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The use of geothermal energy at a chieftain's farm in medieval Iceland

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At a medieval farm site in western Iceland, once occupied by Snorri Sturluson, a famous chieftain and scholar, archaeological evidence has been discovered of stone-built conduits that were built to conduct water and steam to the farm from a nearby hot spring. No other example is known of such use of geothermal energy in medieval Iceland, and multidisciplinary investigations are continuing at the site.

Archaeological investigations at the farm site of Reykholt, in the Reykholtsdalur valley in western Iceland (Fig. 1), have produced evidence of sophisticated use of geothermal energy in the medieval period that is unmatched by comparable finds elsewhere in this geothermally and volcanically active country. These remains proclaim the wealth and power of the best-known occupant of the farm, the thirteenth-century chieftain, writer and politician Snorri Sturluson (Fig. 2), author of *Heimskringla*, a history of the earliest Norwegian kings, and of *The prose Edda*, or *Snorraedda* as it is sometimes called, which contains tales from Norse mythology and is also a general guide to the writing of poetry. Thanks to the historical importance of the site, archaeological investigations, which have been carried out under the auspices of the National Museum of Iceland, have been funded by the Icelandic government. The investigations have also attracted the interest of scholars in other fields.[1]

One of the questions being investigated is why Reykholt became such an important and wealthy farm during Snorri Sturluson's time there. The answer may in part be provided by studying the written sources that exist from this period.[2] It can be assumed that the answer lies to some extent in the way the farm was managed. A study of its economy and resource base is therefore needed, and to accomplish this the excavation has become associated with a project funded by the Leverhulme Trust, entitled "Landscapes circum landnám: Viking settlement in the North Atlantic and its human and ecological consequences".[3] The aim of the project is to examine long-term effects of settlement in environmentally sensitive areas in the North Atlantic, more specifically in the Faroe Islands, Iceland and Greenland. The Reykholtsdalur valley has been chosen as one of the project's study areas.

Figure 1 *Iceland, showing the location of Reykholt and of the Althingi (the former parliament) at Thingvellir.*

The historical background

As far as we know, Iceland was first settled permanently in about 870 AD as part of the second phase of the westward expansion of the Vikings from Scandinavia. There is some written, but so far no archaeological, evidence to suggest that Irish hermits may have reached the country slightly earlier.[4] The earliest settlers were farmers, dependent mainly on animal husbandry. The settlement unit was the individual farm, and the most important criterion in the choice of location was the availability of land that was well suited to grazing and haymaking. Although fishing stations, and centres where people met seasonally for trade or to hold assemblies, existed in the early medieval period, towns did not begin to form until the eighteenth century.

Initially, there was no central power in Iceland to execute law and keep order. The main assembly where important decisions were made, the Althingi, was established in AD 930 at Thingvellir (Fig. 1). It was attended by chieftains (*goðar*), each with authority over a certain group of farmers (*goðorð*). Power was centralized when the Norwegian king added Iceland to his realm in 1262. His attempts to do so were aided by internal strife between the handful of families in whose hands power was concentrated by that time. One of them was the Sturlungs, the family of the chieftain

Figure 2 *A statue of Snorri Sturluson at Reykholt by the Norwegian sculptor Wiegeland, presented to Reykholt by King Olaf of Norway in 1947.*

Snorri Sturluson, who was the first to offer the king his assistance early in the thirteenth century. However, he seems to have lost interest in helping the king and to have become more interested in furthering his own wealth and power, with the result that he was slain at Reykholt in 1241 for disobeying the king.

The excavation

Reykholt is not one of the earliest farms established in the country, but by the twelfth century it had become the main farm in the Reykholtsdalur valley and also an ecclesiastical centre. Archaeological remains have come to light at the site ever since a school was erected there in 1929, but formal excavations did not start until the late 1980s, by which time much evidence had been destroyed by building activities. These excavations lasted for two seasons, but excavation was resumed in 1998. Investigations at the original site of the farm, located between the school and the building known as the Old Church (Fig. 3), have now come to a close, but excavations of a previous church within the area of the present cemetery are still in progress. The earlier church at Reykholt was one of the major churches in Iceland in

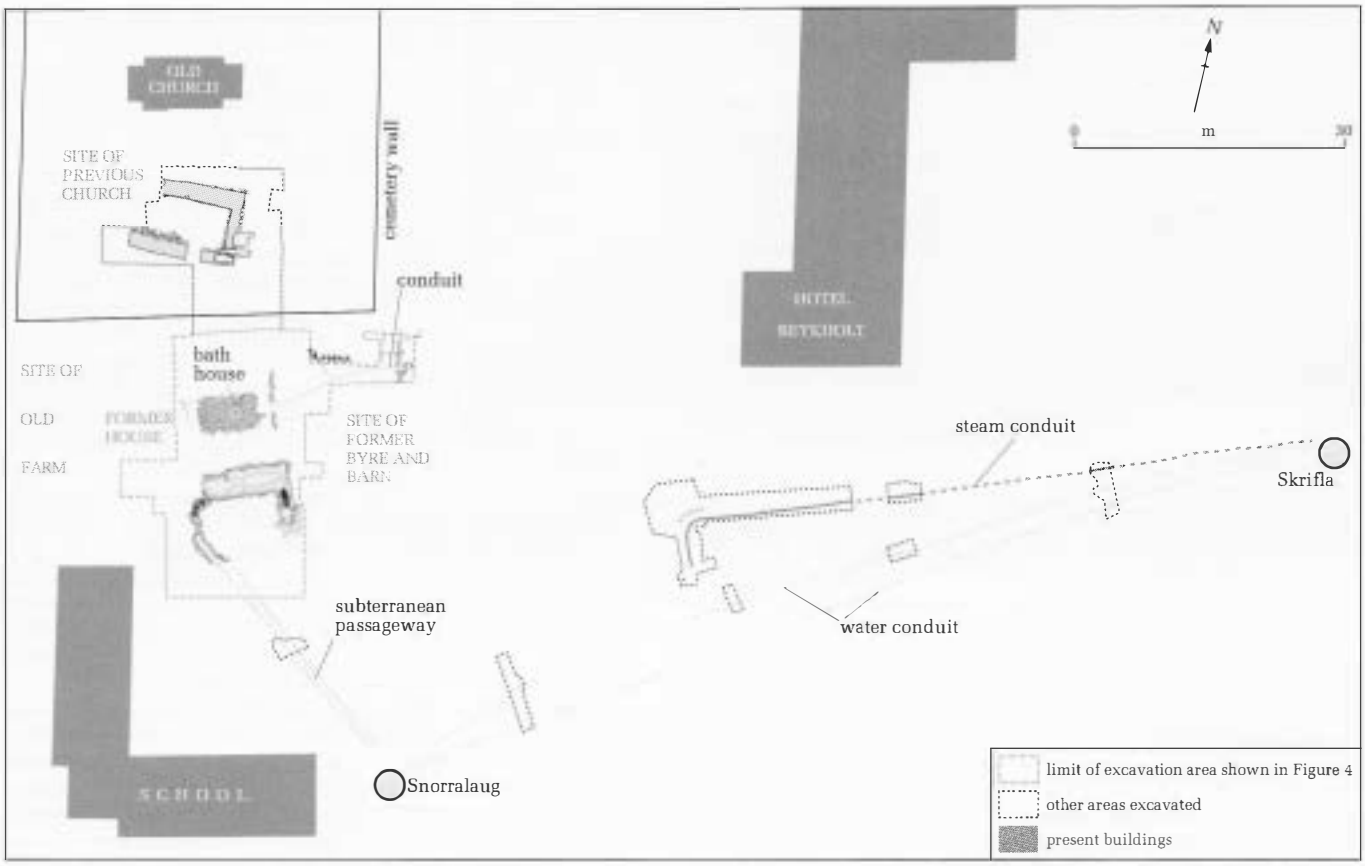

Figure 3 *General plan of the Reykholt site.*

the medieval period. It had a resident priest, and is the first of its kind to be excavated in Iceland.[5]

A group of farm buildings stood at the site of the original farm until the mid-nineteenth century, when the farm was moved slightly to the west (Fig. 3, "site of the old farm"). Beneath the remains of the former buildings at the original farm site, and beneath some earlier fragments of building, well preserved remains were found which have been dated stratigraphically, and by artefacts and radiocarbon dating, to the medieval period. The best preserved of these are directly linked to the use of the geothermal energy provided by the hot spring known as Skrifla, located southeast of the site (Fig. 3).

The geothermal evidence

Water was supplied from the hot spring, through a stone-built conduit in which the flow could be controlled, to a circular stone-built warm-water bath, named Snorralaug after Snorri Sturluson, which was a little less than 4 m in diameter, with a stone ledge to sit on (Figs 3, 5). The oldest description of the bath, as it exists today, dates to 1724, but a warm bath at Reykholt is first referred to in the Book of Settlements (*Landnámabók*),[6] thought to have been originally compiled in the twelfth century. The bathwater, which emerged at boiling point from the hot spring, was cooled down by temporarily blocking the conduit, and hence the flow of water, with

Figure 4 *Plan of part of the area excavated at Reykholt showing the subterranean passageway running into a former building, and, to the north, the putative bath house and the associated (steam?) conduit.*

Figure 5 *View northeast of the reconstructed warm-water bath Snorralaug at Reykholt (diameter of the bath* c. *4 m).*

a flagstone. Two conduits are known to have supplied the bath from the spring, one of which replaced the other. A third conduit was discovered in 1964 running towards the farm site (Fig. 3). It is believed to be a steam conduit that supplied a steam bath.[7] In 2001 a fourth conduit was discovered, this time within the original farm site (Fig. 4).

From the warm bath, a subterranean passageway leads to the area of the original farm buildings (Figs 3, 4). It is an impressive construction, consisting of a trench, into which dry-stone walls were built, leaving a passage 70 cm wide, which curves into the corner of a rectangular building foundation, where it contains several stone steps (Figs 4, 6). It was probably enclosed with a roof made of wood and turf, and it was therefore roofed when it was reconstructed in 1959.

The building foundation, into the corner of which the subterranean passageway from the bath leads, contained no internal features or floor layers. It was dug to variable depth below the surface, as was the access to the entrance, a 2 m-long paved passageway in the southeastern corner (Fig. 4), with massive foundation stones, capable of carrying a substantial structure that has disappeared as a result of later activities at the site. The inside of the building was covered with a pale substance, the colour of which indicates that it may have been subjected to steam or geothermal water, perhaps for heating purposes. However, analysis of the substance has not confirmed this hypothesis, and there is no obvious inlet for steam or water into the building. This could, however, have been destroyed by later activities at the site. Stratigraphical relationships and radiocarbon dates suggest that the building is likely to have been in use (although we do not know for what purpose) during Snorri Sturluson's time at Reykholt.

Another building of a similar date was found farther to the north. It had a paved floor and a conduit running towards it, which probably carried steam into the building from the hot spring (Figs 4, 7). The conduit consisted of a trench into which stones were placed to form a channel on average 20 cm wide, on top of which flat stones were laid (Fig. 8). The sides were packed with clay and there was turf on top for insulation. It seems probable that this paved building was a bath house. Medieval bath houses are known in Iceland, Norway and Greenland,[8] but they have wooden platforms and an oven in which hot stones were doused with water to create steam. At Reykholt the same effect would have been achieved by making use of the geothermal supply of steam or water, which may also have been used to heat the building.

Information from written sources

Hot and warm springs were attractive to, and made use of by, the early settlers of Iceland. Indications of this are farm names that contain elements referring to geothermal activity and references in medieval sources to baths, bathing and the washing of clothes. However, no references are known to the channelling of either hot water or steam into a house for the purpose of heating or cooking in the medieval period. Nor is there any archaeological evidence of such practice before it became common in the twentieth century.

More recent sources indicate that hot springs were sometimes regarded as a nuisance. In an early eighteenth-century land survey there are reports that hot-spring vapours and heat spoiled the home fields at a farm near to Reykholt, and that Reykholt was obliged to rely on the hot spring for its water supply.[9] Both remarks suggest that this resource was not regarded as an asset.

Some comparisons

Heating ducts, referred to as hypocausts and influenced by Roman heating systems, are known in Denmark, where they were common in monasteries and the dwellings of the upper classes between the twelfth and the beginning of the sixteenth century. In Norway such ducts have been found in the floor of the thirteenth-century Archbishop's Palace in Trondheim. The heating systems depended on wood-fuel fires that heated up stones, generating warm air that passed through a system of flues into the rooms.[10]

In southern France at Chaudes-Aigues in the Massif Central, there is evidence that geothermal water was used from at least as early as the fourteenth century for heating houses and other purposes.[11] Here the hot water was led into the houses through

Figure 6 *The stone steps at the northern end of the subterranean passageway (scale bar 1 m).*

Figure 7 *The foundations of the putative bath-house, looking east, before the (steam?) conduit was excavated.*

hollowed-out pinewood pipes. There are also references to houses in Chaudes-Aigues being built over the spring itself and using the hot water directly below the floors for heating. There are also examples of such practice in Iceland, in the Reykholtsdalur valley. According to an early twentieth-century source,[12] a steam bath long existed at the farm known as Sturlureykir, a short distance to the west of Reykholt. It is described as being sunk slightly below ground and entered by stone steps, with a floor paved with flagstones and walls made of stone on the inside and turf on the outside. This description corresponds remarkably well to the putative steam bath excavated at Reykholt. The bath-house at Sturlureykir was said to be used for the treatment of rheumatism. Geothermal water was evidently used at Chaude-Aigues in the medieval period for a similar purpose, a practice that goes back to the Romans and Etruscans.

New environmental investigations

The constructions excavated at Reykholt suggest sophistication and wealth in the thirteenth century. In order to learn more about the economic basis of the site, members of the "Landscapes circum landnám" project are undertaking a programme of sampling for bio- and geo-archaeological evidence from the excavation and its neighbouring area. As part of the excavation, a sampling programme for such analysis has been in operation, and in the summer of 2003 samples were taken in the vicinity of the site.

By analyzing samples of insect and plant remains, including pollen, from different stratigraphical levels, changes in cultivation, climate and other environmental factors can be inferred. These changes can be dated by the radiocarbon method, but in Iceland another very useful method of dating stratigraphical sequences, known as tephrochronology, can be used. It is based on the identification and dating of layers of volcanic ash deposited during eruptions and which are often distributed over extensive areas by the wind. Each tephra layer constitutes a chronological marker that can be used to date the stratigraphy found below and above it. Different tephra layers are identified by colour, chemical composition and stratigraphical relationship.[13]

Another aspect of our environmental work, which relies on the same dating methods, is the study of ancient cultivated fields close to the farmhouse, in an endeavour to detect methods of cultivation and land management. This involves soil analysis, and the results will be used to model past land use.[14] A particular aim of this work is to establish the former extent of cereal cultivation. There is written evidence for cereal growing in the area as early as the twelfth century, but it is thought to have been a marginal activity in medieval Iceland, probably practised only by wealthy farmers.

Conclusion

Reykholt is an important site that invites multidisciplinary study. Snorri Sturluson is of interest to historians and literary critics alike, and, as Reykholt was also an ecclesiastical centre, many written sources exist that relate to it. The discovery of the complex constructions associated with the exploitation of geothermal energy at Reykholt has revealed a wholly new picture of sophisticated life in medieval Iceland. It seems that Reykholt was a centre of learning in the thirteenth century, and the possibility that it was also a place for health treatment, including water and perhaps steam baths, is intriguing, conjuring up images of such institutions in the Classical world. One of the main aims of our current investigations at Reykholt is to throw further light on the use of geothermal energy at the site – a subject of study hitherto unexplored in Icelandic archaeology.

Figure 8 *The (steam?) conduit, looking towards the west, showing the line of cap stones that covered it.*

Notes

1. In 1999 the international and interdisciplinary Reykholt project was established. Its aims are "to provide a better understanding of the process of centralisation of power during the Commonwealth period in Iceland (AD 930–1262), the creation of political and ecclesiastical centres and how this relates to land-use, settlement development and the creation of literature. Reykholt in the time of Snorri Sturluson is at the core of the investigation".
2. This is at present being undertaken by a postgraduate student of history at the University of Iceland.
3. This is a five-year multi-institution study, started in June 2002 and funded by the Leverhulme Trust. The principal investigators are professors Kevin Edwards (University of Aberdeen), Paul Buckland (Bournemouth University), Ian Simpson (University of Stirling) and Thomas McGovern (City University New York), Dr Andrew Dugmore (University of Edinburgh) and Dr Gudrun Sveinbjarnardóttir, UCL Institute of Archaeology and National Museum of Iceland. Several postdoctoral staff and postgraduate students are also involved in the project.
4. G. Sveinbjarnardóttir, "The question of *papar*, in *The papar in the North Atlantic: environment and history*, B. E. Crawford (ed.), 97–106 (St Andrews: The Committee for Dark Age Studies, the University, 2002).
5. Interim excavation reports for each year have been published by the National Museum of Iceland in Reykjavík in its Research Reports series. The most recent are: G. Sveinbjarnardóttir, *Reykholt í Borgarfirði Interim Report 2001*, Research Reports 2001/7, G. Sveinbjarnardóttir, *Reykholt í Borgarfirði Interim Report 2002*, Research Reports 2003/3, and G. Sveinbjarnardóttir & Orri Vésteinsson, *Reykholtskirkja Interim Report 2002*, Research Reports 2003/4.
6. See pp. 192–3 in *Íslensk fornrit I, Íslendingabók, Landnámabók*, J. Benediktsson (ed.) (Reykjavík: Hið íslenska fornritafélag, 1968).
7. Th. Grímsson & G. Ólafsson, "Fornar leiðslur í Reykholti í Borgarfirði", *Árbók Hins íslenska fornleifafélags 1987*, 99–121, 1988.
8. G. Gestsson, "Gröf í Öræfum", *Árbók Hins íslenka fornleifafélags 1959*, 5–87, 1959; and see pp. 74–81 and Figs 47, 53–6 in A. Roussell, "Sandnes and its neighbouring farms", *Meddelelser om Grönland* **82**(2), 1936.
9. See pp. 231 and 235 in *Jarðabók Árna Magnússonar og Páls Vídalín*, vol. 4 (Copenhagen: S. L. Möller, 1925, 1927).
10. J. Hertz, "Värmeledning, Danmark", *Kulturhistorisk Lexikon* **20**, 328–30, 1976.
11. J. P. Gilbert, "Using geothermal waters in France: the district heating system of Chaudes-Aigues from the Middle Ages", in *Stories from a heated Earth: our geothermal heritage*, R. Cataldi, S. F. Hodgson, J. W. Lund (eds), 287–305 (Sacramento: Geothermal Resources Council, International Geothermal Association, 1999).
12. See p. 44 in K. Thorsteinsson, *Héraðssaga Borgarfjarðar*, vol. 2 (Reykjavík: Félagsprentsmidjan, 1938).
13. The earliest historical layers can be directly dated by means of the annually layered ice-core chronology of the Greenland icecap. Other tephra layers have been dated by radiocarbon dating samples of peat or wood from either side of a layer, and by stratigraphical relationships dated by reference to written records. See for example S. Thorarinsson, "The application of tephrochronology in Iceland", in *Tephra studies*, S. Self & R. S. J. Sparks (eds), 109–134 (Dordrecht: Reidel, 1981); W. Dansgaard, S. J. Johnsen, H-B. Clausen, D. Dhal-Jensen, N. S. Gundestrup, C. U. Hammer, C. S. Hvidberg, J. P. Steffensen, Á. E. Sveinbjörnsdóttir, J. Jouzel, G. Bond, "Evidence for general instability of past climate from a 250 kyr ice-core record", *Nature* **364**, 218–20, 1993.
14. See for example I. A. Simpson, S. J. Dockrill, I. D. Bull, R. P. Evershed, "Early anthropogenic soil formation at Tofts Ness, Sanday, Orkney", *Journal of Archaeological Science* **25**, 729--46, 1998.