in semi-historical sagas. However, these sagas are ambiguous, contradictory, or silent on several critical socio-economic issues that would help scholars understand why this Viking Age chiefly society was stable for so long and why, in the end, it finally turned into a medieval manorial state society. Archaeological investigations of the settlements can help by yielding information on economic status of farmsteads. Unfortunately, the archaeology of Iceland is paradoxical: in the fertile coastal lowlands early archaeological sites are difficult to identify. Conversely, once found, preservation at these sites is often outstanding. This research address this paradox with GPR. This research follows up on a successful NSF-funded subsurface survey, which identified a series of previously unknown Viking Age sites. The survey results indicate a dynamic settlement pattern sequence: large farmsteads were initially established, they then later spun off smaller farmsteads, and finally many of those larger farmsteads moved locations (Steinberg and Bolender 2004). GPR-Slice imaging was employed on several Commonwealth sites in Skagafjordur (including Glaumbaer, SS & TG) and on one pagan burial ground (YG). Excavations followed the GPR work at SS and GB, allowing us to test the GPR-Slice images and determine their value for future research.

Our results indicate that GPR-Slice images can aid in excavation of buried turf structures. Excavation of turf structures is notoriously difficult and time-consuming. GPR has the highest resolution of any remote sensing technique. The ability to create accurate subsurface maps of Icelandic buried turf architecture could have a substantial and beneficial effect on archaeological practices in Iceland and in other regions with wet clayey soils. Substantial areas of Iceland are under threat from development and accurate subsurface maps of archaeological deposits would be useful to those agencies in charge of historical preservation. This is especially important since our past work has demonstrated that many of the earliest sites cannot be identified by surface features.

Test pits

As a follow-up to the SASS work in 2001 and 2002, five more test pits were excavated into the middens of farm mounds to provide farm establishment dates. These test pits are a critical component of the assessment of visible surface remains. While the test pits are invasive, they are not particularly expensive or time consuming. In almost all cases, test pits yield very old dates that usually predate the first historical record of the farm. This knowledge is usually of great interest to the locals and the landowner or farmer in particular. After seeing the age and preservation in these farm mounds, farmers and landowners seem to change their opinion of the mound and its value. Farmers tend to seem to think that they should take care and preserve these mounds. Thus, although the test pits are invasive, they do seem to encourage the farmers and landowners to preserve the mound in general, and in some cases even see their value. Therefore, in the long run, we see these test pits as a critical component of preservation.

Proper placement of test pits is critical for the success of the program. We have used four guiding principles for test pit placement. First, and most important, the test pits need to be located in such a way as they intercept the earliest in situ remains. Second, test pits should be located where tephra layers have been preserved. Third, test pits should be located to encounter datable material (e.g., bones). Finally, test pits should be located where they will cut through as little as possible, especially avoiding structures and other turf remains, while still adhering to principles one, two, and three.

We have found that ash middens provide the best locations for test pits. The structure of ash middens is poorly known. However, from our experience, the parabolic ash mound shape is primary a result of thinner and/or fewer layers being deposited at the edges. On the whole, the parabolic shape does not seem to result from the slumping of an older and higher central ash midden. Furthermore, it would not appear that the edges of the midden are used later than the center. It would appear that the basic dimensions of the ash midden are set at the beginning of the occupation and the entire area is used from the beginning until abandonment. For whatever reasons, the edges of the mound, especially away from structures,

Turf is common in the upper portions of ash middens. In most cases, the turf does not seem to be parts of in situ structures, but rather disposed of in the ash midden, or used to cap the midden, in order to keep the ash from blowing. Turf is more commonly encountered closer to the center of the ash midden. This may account for some of the parabolic shape of the ash middens. Turf in ash middens is almost never encountered below the 1104 tephra layer and is most common above the 1300 layer.

Ash midden assessment can be critical in placing test pits. Test pits that do not obtain good datable material, in association with tephra layers are inefficient. The ideal situation is to obtain datable material in close association with a tephra layer. Even if no datable material is recovered, at least tephra layers provide some approximate start date of that area of the farm mound and are probably a good proxy for the farmstead as a whole. For midden assessment, under the current technique is to use 1 in or 1⅝ in Oakfield peat core (http://www.soilsamplers.com) with a 50 cm extension or Eijkelkamp 2 in soil auger (http://www.eijkelkamp.nl). These pieces of equipment can obtain cores from up to1 m bgs. Cores are places ever 10 m over the area that appears to be the ash midden. Test pit locations are determned by the core with the most complete and most shallow sequence of in-situ sequence of tephra layers (e.g., Figure 10).

Syðra Skörðugil:

A series of cores were taken around the eastern periphery of the mound. At E477041 N565561 the best-preserved 1300 tephra was encountered and the southeast corner of the test pit was placed at that location. Because of the depth of the mound no other tephras were encountered during coring. All excavated material was screened through 1 cm mesh by natural layer but no deeper than 10 cm (except for the top humus layer which was bagged as a single unit). None of the collections have been analyzed. The slope of the mound was such that the first 5 layers sloped substantially toward the east and therefore layers 2, 3 and 4 were excavated as natural, sloping, layers. Layer 6 was not excavated separately. The test pit reveled a sequence of mottled ash, soil and turf through layer 5. Most of the artifacts (primarily animal bones) were collected in layer 5 and above. Layer 7 was much more homogeneous consisting primarily of peat ash. All historic tephras were found in that layer. The tephra sequence has not been conformed by a tephrachronologist, but the sequence conforms to our basic understanding of the tephra layers in Skagafjörður. The ≈1000 layer is clearly above the bottom of the peatash layer. There are approximately 3 cm of peat ash below a clearly in situ ≈1000 layer. A dark organic layer (8) contains mixed dark green tephra which is probably the LNL. No cultural material was encountered in it or in the aeoloil material that surrounds it. In this particular spot, unlike so many others we have explored, the prehistoric Hekla tephras (3 & 4) are separated by aeolian material, indicating that sediment deposition was a prehistoric process as well. At this depth (1.8 m bgs) there is some indication of cryoturbation.

In all, there seems to be inhabitation from just before 1000. If soil deposition is constant throughout layer 7, we can hazard a guess as to approximately how long before the ≈1000 layer the site was occupied. The in habitants deposited about 25 cm of ash between 1104 and 1300 (25cm/196y= 0.128 cm/year). Therefore, if the rate was constant (and that is a big if), the bottom of the ash would have been deposited starting about 23 years before the ≈1000 layer (3/0.128 =23.4) or about 975 AD. A bone was collected for AMS dating but the results have not yet been returned.

Figure 1: Syðra Skörðugil test pit, looking west.

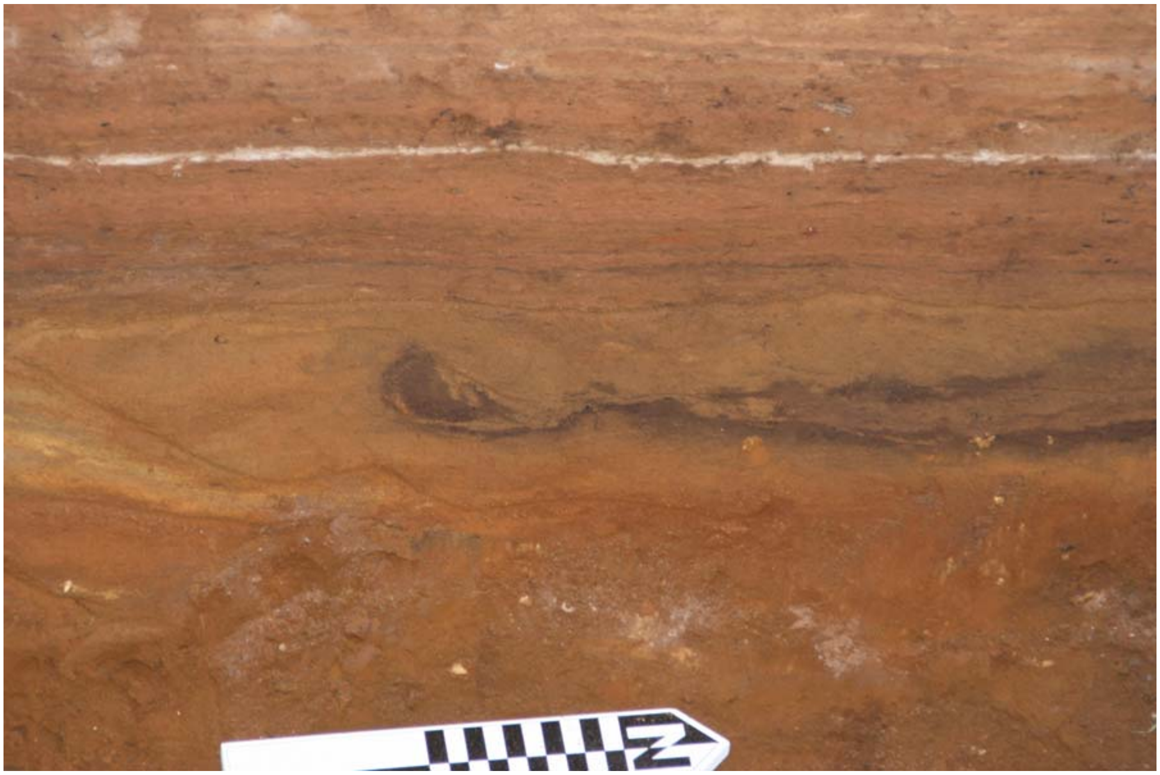

Figure 2: Syðra Skörðugil East wall showing Hekla 1104 tephra and LNL.

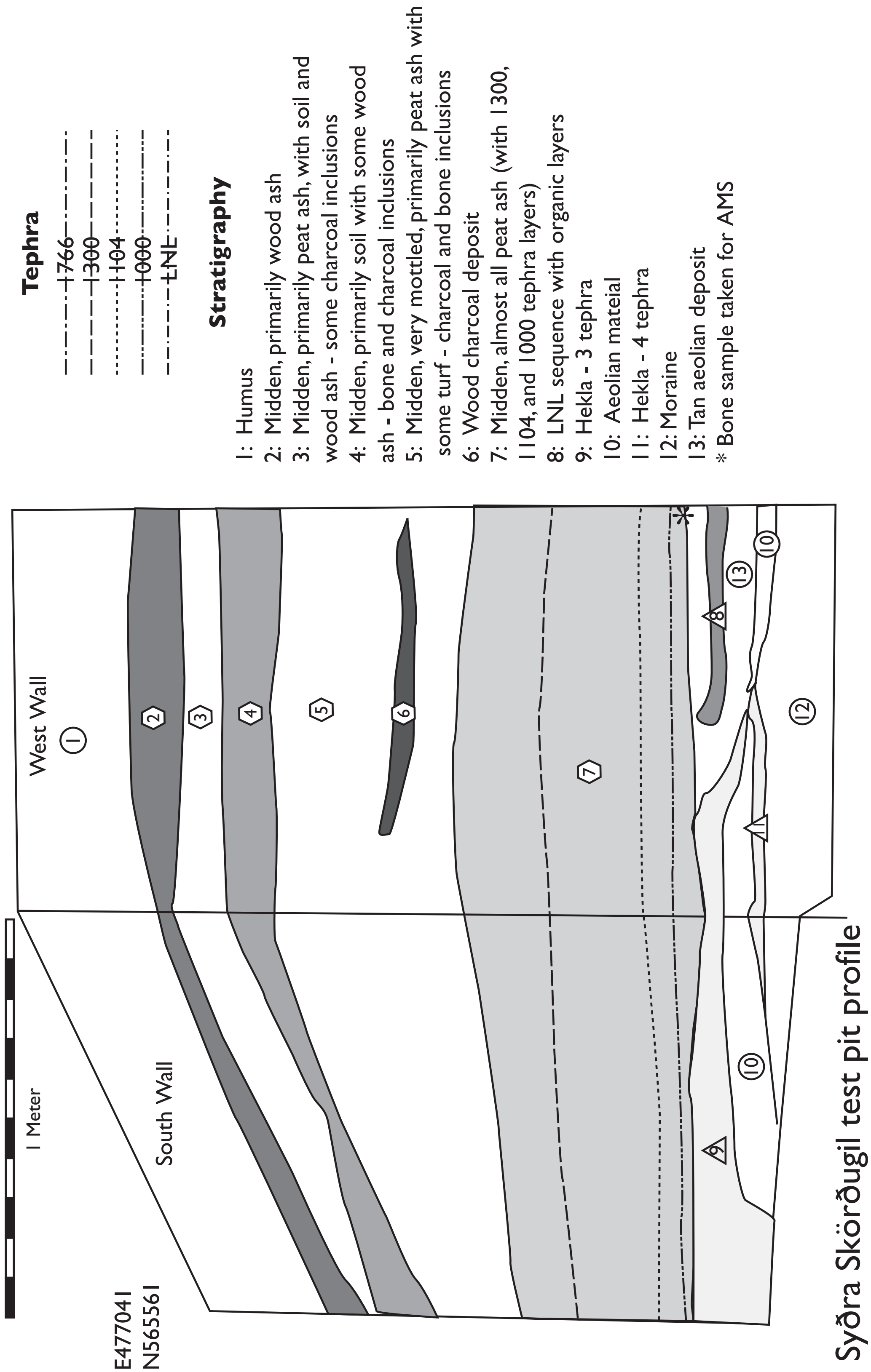

Figure 3: Syðra Skörðugil profile

Ytra Skörðugil

The 1x1 test pit was located after an extensive sequence of 17 cores to identify areas of deep middens with preserved historic tephra. The farm mound area is very low, (1-2m) above the surrounding surface. The midden has seen some modification and is quite widespread, but in most areas, the lower levels seemed to be intact. The modification seems to be primary light bulldozing or other earthmoving of the upper layers.

In the area around 476959, 565959 several tephra layers were preserved in cores taken and in that location, the test pit was placed. The 1x1 yielded a ambiguous sequence without a firm start date. All excavated material was screened through 1 cm mesh by natural layer but no deeper than 10 cm (except for the top buldozed layer which was not screened). None of the collections have been analyzed. The Hekla 1104 was encountered in situ, but substantially above the bottom of the ash layer. The ≈1000 layer was not found at Ytra Skörðugil in any of the cores and not identified in the test pit. Using some rough measures we can gain some clue as to the start date. It is approximately 16 cm from the 1766 to the 1300 (16cm/466 years =0.034 cm/year) and about 19 cm from the 1300 to the 1104 (19 cm/196 years = 0.097 cm year) which yields an average of .065 cm of ash deposited per year. It is about 20 cm from the 1300 layer to the bottom of the ash layer which would take about (15.4 years/cm x 20 cm=) 300 years or about 1000 AD. This is only an approximate estimate. AMS dates are still pending from a bone removed from the bottom of the test pit.

Figure 4: Ytra Skörðugil looking west.

Figure 4: Ytra Skörðugil test pit, east wall

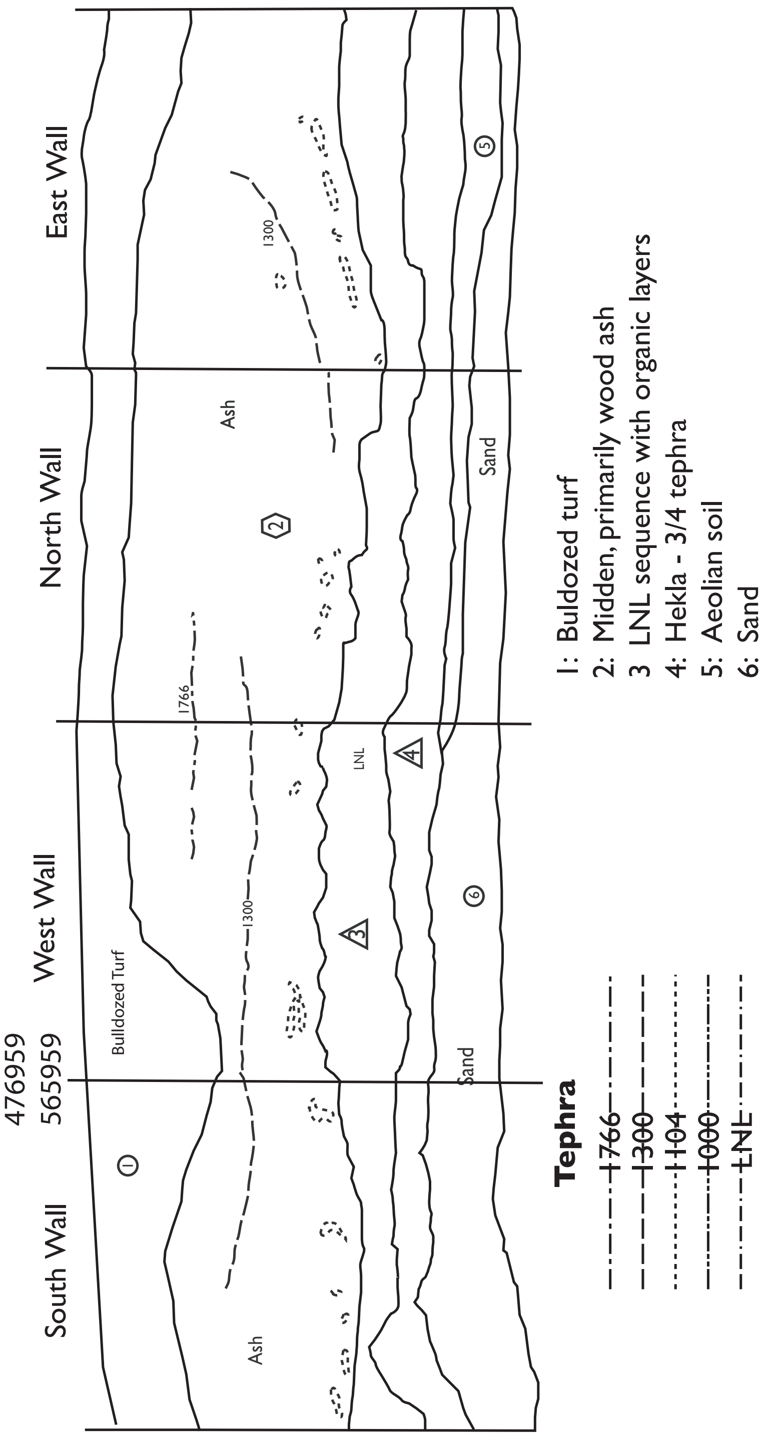

Figure 5: Ytra Skörðugil test pit profile

Geldingaholt

The farm mound at Geldingaholt presented special problems for our methodology of coring for ash deposits on the slopes of farm mounds because of the substantial earthmoving that took place in the 1970's. The entire top of the ash pile was leveled and moved to the sides. The mound was steep enough and the earthmoving substantial enough to prevent us from reaching any tephra layers within the first meter. We felt that enough earthmoving might have taken place that the we could test in the center of the mound. This strategy proved to be ambitious. However, several cores did contain the 1766 layer within the first meter. After an extensive series of cores, the 478445, 565730 was identified has having the shallowest 1766 and the southwest corner of the test pit was placed there. Unfortunately, excavation reveled that these were not in situ, but in turfs.

The sequence reveled alternating layers of peat ash and turf. The pit went so deep that the sidewalls were expanded slightly beyond 1m. Three layers of 2x4 shoring boards were put in place during excavation to maintain a reasonable level of safety. All excavated material was screened through 1 cm mesh by natural layer but no deeper than 10 cm (except for the top buldozed layer which was bagged as a single unit). None of the collections have been analyzed.

Layer 7 is a substantial deposit of building turf and it may be that it represents the remains of a building, although probably not in situ, but rather the turfs from a nearby building were deposited in the mound during a rebuilding phase. Most of the sequence is ash. The Hekla 1104 tephra was identified only in cut turfs, not in the ash. Therefore, the upper part of layer 7 was deposited sometime after 1104 AD. The only historic tephra found in situ was the ≈1000 which was 2-3cm above the bottom of layer 8 a think peat ash layer. This would indicate a start date of just before that time. However, no evidence of the LNL was identified, so there is relatively little context for how long that 2-3 cm took to be deposited. As an estimate the min 1.18 m deposited between sometime between 1104 and ≈1000 indicate a deposition rate of about 0.12 cm/year. Therefore, In all probability, it was not long (maybe 25 years) before 1000 AD.

Figure 6: hay cutting on the ash mound at Geldingaholt in the late 1950's, before earthmoving leveled the hill.

Figure 7: Geldingaholt test pit looking east.

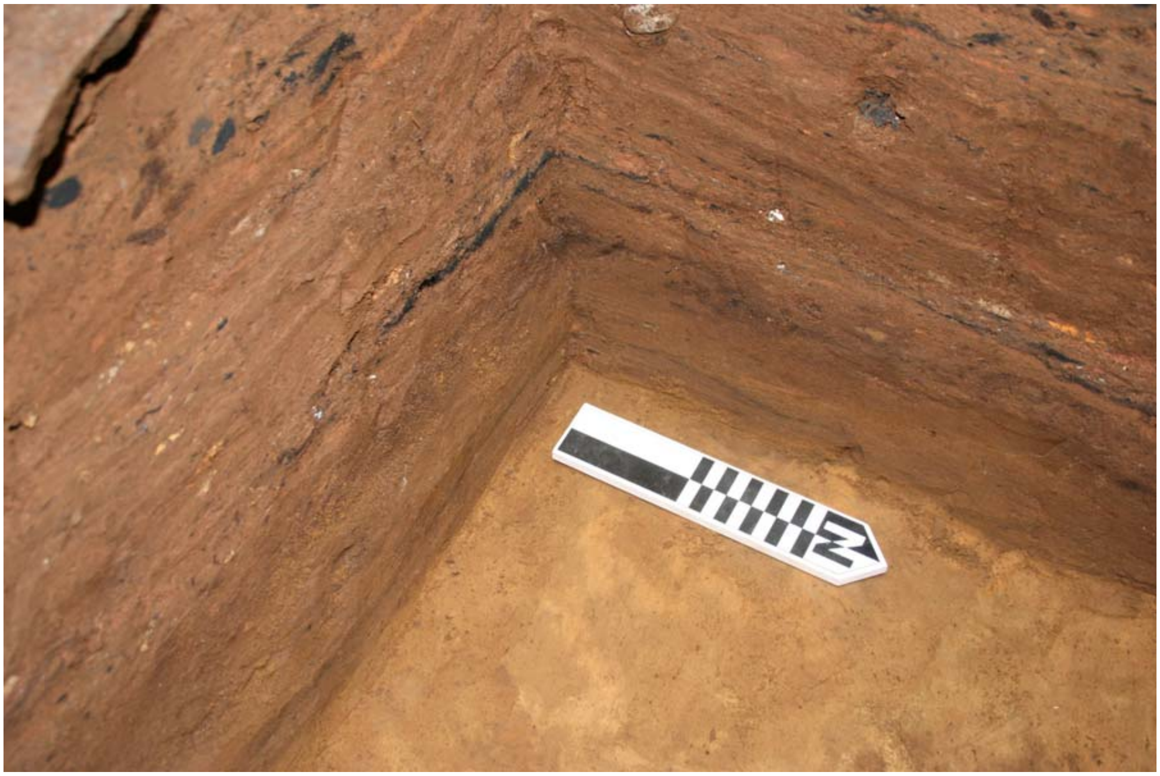

Figure 8: Southeast corner of Geldingaholt test pit. The bottom of the test pit is the H3/4 tephra. The ≈1000 tephra layer can be seen just above the interface of the ash and the H3/4 tephra. It is possible that some excavation may have occurred before the ash was deposited.

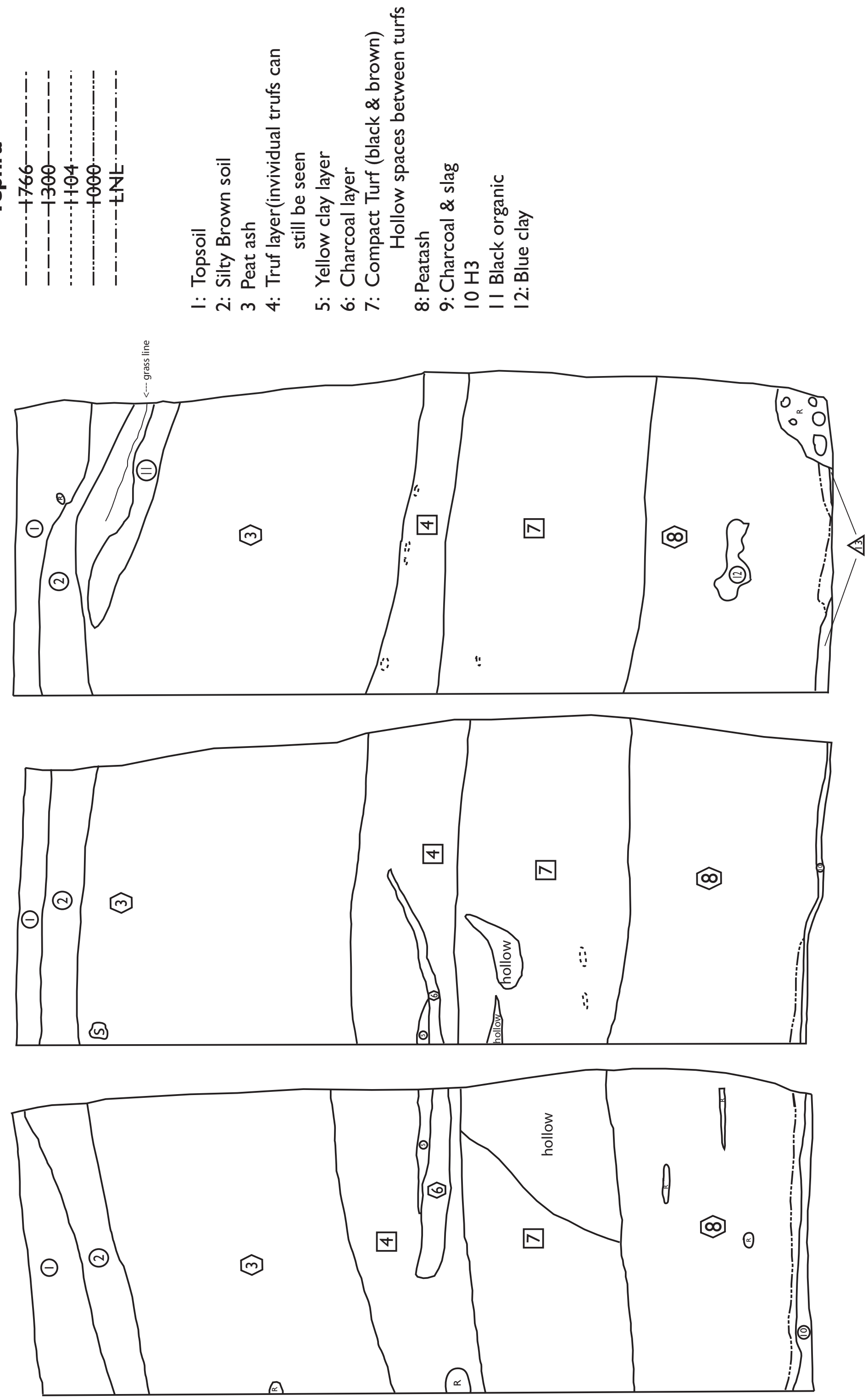

Figure 9: Geldingaholt profile

Meðalheimur

The Meðalheimur test pit was the second attempt to obtain a start date from this site. In 2002 a test pit had been placed on the steeper slopes of the farm mound. That test pit was placed after an extensive series of cores. Unfortunately, that pit yielded almost no tephra and the AMS dates from the bone and burch wood were from the Neolithic. In 2005 a second test pit was placed, this time well away from the farm mound itself. Again, a substantial number of cores were taken (10). No obvious ash deposit was identified. However, most of the cores showed the H 1104 in an ash deposit (Figure 10).

The pit was placed at 477540, 565660 because that was the only test pit with the 1300 tephra and the H 1104.All excavated material was screened through 1 cm mesh by natural layer but no deeper than 10 cm (except for the top humus layer which was bagged as a single unit). None of the collections have been analyzed.

The bottom of the pit is a substantially different deposit than the upper part that contains both the 1300 and H 1104 tephras. Layer 2 is a relatively common peat ash layer. Layer 4 has much more charcoal and was probably different in its origin. Calculations of the rate of deposition indicate this as well. The rate of deposition for layer 2 was about (15cm/196 years=) 0.077 cm per year. If the deposition rate were at all constant this would indicate that the 22 cm deposited before the H 1104 tephra was deposited about (13 years/cm x 20 cm =) 260 years, indicating a start date of about 840 AD, a very unlikely time.

There is a substantial deposit of bright red turf in the south end of the test pit. This is the kind of deposit usually associated with burning and iron production. The northwest corner of the pit may have had an ephemeral hearth. The exact nature of this deposit and its relationship to the farm mound is unclear, but we recommend that this area be investigated further.

Figure 10: Meðalheimur core with H 1104 tephra at 50 cm.

Figure 11: Meðalheimur test pit looking west, across the farm mound.

Figure 12: Meðalheimur test pit west wall profile.

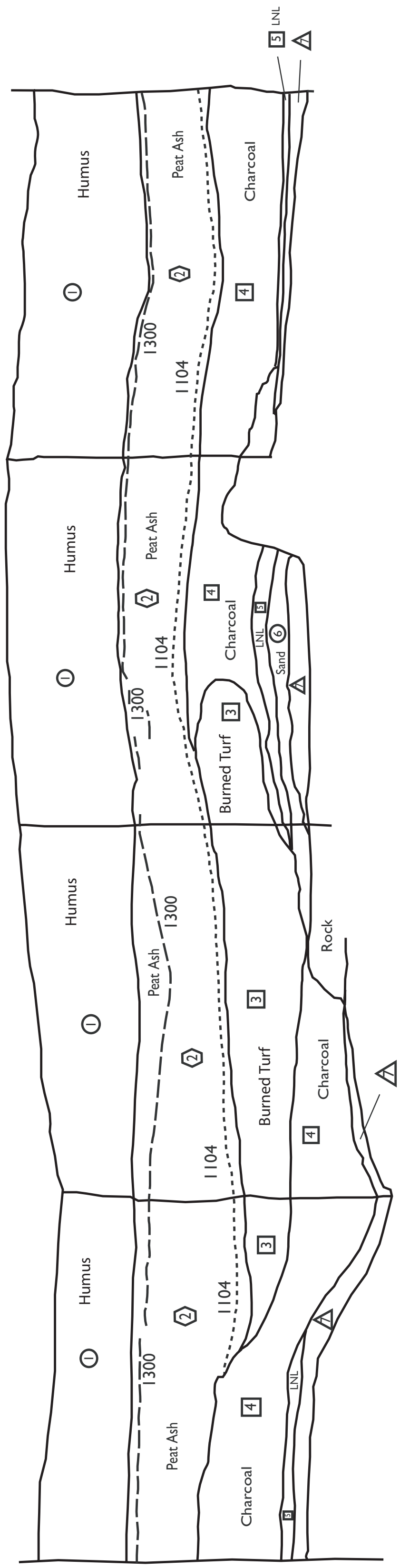

Figure 13: Meðalheimur profile.

Ground Penetrating Radar

We tested Ground Penetrating Radar (GPR) with Slice imaging technology in order to make better subsurface maps of these turf structures. The results are encouraging, but the technology will need to be developed further for use in deeply stratified Icelandic farm mounds. The GPR-Slice images can be a remarkably effective guide to identifying well preserved, buried, structural components of Viking Age turf structures. The effectiveness is highly correlated with data quality. Furthermore, GPR-Slice has, under good conditions, the resolution necessary to identify pagan graves. Finally, by combining GPR and EM methods, preservation can be assessed. While the results of the 2005 experimental season are very gratifying, we need to do much more work to make GPR, and GPR in conjunction with other shallow geophysical prospection methods, ready for general use.

GPR uses microwave propagation and scattering to image, locate, and quantify changes in subsurface electromagnetic properties (Conyers and Goodman 1997). The detectability of a subsurface feature depends upon contrast in electrical and magnetic properties, as well as the geometric relationship of the antenna. Higher frequency antennas allow GPR to provide the best resolution of any geophysical prospection method. Interpretation of GPR images can assess depth, orientation, size, and shape of buried objects (Appel, Wilhelm and Waldhör 1997; Olhoeft, 2000).

The raw data output from GPR surveying is usually displayed in the form of a radargram which plots the strength and depth of the reflections along a transect over which the radar antenna is pulled (Scollar et al. 1990). The radargram is a graph of the reflection amplitudes and the travel time that the reflections take—reflections off of deeper objects take more time to return to the surface and are displayed below readings that arrive at the antenna earlier from shallower reflectors. The radargram is akin to a profile, but it is notoriously difficult to interpret. Difficulties in interpretation are exacerbated close to the ground surface where reverberations and strong ground-surface waves distort the radargrams. Furthermore, GPR surveying through wet soils with high clay content (as found in Iceland) can render whole radargrams of archaeological sites uninterpretable (Leckebusch 2002). However, we can identify turf walls and other archaeological features using GPR.

The identification of turf walls using GPR is not without difficulties. Our work, along with that of Tim Horsley (e.g., Horsley and Dockrill 2002; Horsley, Schmidt and Dockrill 2003), indicates that the contrast of electromagnetic properties between turf walls and the surrounding soil is large enough to be detectable with GPR (see also Beven 2006). However, the wet soils; the high clay content of the lowland Icelandic andisols; the substantial turf wall fall; and the repeated rebuilding and rearrangement of turf structures all make identification of the subtle features contained in only vertical radargram displays almost impossible (e.g., Snorrason 2001). Identification of these same features with GPR-Slice images is substantially easer.

In our 2005 proposal we asked if GPR was effective in Iceland. To test GPR, we experimented with different techniques and then excavated several sites at various levels. The experimental techniques yielded a clear direction for further work: high frequency antennas. We first tried a low frequency antenna (200 MHz) in 2005 (the lower the frequency, the greater the depth of penetration, but poorer resolution). Because, in many cases we were working on sites where the basic feature dimensions were known, we found the GPR-Slice images produced from the 200 MHz antenna using 1 m spacing between survey lines in both N-S and E-W directions, to be wholly unsatisfying. In fact, conductivity and resistivity produced better (easer to interpret) images that more closely correlated with the excavated archaeology. Other researchers have not had much success with 100 and 200 MHz antennas either. (e.g., Einarsson 2002; Helgason and Einarsson 1998; Ísaksson, Helgason and Vésteinsson 1995; Marteinsdóttir, Ísaksson and Helgason 2001).

Our 2005 work indicates that, even under good conditions, an FCC approved 200 MHz antenna does not reliably image standing turf walls. We also employed a higher frequency FCC approved (400 MHz) antenna (better resolution, shallow penetration, more easily affected by high clay content). This higher frequency antenna provided excellent resolution (under good conditions) even at depths greater than 1 meter.

To judge the effectiveness of GPR in Iceland we excavated known sites to different depths. Stóra-Seyla we excavated through overburden and stopped at preserved archaeology to assess GPR-slice images at different levels. At Glaumbær we cleared a large area and excavated just to the top of the site in order to assess the ability of GPR to image architectural structures. We planned a third excavation, through a farm mound to see how effective GPR was at very complex sites. However, the readings from the farm mounds were not of sufficient quality to assess GPR-Slice images at depth through multiple complex phases. Furthermore, the terrain at the farm mounds tested was rough and contained many frost-hummocks. It may be that GPR is not effective in these contexts, but we still believe that it might be effective and therefore propose to continue to experiment with GPR-Slice images through complex farm mounds over the next three years.

Clearly, GPR and GPR-Slice images are effective in Iceland, and the technology should be further developed for wider use. Even with our present understanding of GPR in Iceland, it seems clear to us that GPR is effective enough to allow us to target excavations at these sites and therefore to allow comparative excavations to take place quickly and economically.

Althing

A reconnaissance Ground-Penetrating Radar (GPR) survey was conducted to assess its usefulness in detecting archaeological targets in a shallow bedrock environment (<1 m). The primary features of interest are turf structures (e.g., booths). The GPR method was selected based on the potential for detecting the geophysical contrasts between rocks, turf and soil. The work was performed by personnel assembled for the Skagafjordur Settlement Survey for Howell Roberts

The data were processed to display horizontal maps of the recorded radar amplitudes (i.e., two-way travel time to GPR reflectors), referred to as time-slice processing (see Goodman et al., 1995). The horizontal maps were generated for various time (depth) windows to provide detailed information regarding the size, shape, location and depth of reflectors. The contact between rock and soil should give rise to relatively strong reflections whereas weak reflections are expected between turf and soil. The presence of a shallow undulating bedrock surface, however, complicates the situation. Such a surface produces strong reflections but will tend to appear as discontinuous reflectors with respect to the time slices and hence, may be misinterpreted as isolated discrete features.

The GPR survey covered an area of approximately 17 x 35 m. A grid was established based on pre-existing control points and using fiberglass measuring tapes for triangulation. Data were collected using a Geophysical Survey Systems Inc. SIR 3000 control unit equipped with a 400 MHz antenna. The antenna was hand-towed along transects spaced 0.5 m apart (Fig. 15). A rate of 64 scans/second was selected which yielded at least one scan per every two centimeters in the horizontal direction. Fig. 16 depicts representative radar profiles that were collected.

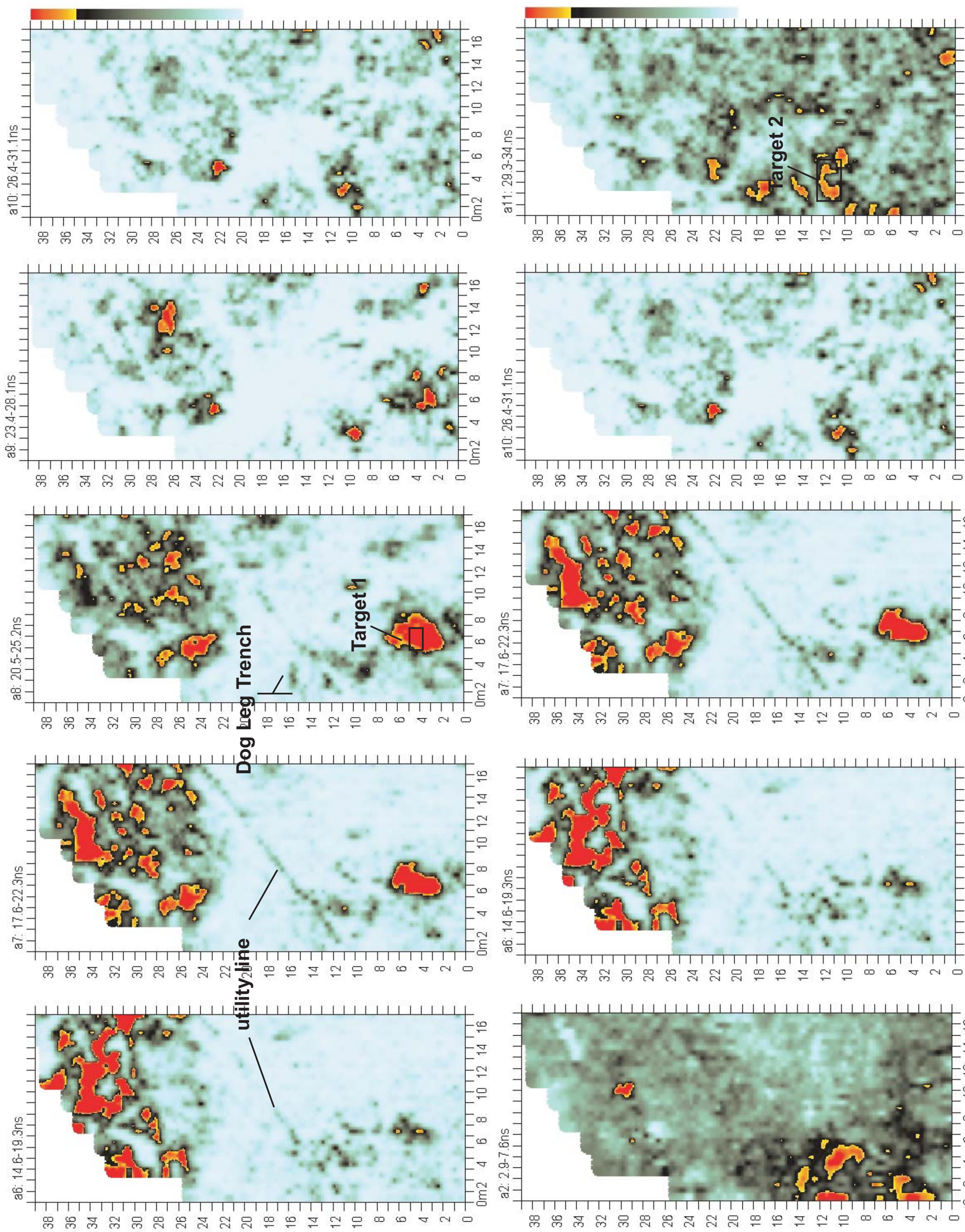

Figure 14: GPR Slice images of Althing at increasing depths.

Figure 15: Using the 400 MHz antenna.

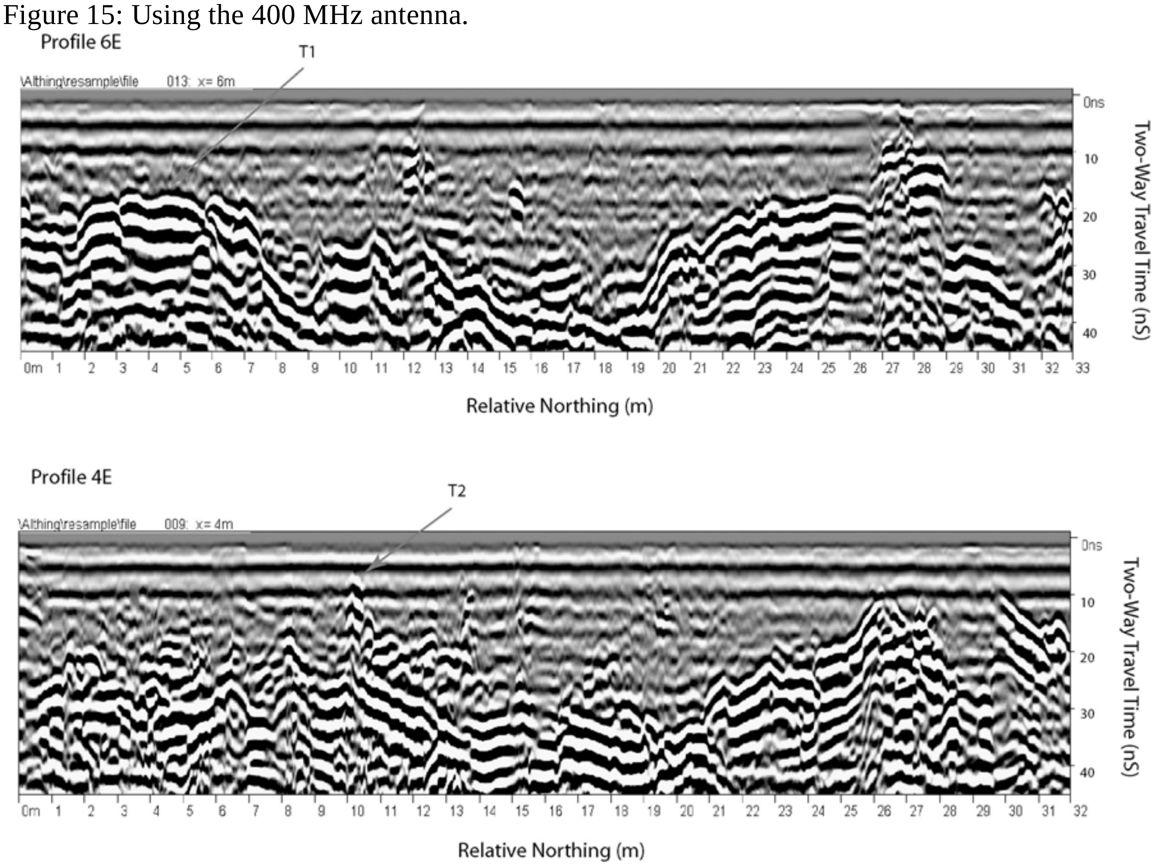

Figure 16: Representative GRP profiles

Based on analysis of the time slices, two potential targets were identified that warranted further investigation: T1 (5-7E, 4-5N) is a strong shallow reflector while T2 (3-4E, 10-11N) is "U-shaped" reflector (see Figs. 14 and 16). The previously dug trenches are reflectors, but relatively weak reflectors. The same is true for the utility line. There is an unusually weak area nearby the two previously excavated trenches.

It would appear that the very strong reflectors in the north are bedrock. Target 1, in the south has that same signal, but it is all by itself and slightly deeper. Target 2 has some medium-strong reflectors high up that becomes unusually strong deeper down.

In his excavations, Howell Roberts reported brefily on the following excavations:

> "An excavated 4x1m N-S trench across the northern portion of target 1 and a 3x1m E-W trench across target 2.
>
> Target 1 - Some conceivably structural stone debris under 30cms of topsoil at the northern limit of the trench, but straight down to bedrock at 35cms across the south. This anomaly looks like a lava dome, and I guess that correlates reasonably well with the strong signal.
>
> Target 2 - Degraded structural remains of turf and stone at about 20-30cms, aligned at about 45 degrees to the trench, also a charcoal rich occupation surface of some kind at up to 40cms. This correlates well with the remains found at the junction of the "dog-leg" trench."

Ytra-Garðshorn

In our 2005 proposal we asked if GPR-Slice could be used to identify pagan graves. Data were collected at Ytra-Garðshorn using a Geophysical Survey Systems Inc. SIR 3000 control unit equipped with a 400 MHz antenna. The antenna was hand-towed along transects spaced 1 m apart in both north-south and east-west directions. A rate of 64 scans/second was selected which yielded at least one scan per every two centimeters in the horizontal direction. Fig. 16 depicts representative radar profiles that were collected. As it turns out, GPR-Slice images can, in all likelihood help identify pagan graves. At Ytra-Garðshorn, a pagan grave field partly excavated by Kristján Eldjárn, (Eldjárn and Friðriksson 2000), the GPR-Slice images clearly show breaks in the stony layer through which the pagan graves were dug (A in Figure 17) which can be contrasted with profiles without such deep breaks (B in Figure 17). It appears that graves can be identified in an area of shallow strong reflections as breaks in that strong reflection (Figure 18).

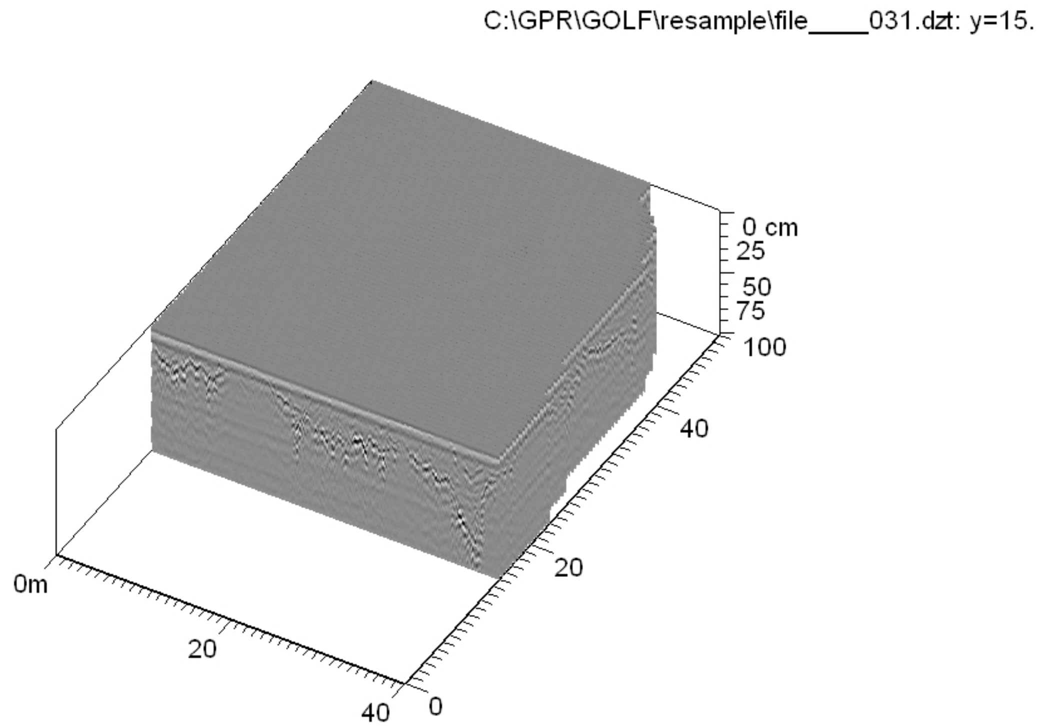

Figure 16: Ytra-Garðshorn representative black and white radargram

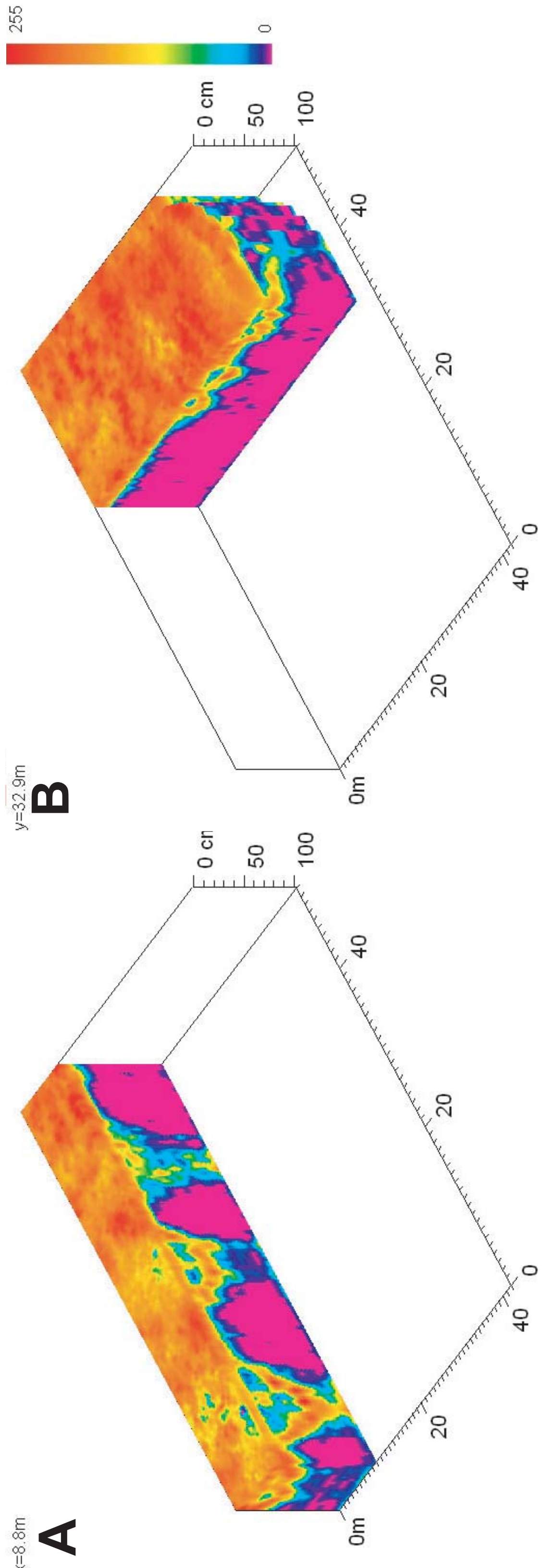

Figure 17 Colorized radargrams of Ytra-Garðshorn

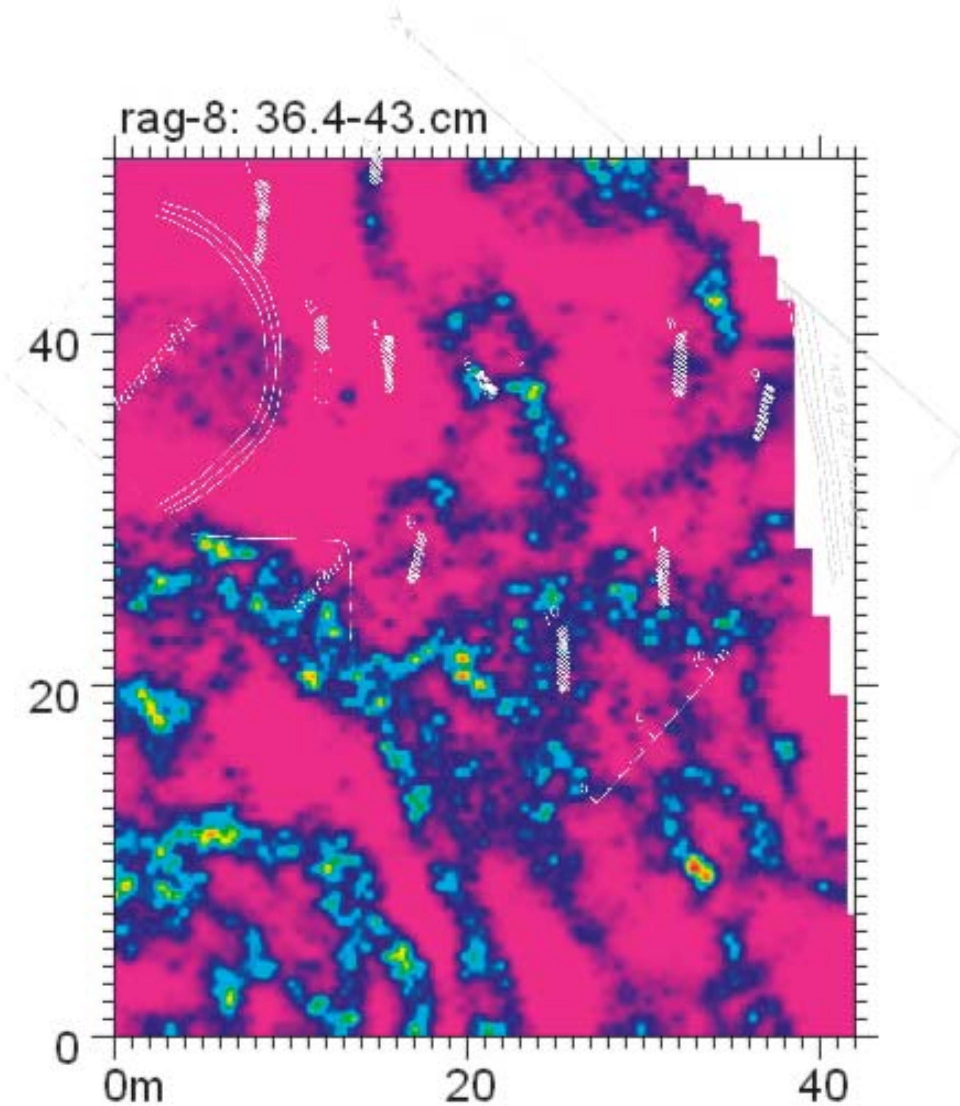

Figure 18 GPR silze of 40 cm bgs with Eldjárn's map superimposed.

Stóra Seyla

In our 2005 proposal we asked if there were important archaeological features that were not visible in GPR-Slice images. As it turns out, fallen turf walls sometimes reflect almost no energy back to the antenna—and therefore do not appear in GPR imagining. Used in combination with EM methods, which identify collapsed turf, this apparent deficiency has a potentially beneficial use: when GPR-Slice images are combined with EM methods, wall preservation can be assessed.

Data were collected using a Geophysical Survey Systems Inc. SIR 3000 control unit equipped with a 400 MHz antenna. The antenna was hand-towed along transects spaced 1 m apart in an east-west direction. A rate of 64 scans/second was selected which yielded at least one scan per every two centimeters in the horizontal direction. At Stóra-Seyla conductivity maps (A in Figure 19) and corresponding excavations indicate a series of turf walls and rooms from a date well before 1000 AD and probably close to 875 AD. This site was used to evaluate GPR-Slice images from the 400 MHz antenna at 45cm (B in Figure 19) and at 75 cm (C in figure 19) that generally correspond with the low conductivity areas, but are harder to interpret. Two areas of contradiction were selected. The first, 5x5 m excavation in the NW corner was placed at the edge of a high conductivity anomaly (570087, 7273543). GPR-Slice images suggested that at 45 cm (B in figure 19) there were no strong reflectors, while at 75 cm (C in Figure 19) there were strong reflections.

This 5x5 yielded a floor at 70 cm bgs with a stone pavement in the southwest corner as indicated on the GPR. In the center of the surveyed area (570067, 7273519) conductivity (A in figure 19) as well as resistivity indicated the signature of a turf wall. GPR-slice images showed nothing there at any depth. Excavation at that spot revealed a fallen turf wall curving convexly and individual blocks fallen like dominoes (Figures 21 & 22). Simulations with GPRSIM are consistent with that reading. We believe that, by combining GPR-Slice images with conductivity and resistivity, preservation may be assessed. Conductivity and resistivity turf wall signatures do not seem to be appreciably different between preserved wall and wall fall. Clearly, because fallen turf walls do not show up well in GPR-Slice images, structural identification must be done with multiple methods, not only GPR.

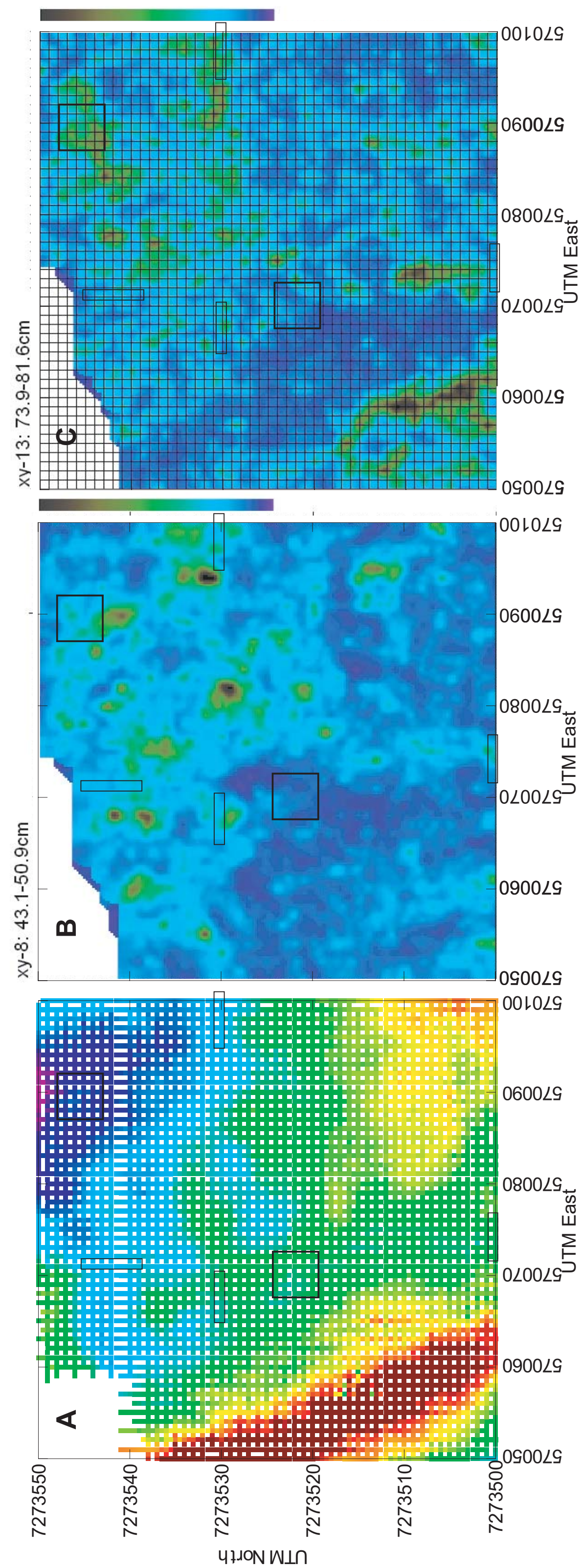

Figure 19: Stóra-Seyla shallow geophysics. A:conductivity map, B: GPR slice at 45 cm, C; GPR slice at 75 cm


Figure 20: Stóra-Seyla 5x5 m excavation at 085, 540, looking west.


Figure 21: Stóra-Seyla 5x5m excavation at 065,530 looking north. The line of rocks would appear to be well above the cultural layer.

Figure 22: Stóra-Seyla 5x5m excavation looking north. Fallen turf wall in center of pit.

Glaumbær

In our 2005 proposal we asked how accurate GPR-Slice images are of turf architecture. GPR images can be very accurate from right below the surface. However, accuracy is highly correlated with data quality. At Glaumbær we surveyed with GPR seven times over the same area. We did various combinations of 400 MHz & 200 MHz; tall grass & cut grass; with & without the meter marking wheeled "baby carriage" that holds the antenna onto the ground; and with and without a weight to keep the instrument in good contact with the ground. In all of these instances we used 1m spacing between survey lines in both N-S and E-W directions. We processed the data in a myriad of ways and used both survey directions independently and combined together. For a more detailed report on the excavations and GPR work at Glaumbær, see Bolenders (2007) report.

As indicated above, all of the 200 MHz data was uninterpretable. The 400 MHz with long grass yielded useable images (see also Stóra-Seyla–Figure 19) so long as the unit was weighed down with a heavy rock duct-taped to the top. The 400 MHz with cut grass was even better, but a plowing several years earlier still substantially disturbed the images from the upper 25 cm of the survey (Figure 24 A). However, below that depth the images were good. Details from within the house are a little difficult to discern in the composite "deep overlay" image (Figure 24, Goodman et al 2004, 2007); but many of the extra-mural images are discernable, including the midden, an entrance, and what appears to be a stone bench in a smithy. However, even at this level, GPR is only moderately better than conductivity or resistivity.

Finally, at Glaumbær, we surveyed with the grass sod removed at 25 cm line spacing in and E-W direction (Figure 25). This produced superb detail that can be easily interpreted slice by slice (Figure 26). In fact, when half the survey lines are removed (0.5m survey line spacing), the image is not appreciably different. At the upper levels (9 cm bgs, A in Figure 26) a complex series of strong reflections in the southwest corresponds to a series of walls, passages, and narrow dead-end alleys that are very well preserved and are found just below the humus layer (Figure 24 B). Corresponding walls could not be found just below the surface in the east central, but this is an area where the excavation, lower down, revalued two walls coming together. In both cases, these multiple walls are also visible in the profiles as well as the slice images. At 35-49 cm bgs (B in Figure 24) the open space can be identified in the center of the longhouse as an area of very weak reflection, and the sand from a partially excavated storage pit also shows up as a very weak reflector. Towards 70 cm bgs (C in Figure 26) only the strongest reflectors show up, in particular, what are apparently rows of flat stones just inside the turf wall in the south of the structure. While there has been very little excavation in this portion, the bright red turf, high concentrations of peat ash, and numerous pieces of slag suggest that this is a smithy and that those are the workbenches.

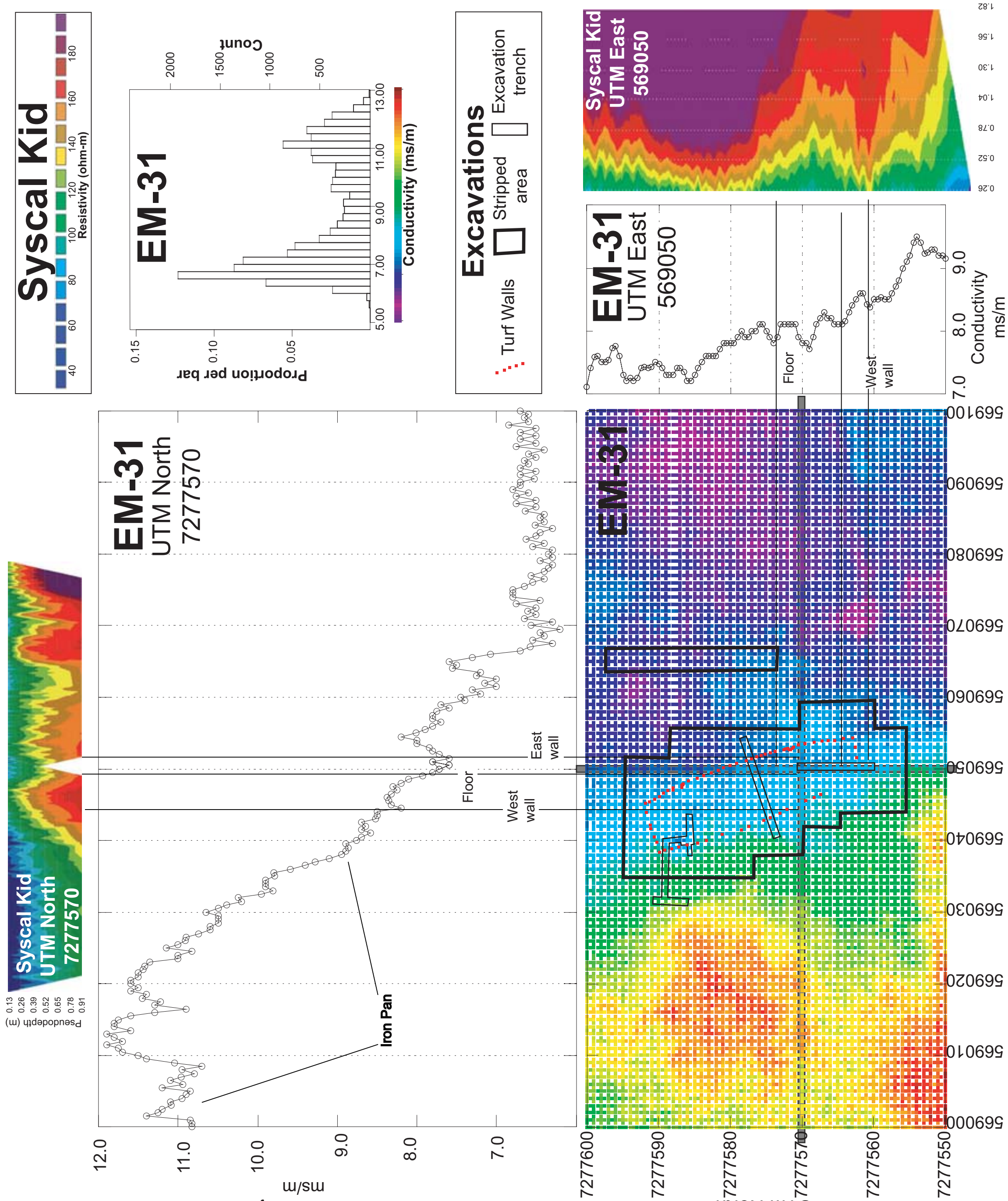

Figure 23: Glaumbaer conductivity map showing area of GPR concintration and surface cleaning.

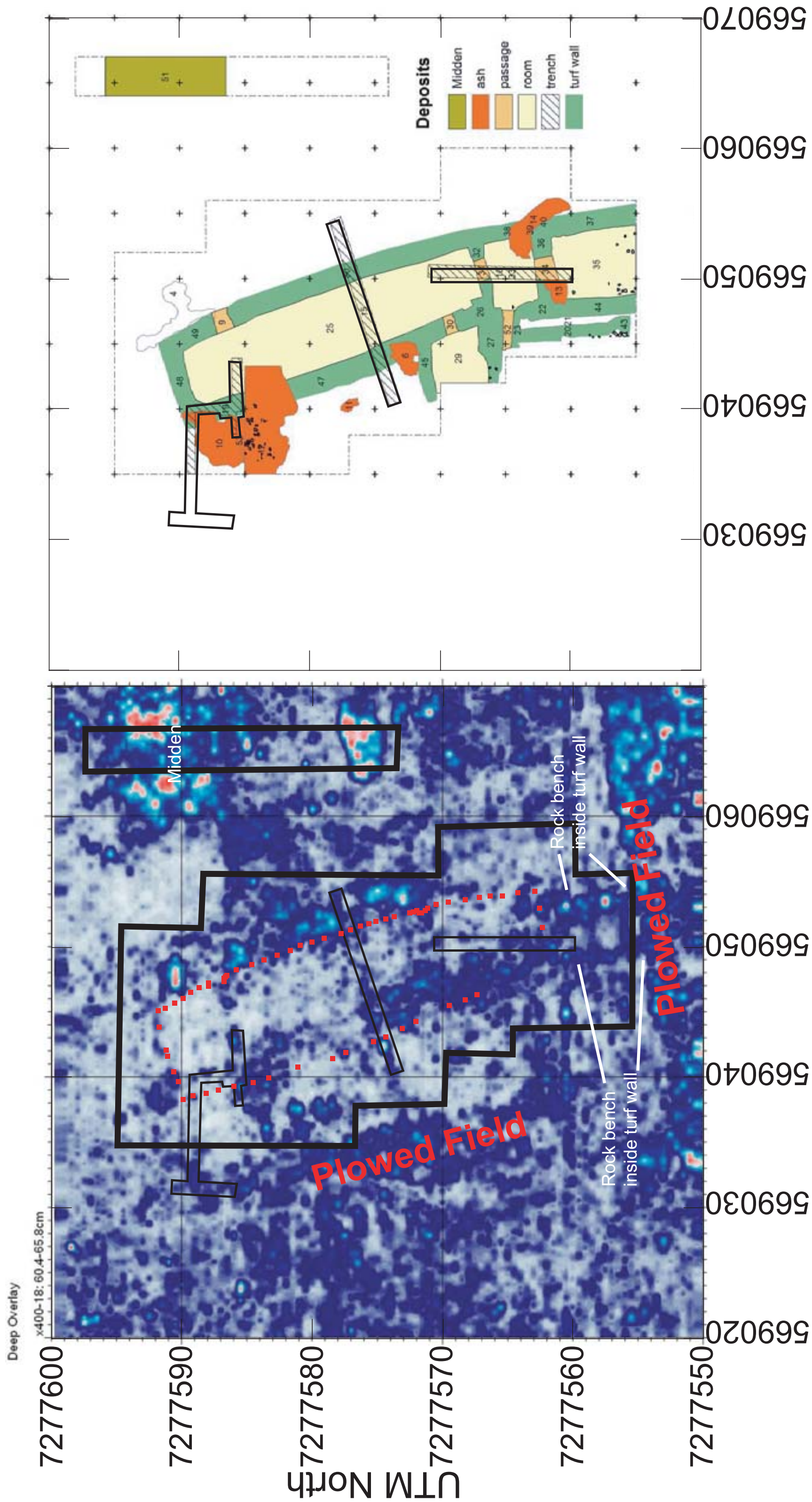

Figure 24: Glaumbaer GPR slice image with 400 MHz antenna (A) and map of surface clearing (B)


Figure 25: Using the 400 MHz antenna at Glaumbaer.

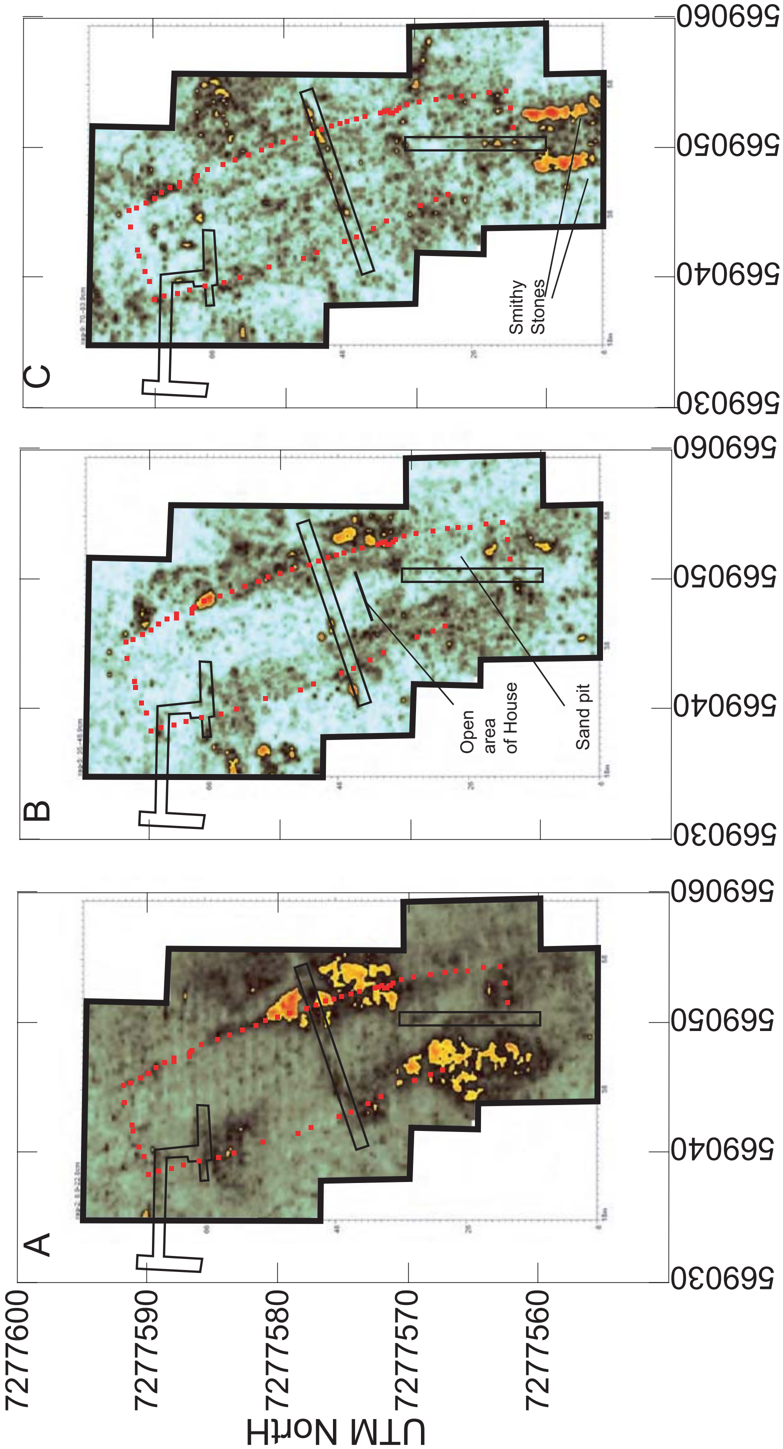

Figure 26: GPR images from Glaumbaer. A: about 9 cm bgs; B: about 40 cm bgs; and C: about 70 cm bgs


Figure 27: Glaumber looking east from cherry picker.

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