Chapter 11

Ore, Fire, Hammer, Sickle: Iron Production in Viking Age and Early Medieval Iceland*

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Iron production may be used as a window through which to view, in part, the economic structure of Icelandic society during the Viking Age (*c.* AD 870–1000) and Early Medieval (AD 1000–1264) periods. Iron was a critical resource for maintaining and reproducing medieval Icelandic society, yet while several medieval sagas and related sources[1] mention iron smelters and smiths, documenting their presence within the society, they provide insufficient information to reconstruct the iron industry's technological basis, organization or role in the larger economy.[2] Recent archaeological research, combined with information gleaned from medieval texts, provides opportunities for addressing these issues.

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1 The term *saga*, as used here, follows general usage in Icelandic studies and refers to literary-historical works produced indigenously, in the vernacular, from the mid-twelfth century onward that incorporate historical themes, events, and personages presented by their authors as real, rather than mythic or heroic, figures in Icelandic, Scandinavian and related early medieval societies. See Jónas Kristjánsson, *Eddas and Sagas – Iceland's Medieval Literature* (Reykjavík, 1997), for a more detailed discussion. In addition to the sagas, limited information on the roles and products of smelters and smiths can be gleaned from Iceland's medieval law code, *Grágás* (see notes 8 and 9, below).

2 See Mark Hall, "Viking Age Ironworking: The Evidence from Old Norse Literature," in *The Written and the Wrought: Complementary Sources in Historical Anthropology*, Kroeber Anthropological Society Papers 79 (1995), pp. 195–203.

The expansion of the Norse across the North Atlantic and their establishment of sustainable colonies were predicated, in part, on their ability to find and exploit sources of ore suitable for smelting into useable iron. The presence of a smelting facility at the Norse exploration base of L'Anse aux Meadows, Newfoundland, testifies to the importance the Norse placed on locating and testing sources of iron ore in the process of colonization.[3] After smelting, raw iron "blooms" were forged into billets and bars, and were then transformed into the essential equipment required to sustain the colony's expansion. This equipment included agricultural instruments such as the scythes, sickles and pack saddles required for the summer hay harvests that were the foundation of Iceland's subarctic pastoral economy.[4] It also included household tools, ships' parts, household fittings and weapons. Iron jewelry from a Viking Age grave at Sílastaðir, northern Iceland, and iron amulets from other sites around the island demonstrate that ironworking played an additional role in the secular and sacred strategies medieval Icelanders used to display identity, affirm status, and confer with supernatural realms.[5]

A metaphoric statement about the essential nature of metalworking to society is found in Norse myths attributed to the Viking Age but recorded in the early thirteenth century by the Icelandic chieftain Snorri Sturluson. In "The Deluding of Gylfi" – part of Snorri's *Prose Edda* – the Norse gods under Óðin's guidance vanquished the forces of elemental chaos and immediately began to establish their own society upon which human societies were later modeled. Their first three steps were to organize themselves into a governing body, build temples as their homes, and then "next they laid the hearth of a forge and made hammer and tongs and an anvil, and thenceforward all other tools, and went on to work in metals."[6] Thus a paradigm is established that ties metalworking and skilled crafting to the creation of new societies and identifies these technological and aesthetic endeavors as gifts from the gods, equal in importance to, and essential for supporting the establishment of governments, domestic units, and religious institutions.[7]

3 See Kristján Eldjárn, "Investigations (House Site J: The Smithy)," in *The Discovery of a Norse Settlement in America, Excavations at L'Anse aux Meadows, Newfoundland, 1961–1968*, ed. Anne Stine Ingstad (Oslo, 1977), pp. 87–96; and Birgitta Wallace, "L'Anse aux Meadows: Gateway to Vínland," *Acta Archaeologica* 61 (1991), pp. 185–6.

4 Sturla Fridriksson, "Grass and grass utilization in Iceland," *Ecology* 53 (1972), 785–96.

5 See Michèle Hayeur Smith, "A Social Analysis of Jewellery from Viking Age Iceland" (PhD diss., University of Glasgow, 2003); and eadem, "Silfursmiðurinn frá Sílastöðum," *Árbók hins Íslenzka Fornleifafélags* 1999 (Reykjavík, 2001), pp. 191–202.

6 Snorri Sturluson, *The Prose Edda: Tales from Norse Mythology*, trans. Jean I. Young (Berkeley, 1954), p. 40.

7 It is worth noting that the Norse pantheon, as described by Snorri and other medieval writers, included no deity specifically identified as the gods' blacksmith. Dwarves and other elemental beings, at times, served this role – for example, forging Thór's hammer Mjölnir. However, Mirica Eliade, in *Forgerons et Alchemistes* (Paris, 1956), suggests that Thór's emblematic hammer, strength, and gloves imply that he was originally a blacksmith god (Hayeur Smith, pers. comm.).

Independent Households and Economic Networks in a New Society

The mixed ethnic population that colonized Iceland during the late ninth and tenth century was drawn primarily from mainland Scandinavia and the British Isles. According to medieval Icelandic documentary sources and convergent archaeological data, by AD 930 most of the island had been settled (or at least claimed) and the numerically dominant Norse population had established hegemony over the island society's political, religious and cultural spheres.[8] In AD 1000, according to medieval texts, Icelandic elites adopted Christianity as the politically sanctioned religion, formally ending the Viking Age with its pagan Scandinavian belief systems and iconography.[9] Yet the political and economic structures of the Viking Age persisted with internal changes until 1264, when the island was absorbed into the expanding Norwegian state.[10]

Over the past two decades, archaeological research, largely emphasizing zooarchaeological and ecological perspectives, has expanded our understanding of medieval Icelandic household subsistence, yet our understanding of the economic institutions and practices linking households at the regional level remains poorly developed.[11] Many historical and anthropological views of the early Icelandic economy posit household self-sufficiency and economic autonomy as preconditions for medieval Icelandic households' legally defined abilities to be largely independent in the political arena.[12] While the concept of household

8 Concerning literary evidence for the mixed ethnic composition of the founding Icelandic population, see Gísli Sigurðsson, *Gaelic Influence in Iceland: Historical and Literary Contacts, a Survey of Research*, Studia Islandica 46 (Reykjavík, 1988). On various aspects of the archaeological evidence, see Bjarni F. Einarsson, *The Settlement of Iceland: A Critical Approach – Granastaðir and the Ecological Heritage* (Reykjavík, 1995); Kevin P. Smith, "Landnám – the Settlement of Iceland in Archaeological and Historical Perspective," *World Archaeology* 26 (1995), pp. 319–47; and Hayeur Smith, "Social Analysis of Jewellery."

9 See *The Book of Icelanders (Íslendingabók) by Ari Thorgilsson*, trans. and ed. Halldór Hermannsson, Islandica 20 (Ithaca, NY, 1930).

10 General treatments in English of medieval Icelandic history have recently been produced by Jón R. Hjálmarsson, *History of Iceland From the Settlement to the Present Day* (Reykjavík, 1993); Gunnar Karlsson, *Iceland's 1100 Years: History of a Marginal Society* (Reykjavík, 2000); and Jesse Byock's *Viking Age Iceland* (Harmondsworth, UK, 2001).

11 On the need for regional perspectives see Kevin P. Smith and Jeffery Parsons, "Regional Archaeological Research in Iceland: Potentials and Possibilities," in *The Anthropology of Iceland*, ed. E. Paul Durrenberger and Gísli Pálsson (Iowa City, 1989), pp. 179–202. A good summary of recent work using zooarchaeological data is Thomas H. McGovern, Sophia Perdikaris and Clayton Tinsley, "The Economy of Landnám – the Evidence of Zooarchaeology," in *Approaches to Vínland*, Sigurður Nordal Institute Studies 4, ed. Andrew Wawn and Þórunn Sigurðardóttir (Reykjavík, 2000), pp. 154–65.

12 Iceland's medieval law code, *Grágás*, has been published, in part, in English by Andrew Dennis, Peter Foote and Richard Perkins, trans. and eds, as *Laws of Early Iceland: Grágás I* (Winnipeg, 1980); the complete text in modern Icelandic appears as Gunnar

political autonomy is based on provisions incorporated in the medieval Icelandic law codes, the perspective that Icelandic households were *economically* autonomous gained its current form in response to dialogues forged during Iceland's nineteenth-century struggle for independence.[13] According to this perspective, households were self-sustaining and linked to the outside world through periodic visits to harbors where they traded with foreign merchants. Internally there was little, if any, economic activity beyond the household other than the tributary movement of goods from non-elite to elite households in the form of rents, tribute, tithes and gifts.[14]

Iron production is one area where exceptions to this model have been considered. For example, Jón Jóhannesson wrote that it was "necessary for every farm to have a smithy, and to produce charcoal as well, where woodland areas existed," and that smelting was most commonly done "by the blacksmiths themselves to extract from the haematite the iron which they used in their craft." However, he felt that "smelting was not practised at every farm ... since haematite varies in quantity from one marshland to the next, and in some areas is completely non-existent. Thus one may safely conclude that the production of iron reached its peak in districts where both haematite and wood were abundant. Supplies of iron must then have been sold to regions where it was scarce."[15]

Karlsson, Kristján Sveinsson and Mörður Árnason, eds, *Grágás: Lagasafn Íslenska Þjóðveldisins* (Reykjavík, 1992). Secondary sources incorporating the idea that household economic autonomy in early medieval Iceland underpinned political independence include E. Paul Durrenberger, *The Dynamics of Medieval Iceland: Political Economy & Literature* (Iowa City, 1992); idem, "Production in Medieval Iceland," *Acta Archaeologica* 61 (1991), pp. 14–21; and Byock, *Viking Age Iceland*.

13 For the law codes, see Dennis, Foote and Perkins, *Laws*; and Karlsson, Sveinsson, and Árnason, *Grágás*. A classic statement on the supposed political and economic independence of Icelandic householders is Einar Ólafur Sveinsson's *The Age of the Sturlungs: Icelandic Civilization in the Thirteenth Century*, Islandica 36 (Ithaca, NY, 1953). Concerning linkages between household autonomy, political power, and the Icelandic independence movement see Orri Vésteinsson, "Patterns of Settlement in Iceland: A Study in Pre-history," *Saga-Book of the Viking Society* 25 (1998), pp. 1–29. Halldór Laxness's Nobel Prize-winning novel *Independent People*, trans. by J. A. Thompson (New York, 1946), traces this Icelandic theme of extreme independence fictionally to both its logical and tragic ends.

14 Statements of this perspective in historical, anthropological, and archaeological studies can be found in many sources, including Jón Jóhannesson, *A History of the Old Icelandic Commonwealth*, trans. Haraldur Bessason, University of Manitoba Icelandic Series 2 (Winnipeg, 1974); Bruce Gelsinger, *Icelandic Enterprise: Commerce and Economy in the Middle Ages* (Columbia, SC, 1981); and Durrenberger, *Dynamics*.

15 Jóhannesson, *History*, pp. 300–301; these views have recently been resurrected by Thorbjörn Fridriksson and Margrét Hermanns-Auðardóttir, "Ironmaking in Iceland," in *Bloomery Ironmaking During 2000 Years: Seminar in Budalen 1991, Volume II: Iron in the West Nordic Region During the Middle Ages*, ed. Arne Espelund (Trondheim, 1992), pp. 5–16. It should be noted as well that despite Jóhannesson's use of the term, bog ore is not synonymous with hematite/haematite (Fe_2O_3). Bog ore is a combination of hydrated iron oxides, commonly *goethite* (FeOOH), which, when heated or roasted to drive out water, can produce hematite, among other oxides, from which iron can be produced directly in the reducing atmosphere of the bloomery furnace.

Iron production provides a particularly useful basis for examining the economic system of medieval Iceland archaeologically, since iron was one of the few durable materials produced in Iceland from raw material to finished object. Production sites offer unique opportunities for monitoring variability through time and space in the scale, organization and environmental impacts of industrial activities that were essential to the society's operation. Furthermore, iron, in the form of tools, weapons, and even jewelry penetrated into every household and is present on every excavated Icelandic site. Domestic sites, therefore, provide opportunities to monitor variability through time and space in the rates at which iron was acquired and consumed, the range of object types used and discarded, and the abilities of households to repair and produce their own iron tools. As a critical resource with limited distribution and an ideological charter linking its production to the realm of the gods, iron could potentially have been monopolized by Icelandic chieftains. Comparisons of iron production and maintenance debris at sites occupying different positions in regional socio-political hierarchies may therefore provide data on whether iron production was centralized or decentralized, how its distribution was organized, and whether these relationships changed through time. While it is not possible to address all of these issues here, the remainder of this paper initiates a discussion about them, starting with an examination of a Viking Age iron production complex under excavation at a western Icelandic site called Háls.

Háls: A Viking Age Iron Production Complex in Western Iceland

The site of Háls is located on a low ridge crest, 100 m above modern sea level, in the interior portion of western Iceland's Borgarfjörður district (Fig. 11.1). Excavations at the site began in 1988 and focussed initially on the remains of an Early Medieval farmstead occupied *c*. AD 1000–1275. In 1989 the remains of an iron production complex were identified in the south-eastern corner of the site. Subsequent excavation and dating demonstrated that this iron-production complex, covering approximately 0.1 hectare, pre-dated the farm's foundation and could be attributed to the Viking Age.[16]

Evidence of iron-production facilities at Háls, concentrated in the northern half of this zone, include at least one slag heap covering 45 m^2 with semi-stratified deposits 20–30 cm in maximum thickness, smaller slag concentrations potentially

16 The iron production complex at Háls was discovered during a season of survey and test excavations undertaken in collaboration with the National Museum of Iceland and the American-Scandinavian Foundation to document the extent and structure of an eleventh–twelfth century farmstead at the site. Further investigation of the iron-production complex at Háls (excavation areas Háls 5 and Háls 6) was undertaken in 1996 and 2000, again in collaboration with the National Museum of Iceland, with grants from the National Geographic Society and support from a coalition of local industries, businesses and community groups (see note * above).

representing additional, outlying slag heaps, and a cluster of production features including furnace bases, pits, and smithing debris forming an arc around the western end of the main slag heap. Twenty meters south of the production zone is an associated area containing two superimposed pit-houses, each of which has debris from smelting and forging in its floor and fill deposits (Fig. 11.2).

A characteristic bi-chromatic volcanic ash layer called the "Landnám tephra," dated in the Greenland ice cap to 871 ± 2 AD,[17] lies just below the charcoal and slag-rich deposits at Háls and was present in the upper surface of turf blocks used to construct both of the pit-houses and the furnace excavated at the site. Six radiocarbon dates on birch charcoal recovered from iron production features and the associated pit-houses indicate that iron production took place at Háls over a span of nearly one century in the late ninth and tenth centuries (Fig. 11.3). A bimodal tendency in the dates suggests two separate periods of intense production near the start and the end of the tenth century. Two grayish-white undecorated glass beads recovered from the iron-production deposits are types that were most popular in Scandinavia *c.* AD 875–955, supporting other chronometric information from the site.[18]

Although the upper levels of the site have been disturbed by frost-heaving, the lower layers preserve traces of a complex stratigraphic record suggesting that production took place at the site episodically, rather than continuously, over this period of time. Throughout the northern part of the complex, thin, often discontinuous layers of wind-blown silt separate strata representing episodes of intense industrial activity. In one particularly clear case, seven distinct layers of fill that accumulated in a pit excavated during the late tenth century for making charcoal were associated with different aspects of iron and charcoal production.[19] This sequence suggests that several different iron-production campaigns contributed to the accumulation of debris in this feature, in which different aspects

17 On the dating of the "Landnám tephra," see Karl Grönvold et al., "Ash Layer from Iceland in the Greenlandic GRIP Ice Core Correlated with Oceanic and Land Sediments," *Earth and Planetary Science Letters* 135 (1995), pp. 149–55. Identification of the Landnám tephra at Háls was done through microprobe analyses by Karl Gronvöld and Níels Óskarsson of the Nordic Volcanological Institute, University of Iceland, Reykjavík.

18 These two beads, of types A010 and A020, are members of the Viking Age Ab and Ac bead groups defined in Johan Callmer's *Trade Beads and Bead Trade in Scandinavia, ca. 800–1000 A.D.*, Acta Archaeologica Lundensia 11 (Lund, 1977). Ab group beads, including Type A010, are generally rare but are most frequently recovered in Scandinavian deposits dated circa AD 845–955. Group Ac beads are more common and have more complex histories of use and popularity: Type A020 Group Ac beads are most frequently found in contexts dated before AD 845, but had a second peak in popularity *c.* AD 875–955 (pp. 78, 170, 219).

19 These strata included two layers of compact charcoal separated by a layer of wind-blown silt – documenting two separate phases of charcoal production early in the use of this pit, one thick layer of roasted bog ore mixed with silt from the walls of the pit, and three separate strata with quantitatively, qualitatively and visually distinct combinations of slag, fire-cracked rock, charcoal and artefacts filling the upper half of the pit.

of ironworking activity shifted across this part of the site during its latter period of use. Similar movements of production activities around the site probably characterized each major industrial phase and contributed to the overlapping, palimpsest nature of the site's features and stratigraphy. Additional evidence for episodic activity at the site is presented by the complex construction and abandonment histories of the two pit-houses constructed sequentially at the southern end of the site.

Our "best guess" reconstruction, combining all information currently available, is that production took place at Háls in two major phases, thirty to sixty years apart, with each phase incorporating several distinct smelting campaigns in which iron was produced episodically over an unknown span of years. Each iron production episode, in turn, included many separate smelts and their related activities, quite likely undertaken on a seasonal basis.

The principal raw material used at the site was bog ore, gathered from marshlands adjacent to the production area. Bog ore is widely distributed in Iceland and is produced as water percolates through basaltic bedrock, dissolving and transporting iron oxides that precipitate in the acidic waters of sedge and peat bogs, where it is fixed as nodules around the roots of plants.[20] Although common, iron-producing bogs are unevenly distributed across the landscape. Their productivity shifts rapidly with changing hydrological regimes; deforestation or drainage can completely disrupt the precipitation cycles in bogs that were once iron-rich. However, without major disruptions, it is said that iron-rich bogs could be harvested anew each generation after being allowed to lie "fallow" for twenty to thirty years.[21]

Although fist-sized nodules of bog ore can easily be found within walking

20 The abundance of iron-producing bogs in Iceland was sufficiently remarkable to medieval Norwegians that the thirteenth-century author of *Konungs skuggsjá (The King's Mirror)* noted it in his otherwise limited description of Iceland (Lawrence Marcellus Larson, trans., *The King's Mirror [Speculum regalae – Konungs skuggsjá]*, New York, 1917, p. 134). On the process of bog ore formation, see Arne Espelund, "Bog Iron Ore for the Bloomery Process," in *Bloomery Ironmaking During 2000 Years, Volume I, Ancient Ironmaking in a Local and General Norwegian Context*, ed. Arne Espelund (Trondheim, 1991), pp. 36–49; Anna M. Rosenqvist, "Report on Chemical and Mineralogical Analyses of Norwegian Ores, Slags, and Iron," *Offa* 40 (1983); and Ronald F. Tylecote and Rodney E. Clough, "Recent Bog Iron Ore Analyses and the Smelting of Pyrite Nodules," *Offa* 40 (1983), pp. 115–18.

21 The regeneration of bog ores is a subject better known through anecdotal reports than detailed study, and may well vary from place to place. Nevertheless, the author of *Konungs skuggsjá* appears to note the transitory nature of bog ore deposits in describing the Icelandic "ore-marvel": "It has happened at times that great deposits of this ore have been found, and men have prepared to go thither the next day to smelt it and make iron of it, only to find it gone, and none can tell what becomes of it." (p. 134) While the descriptions of "marvels" in *Konungs skuggsjá* do not always inspire full confidence in their accuracy, this passage accords well with the response of bog ore deposits to changes in hydrology. By the mid-thirteenth century, when *Konungs skuggsjá* was most likely written (pp. 58–64), environmental degradation appears to have been well underway in many parts of Iceland and might have been locally severe enough to provoke instability in ore deposits' locations and productivity.

distance of the site today, it no longer accumulates in the bogs immediately surrounding the site, pointing to changes since the Viking Age in the bogs' hydrology. However, hundreds of lumps of bog ore found cached in a pit and scattered throughout the site's deposits document that ore was harvested nearby and stored for processing at Háls. Although obvious ore-roasting features have not been located, shallow pits containing charcoal and small amounts of ore may have served this purpose.

The fuel used for roasting ore and making iron at the site was birch charcoal. Two large charcoal-burning pits – the largest 3 m in diameter, nearly 1 m deep, and with two separate layers of charcoal in its base – testify to the production of fuel on-site.[22] Although the landscape around Háls is today completely treeless, logs of fully grown birch trees were present in the peat deposits of the bogs adjacent to the site, below the Landnám tephra layer. Their presence, coupled with high levels of birch pollen in the bogs' pre-Landnám strata, indicate that the site was wooded when the Norse arrived. Shortly after iron production started, birch pollen influx into the bog dropped precipitously, birch macrofossils decreased dramatically in number, and wood charcoal from nearby burning began to accumulate in the peat strata.[23]

Until the 2000 excavations, smelting could be inferred at the site only from the size of the slag heaps and the nature of the slag recovered; furnaces used for smelting eluded our investigations. Work in 2000 uncovered what appears to be the first well-documented series of Viking Age smelting furnace bases from Iceland (Fig. 11.4). These were recognizable as a stacked series of C-shaped, shallow bowls of slag, each 25–35 cm in diameter and 5–10 cm thick, and each with a lower, "broken-out" zone on the eastern side of the ring. In plan view, at least four of these rings, each representing a separate episode of furnace construction, could be seen superimposed above and beside traces of a larger, earlier, damaged ovate base with a diameter of 45–50 cm and a thick deposit of slag along its southern side. So far, only the upper part of this complex deposit has been excavated.

Flat, fire-shattered pieces of basalt, many with adhering slag, were found clustered around these rings, while a tightly constrained zone of charcoal-stained soil extended eastward from the center of the deposit, suggesting the location of a port through which air could be introduced. A roughly V-shaped arrangement of small, heat-fractured stones extended from the broken-out portion of the uppermost slag ring into the inner end of this charcoal-stained zone. This most likely provided support and protection for a bellows nozzle. The absence of ceramic tuyère fragments at the site suggests that iron bellows nozzles were used

22 The earlier of these pits was used and infilled early in the sequence of site use, according to radiocarbon dating and stratigraphic sequencing, while the latter pit appears to belong fully to the late tenth-century phase of iron-production activity at the site.

23 Alexander T. D. Dixon, "Landnám and Changing Landuse at Háls, Southwest Iceland: A Paleoecological Study" (MSc thesis, University of Sheffield, 1997).

to force a controlled air blast directly into the furnace shaft through this port.[24] The general absence of ceramic tuyères at Icelandic and Scandinavian bloomery sites implies they were not integral components of smelting technology in the North Atlantic Viking Age.[25]

Although neither standing furnace walls nor clay linings were preserved *in situ*, small frost-shattered fragments of fire-hardened and vitrified silty clay have been found scattered throughout the slag heap. At least one of these preserved the edge of what appears to be a circular, vitrified opening for a bellows nozzle. These, the first ceramic furnace linings reported from Iceland, were recovered only by water-screening bulk soil samples from the slag heaps. Although small, they are clearly remnants of once more abundant, expediently produced, fragile ceramic linings that have not withstood the intense freeze-thaw cycles characteristic of the Icelandic setting. The remnants of these ceramic linings from Háls are no more than 3 cm thick and would certainly not have allowed the furnaces to be self-standing. Nor did excavations suggest that thicker, unfired clay walls were once present. However, slag lumps found adhering to samples of this clay-like matrix as well as to fire-reddened slabs of basalt suggest that both materials may have been used to line the furnace shafts.

24 Experiments using direct bellows blasts into a reconstructed low-shaft bloomery furnace were undertaken in May 2002 in southern Ontario, with Darrell Markewitz of Wareham Forge and members of the Dark Ages Re-Creation Company (DARC). These experiments demonstrated that iron bellows nozzles, employed without ceramic or other shielding tuyères, could be used effectively to introduce air into the furnace without significant clogging of the bellows or attrition of its nozzle.

25 Despite a century of archaeological investigations in Iceland, no complete or fragmentary ceramic tuyéres have been recovered from smelting or smithing sites and tuyére fragments are rarely mentioned in the copious literature on Norwegian smelting sites. Four semi-vitrified basalt slabs with semicircular indentations suitable for protecting a bellows nozzle, recovered from a Viking Age smithy in Reykjavík (Else Nordahl, *Reykjavík from the Archaeological Point of View*, Aun 12, Uppsala, 1988, 58, 98 and Figs 73, 140), are most likely bellows shields from Viking Age forges, homologous with the famous engraved "forge stone" from Snaptun, Denmark (P. V. Glob, "Avlsten: Nye Typer fra Danmarks Jernalder," *Kuml*, 1959, p. 69, Fig. 2), the ceramic forge stones ("*essesteine*") from smithies in early Viking Age Ribe (Helge Brinch Madsen, "Die Eisenschlacken von Ribe," *Metalla*, Bochum, 1999, pp. 5–11), and similar ceramic examples from Early Iron Age smithing facilities at Heek, Germany, and Viking Age forging deposits at Haithabu/Hedeby, Denmark (see Frank Nikulka, "Between the Mountains and the Sea: The Development of Iron Production in Northwestern Germany," in *Prehistoric and Medieval Direct Iron Smelting in Scandinavia and Europe*, ed. Lars Christian Nørbach, Aarhus, 2003, pp. 63–6). These examples suggest that flat, perforated forge stones, both ceramic and stone, may have taken the place of ceramic tuyéres in Nordic Viking Age smithies, but their use in smelting furnaces is, to my knowledge, unproven. No such "forge stones" or fragments thereof have been recovered from Háls. In later Icelandic forges, such as those maintained in nineteenth-century turf-houses (and preserved as open-air museums in northern Iceland), no such forge stones or shields were employed; the blast from the bellows reached the smithies' hearths directly through long iron tubes, discharged through the stone-built walls forming the backs of the forges themselves.

Surrounding the furnace bases was a matrix of dense silt-based turf. In cross-section it could been seen that this matrix, surrounding the uppermost and latest furnace base, included turf blocks incorporating the Landnám tephra stacked at an angle against the inner core of the furnace to form the furnace stack itself. Heaped around the turf blocks was an extensive deposit of loose, sterile silt that surrounded and supported the furnace's core and would have prevented air from entering the shaft through its turf wall. A well-defined, vertical edge between this silt deposit and the surrounding trampled surface of the iron-production work area suggests that the silt and turf body of the furnace had been enclosed in a rectangular crib-like structure, presumably of wood, with a stone-flanked opening to the east through which bellows could have been inserted and through which slag may have been removed.

Overall, the size, shape, and construction of the furnaces and their associated debris are generally consistent with untapped, low-shaft bloomery furnaces known from early Viking Age Norway. These have been well documented by Irmelin Martens and others, and are thought to have produced blooms of raw iron 8–10 kg in mass during good smelts.[26] What clearly differs from the Norwegian furnaces is the absence of a thick ceramic furnace stack – a point that may be directly related to a paucity of substantial deposits of good clay in Iceland's young geological landscape. Small deposits of mixed glacially deposited clay and silt are found along the banks of some glacial rivers, but these have never proven suitable for producing ceramic vessels and may have been unsatisfactory for building either self-supporting or slab-framed clay furnace stacks. Instead, the evidence from Háls suggests that these furnaces had stacks built of turf blocks, lined internally with pieces of basalt cemented into a thin veneer of silty glacial clay.[27]

Given the small diameters of the furnace bases exposed in 2000, it is unlikely that the furnace stack was higher than 70 cm. The wooden-framed construction surrounding the furnace stack may also have, therefore, served as a platform for loading, charging, and emptying the furnaces after each smelting episode. Figure 11.5 provides a tentative reconstruction of this furnace's appearance during use.

As in other parts of the site, the superimposed series of furnace bases exposed in 2000 preserves suggestions of episodic use and change. For example, the earliest furnace base identified at this location appears to have been almost twice as large as those that were built over it. Stratigraphic cross-sections adjacent to

26 See Irmelin Martens, "Blåsterjern og Fellujern: Noen Synspunkter på en Lite Påaktet Funngruppe," in *Universitetets Oldsaksamling 150 år, Jubileumsårbok 1979* (Oslo, 1979), pp. 190–97; idem, "The Norwegian Bloomery Furnaces and Their Relation to the European Finds," *Offa* 40 (1983), 119–24; and idem, "Iron in Southeastern Norway in the Medieval period," in *Bloomery Ironmaking*, vol. II, pp. 55–68.

27 Although the construction of the furnace at Háls differs in significant details from their tentative reconstruction, the possibility that turf-built furnaces were produced in Iceland was previously suggested by Fridriksson and Hermanns-Auð ardóttir, "Ironmaking in Iceland" (see notes 43, 44, and 47, below).

this base suggest that it may have been rebuilt at least three times before being abandoned. The smaller-diameter furnace bases described above appear to sit off-center to this earlier construction, yet within the same general area, suggesting re-use of the frame and facility after a period of disuse. Although none of the furnace bases have yet been individually dated, or fully excavated, the observed differences in the sizes and orientations of the furnace bases raise questions about whether more than one type of furnace was employed at the site during the course of its use.

No slag-tapping basins were found in the vicinity of the furnace bases exposed in 2000 and virtually no tap slag has been recovered from the site – 97 per cent of the estimated 5000 kg of slag present in the main slag heap appears to be amorphous furnace slag typical of non-tapped shaft furnaces.[28] The main slag heap itself covers an area of at least 45 m², blanketing a shallow slope between the production area and the margins of the adjacent bog. Between the furnace and this slag heap was a zone in which charcoal was abundant but large concentrations of smelting slag were relatively infrequent. At the eastern edge of this zone lay a battered boulder, beyond which plano-convex smithing hearth bottoms were clustered. Miniscule spheroids of slag and hammer scale, typical products of secondary smithing during bloom consolidation, were common in this area.[29] Several broken or fragmentary pieces of semi-fabricated iron tools were also recovered from the same general area. The size of the spheroids, the number of smithing hearth bottoms and the relative concentration of semi-processed iron objects strongly suggest that raw blooms (*blásturjárn*) were processed here into compressed blooms (*fellujárn*), and perhaps further into semi-fabricated forms.

During the 1996 season a broken iron shaft with a fragmentary, flattened expanding end was recovered from the fill of the earlier of the two pit-houses identified at the site, and in 2000 two flattened spatulate fragments of forged iron with rounded ends were recovered from the site (Fig. 11.6). One came from the production area near the boulder; the other was recovered from the fill of the same pit-house that produced the expanded shaft in 1996. In size and shape, these three objects match remarkably well the spatulate ends and shafts of Norwegian Viking Age "currency bars" – forged iron bars of consistent size and mass generally thought to have been produced as standardized units of exchange, in which the

28 Dr Elizabeth Hamilton, notes (files, Haffenreffer Museum of Anthropology, Brown University); see also note 31, below. However, fragments of tap slag, including both runnels and fractured tap-basin slags, were recovered in 1989 from another eroding slag concentration located to the southeast of the slag heap excavated in the 1996 and 2000 seasons at Háls. This suggests the possibility that additional furnaces, with slag-tapping capabilities, were used at the site. If so, those furnaces have yet to be located or exposed.

29 On the identification of archaeologically recoverable by-products from forging and smithing, see J. G. McDonnell, "A Model for the Formation of Smithing Slags," *Materialy Archeologiczne* 26 (1991), pp. 23–7; and Peter Crew, "Bloom Refining and Smithing Slags and other Residues," *Archaeology Datasheet No. 6*, Historical Metallurgy Society (1996).

final shape demonstrated both the iron's qualities and perhaps also its regional origin.[30] The presence of these fragments at Háls suggests that they represent waste from bars broken during forging, perhaps because of poor iron quality.[31]

A small number of artifacts found at Háls also testify to ancillary activities undertaken at the site, including generalized repair of iron and composite tools and limited non-ferrous metalworking. Clipped nails imply the repair of objects brought to the site. A riveted bucket patch suggests some work fabricating or repairing compound iron objects. Two small iron carving knives, discarded near the pit-houses, hint at craftwork or domestic activities undertaken in support of iron production. Small pieces of copper alloy scrap and possible flecks of silver in one block of slag examined by scanning electron microscopy also suggest some level of on-site work in non-ferrous metals, concurrent with iron production.

Based on the evidence at hand, it is difficult not to conclude that the ironworkers gathered at Háls brought with them a diversified range of skills, some quite specialized and others less so, which enabled them to undertake nearly the entire iron-production process from ore and fuel gathering to the production of standardized iron objects for exchange (Fig. 11.7). At the same time, the lack of evidence for comparably intensive smithing on-site suggests that most of the final fabrication of tools made from the iron produced at Háls was done elsewhere. As noted above, there is no evidence for an inhabited farm-site at Háls contemporary with this iron-production phase, rendering it impossible to suggest where the next stages of fabrication were undertaken. However, the majority of well-dated early Viking Age habitation sites in Iceland are located in the coastal and near-coastal lowlands.[32] Some, but not all, of these sites have smithies, yet few have produced evidence of on-site smelting facilities.[33] Thus it is possible that the iron produced

30 On currency bars, see Peter Crew, "The Experimental Production of Prehistoric Bar Iron," *Historic Metallurgy* 25 (1991), pp. 21–36; also Peter Crew and Christopher J. Salter, "Currency Bars with Welded Tips," in *Bloomery Ironmaking During 2000 Years, Volume III: Smelting and Excavation in Budalen*, ed. Arne Espelund (Trondheim, 1993), pp. 11–30. On Viking Age Norse currency bars analogous to the fragments from Háls, see Irmelin Martens, "Some Reflections on the Production and Distribution of Iron in Norway in the Viking Age," in *Economic Aspects of the Viking Age*, British Museum Occasional Paper 30, ed. David M. Wilson and Marjorie L. Caygill (London, 1981), pp. 41–2, Pl. III; and Hans Georg Resi, "The Norwegian Iron Bar Deposits: Have They Most to Tell about Production, Distribution, or Consumption?," *Varia* (Oslo) 30 (1995), pp. 131–46.

31 That the Old Norse term for such currency bars, *teint járn*, was used both in medieval Norway and in early Icelandic law codes (Martens, "Some Reflections," p. 41, and *Grágás*, p. 478) suggests that currency bars circulated in Early Medieval Iceland, when the laws were recorded. The evidence from Háls appears to be the first material documentation of their production and presence in Iceland during either the Viking Age or the Early Medieval period.

32 On the distribution of early Icelandic sites, see Smith, "Landnám," and Orri Vésteinsson, Thomas H. McGovern and Christian Keller, "Enduring Impacts: Social and Environmental Aspects of Viking Age Settlement in Iceland and Greenland," *Archaeologia Islandica* 2 (2000), pp. 98–136.

33 For evidence of metalworking activities exclusive of smelting in early settlement

at Háls was later forged into objects for household use at such coastal sites. The recovery of seal and cod remains in the pit-house deposits at Háls suggests contact, at least, with the coastal zone, and may provide tentative support for a model of coastal–interior economic interaction during the first century of Norse settlement in Iceland.[34]

Scale of Production

Based on data collected at Háls in 1996 and 2000, it is possible to estimate roughly the scale of production at Háls, and from that basis to consider how it fit into the regional economic system and whether it was unique or representative of a larger class of sites. Controlled volumetric sampling within the main slag heap and surrounding production features indicates that they contain at least 5000 kg of smelting slag.[35] Experimental work by Peter Crew and Arne Espelund, among others, along with published laboratory work and limited ethnohistoric data from

sites at Reykjavík, see Nordahl, pp. 55–9 and 90–99, and Howell M. Roberts, ed., *Fornleifarannsókn á Lóðunum/Archaeological Excavations at Aðalstræti 14-18, 2001: A Preliminary Report/Framvinduskýrslur* (Fornleifastofnun Íslands, Reykjavík, 2001), p. 71. For comparable evidence at Herjólfsdalur, Vestmannaeyjar, see Margrét Hermanns-Auðardóttir, *Islands Tidiga Bosättning, Studier med Utgångspunkt i Merovingertida-Vikingatida Gårdslämningar i Herjólfsdalur, Vestmannaeyjar, Island*, Studia Archaeologica Universitatis Umensis 1 (Umeå, 1989), pp. 118–20.

34 Thomas Amorosi and Thomas H. McGovern ("Archaeofauna Samples from the Háls Site, Hálsasveit, Borgarfjarðarsýsla," unpublished report, 1997, Haffenreffer Museum of Anthropology, Brown University) identified one calcined seal bone from the floor of the earliest pit-house identified at the site; a large, articulated series of cod vertebrae was recovered as well, from midden deposits filling that pit-house's depression. Both finds imply connections with coastal districts, but it is unknown whether they reflect provisioning through trade with coastal farms or expeditions into the interior to produce iron. According to *Landnámabók*, trans. Hermann Pálsson and Paul Edwards (Winnipeg, 1972), the land on which Háls is located was within the land-claim of Thorkell Kornamulí, an early settler whose farm at Stóri-Ás, located less than 3 km north-east of Háls, later claimed tithing rights from the Early Medieval farm at Háls. Although iron production at Háls may have been undertaken by workers dispatched from Stóri-Ás, no archaeological investigations have been undertaken at that site to determine the age of its earliest occupation or whether it contains evidence of forging to complement the smelting evidence at Háls. It is also unknown to what degree the land-claims described in the twelfth–thirteenth century *Landnámabók* reflect Viking Age realities versus later medieval claims to property and political rights; see Sveinbjörn Rafnsson, *Studier i Landnámabók: Kritiska Bidrag till den Isländska Fristatstidens Historia* (Lund, 1974).

35 Dr Elizabeth Hamilton sorted, classified, and quantified slag recovered in volumetrically controlled bulk soil samples from the main slag heap during the 1996 Háls Archaeology Project field season. Analytical results from the volumetric sampling program were presented in summary form by Elizabeth Hamilton and Kevin P. Smith as a poster session entitled "Viking Period Iron Production at Háls, Borgarfjarðarsýsla, Iceland" at the 63rd Annual Meeting of the Society for American Archaeology, Seattle, WA, 28 March 1998.

post-medieval Norwegian bloomery production, allows rough estimation of the amount of iron produced there, the mass of ore and charcoal consumed, and the number of smelting runs undertaken at the site.[36]

Peter Crew's experimental work using reconstructed Iron Age bloomery furnaces of similar size and structure suggests that a 5000 kg heap of slag containing 45–60 per cent residual iron oxide content could represent the production of roughly 1400 kg of raw iron blooms from approximately 6200 kg of bog ore and 22 300 kg of charcoal.[37] After primary and secondary smithing on-site, these blooms would consolidate into roughly 370 kg of finished bar iron, with the total consumption of over 50 000 kg of charcoal. At 8–10 kg per raw bloom, it would have taken nearly 140 smelts to produce this amount of bar iron, with a team of three to five metalworkers putting in more than 9200 person-days of labor from start to finish.[38] This labor estimate includes the costs of fuel production, smelting, forging and facilities management, but not the time required to provision or house the crews, who apparently lived, cooked and ate in pit-houses built at the site for their use while making iron and tending charcoal pits.

36 A sampling of reports on laboratory and in-field experiments with Northern European Iron Age and Viking Age smelting furnaces includes E. J. Wynne and R. F. Tylecote, "An experimental investigation into primitive iron smelting technique," *Journal of the Iron and Steel Institute* (December 1958), pp. 339–48; Sigmund Jakobsen, Jan Henning Larsen and Lars Erik Narmo, "'Nå Blestres det Igjen Jern ved Dokkfløy' Et Forsøk på Eksperimentall Arkeologii," *Viking* 51 (1988), pp. 87–108; Crew, "Experimental Production," and Arne Espelund, "The Value of a Tradition in Ironmaking: Smelting in Budalen, According to O. Evenstad's Description from 1782," in *Bloomery Ironmaking*, vol. III, pp. 149–66.

37 Crew, "Experimental Production." Differences in the cultural context within which the Iron Age Welsh and Viking Age Icelandic furnaces operated, as well as in specific parameters of the ore and other raw materials used, imply that calculations based on Crew's impeccable experimental work must be considered rough estimates, at best, when extrapolated to Háls. Further analytical work on ore and slag samples from Háls, combined with experimental reconstruction and use of furnaces under Icelandic conditions, will eventually allow more precise calculations of these furnaces' input requirements and output yields. Nevertheless, cautious extrapolation from Crew's work provides at least a general sense of the scale of production at Háls and is not inconsistent with less detailed calculations for Viking Age Norwegian bloomery furnaces (as, for example, Irmelin Martens, "Iron Extraction, Settlement, and Trade in the Viking and Early Middle Ages in South Norway," *Proceedings of the 10th Viking Congress*, Oslo, 1987, p. 73). The amount and nature of iron oxides remaining in the slag recovered from Háls, primarily *wüstite* and *fayalite*, were determined through SEM/EDX (scanning electron microscopy/electron-dispersive X-ray) analyses done by Peter Bush of the Biomaterials Laboratory, State University of New York at Buffalo, and were confirmed by independent SEM/EDX analyses undertaken by Elizabeth Hamilton at the University of Pennsylvania's MASCA Laboratories, and by microprobe analyses undertaken by Kristín Sigurðardóttir (pers. comm.). Approximately 0.8 ton of fuel ash from the charcoal are assumed to contribute to the formation of the slag, accounting for the difference in apparent weights of input and output products.

38 See Martens, "Blåsterjern og Fellujern," and Crew, "Experimental Production."

Stratigraphic evidence from the site suggests that iron was produced at Háls in at least three to six campaigns, perhaps separated into two phases nearly half a century apart. If there were six campaigns of iron production, each would have produced about 60 kg of iron suitable for final fabrication into tools, weapons, and other objects. This amount represents far more than the annual consumption and replacement requirements of even the largest Icelandic farm, based on later post-medieval data regarding Icelandic importation of iron.[39] These figures can be considered no more than rough initial calculations (and may well underestimate the scale of industrial activity at the site), yet they imply that production at Háls was undertaken at a level exceeding an individual household's needs and that the products were intended for distribution or sale to other farms in a wider surrounding region. This inference is supported by the possibility that currency bars were produced there.

A rough estimate of the potential value of the iron produced at Háls can be derived from an early thirteenth-century equivalency list establishing the relative values of domestic products to one another in southern Iceland.[40] At that time, 370 kg of forged bar iron (*teint járn*) could have purchased 3 cows or 19 sheep. Forged into scythes, the same amount of iron could have purchased 10 cows or 60 sheep. Forged into kettles, it would have purchased 16 cows or 99 sheep. In actuality, the exchange lists are standardized in units of homespun wool cloth, medieval Iceland's *de facto* currency, which was convertible for many different products and was itself conventionally equated to fixed weights of silver. These exchange rates clearly demonstrate the increasing value of iron products relative to other goods (such as livestock) due to the specialized skills and labor required to transform raw ore into metal and, from there, into more complex tools. While logically similar steps in valuation may have structured Viking Age transactions, in the absence of similar documents for the ninth–tenth centuries we cannot be certain of the comparability of these thirteenth-century exchange rates. Nevertheless, the economic values of both smelters and smithies are clearly apparent for both the householder and society.

Technological Innovation in Icelandic Viking Age Iron Production

Iron was produced in Iceland from shortly after the time of the island's settlement, *c.* AD 870, until the early post-medieval period. According to the thirteenth-century *Hauksbók* redaction of *Landnámabók* (the *Book of Settlements*), Rauða-Björn – literally "Ore-Björn," a putatively early settler in the same general part of

39 For information on the scale and origins of post-medieval iron imports to Iceland, see Þórkel Jóhannesson, "Járngerð," in *Iðnsaga Íslands*, ed. Guðmundur Finnbogason, (Reykjavík, 1943), vol. 2, pp. 40–58; and Þórarin Þórarinsson, "Þjóðin Lifði en Skógurinn Dó," *Ársrit Skógræktarfélags Íslands* (1974), pp. 16–29.

40 *Grágás*, pp. 476–8; Gelsinger, *Icelandic Enterprise*.

Iceland as Háls – was remembered as the first man to discover how to make iron in Iceland.[41] His story is not told anywhere in great detail, yet immediately raises questions since many of Iceland's settlers came from western and southern Norway, where iron had been smelted for centuries from bog iron.[42] The fact that Rauða-Björn's accomplishment was remembered four hundred years after his apparent "discovery" suggests that he may have devised a solution to a critical but unrecorded technological problem, unique to Iceland, that stood in the way of successful provisioning, rather than simply having been the first man to smelt iron in Iceland using tried-and-true Scandinavian bloomery furnace designs.

Understanding the technical details of Icelandic iron production is made especially difficult since iron ceased to be produced in quantities useful for provisioning the society by the mid-sixteenth century. As a result, there are no detailed written descriptions of the Icelandic iron industry or its technological components. Although smithies used to forge imported iron are well known from documented seventeenth- through nineteenth-century structures, no Icelandic bloomery furnaces have been preserved or described. Archaeological documentation has been elusive as well.

In the early twentieth century, Niels Nielsen surveyed the evidence for ironworking in Iceland and excavated what he believed to be a stone-lined pit furnace at Belgsá in northern Iceland.[43] He argued that he had found evidence for two types of medieval furnace – a pit furnace and an above-ground kind. Unfortunately, his documentation and descriptions are insufficiently clear to evaluate his claims or to compare his furnaces adequately with later-documented finds from Scandinavia. Nielsen also had no way to date his sites. The pit furnace he described from Belgsá, if it is indeed a furnace, is unlike known examples from the Scandinavian Viking Age. If it represents a slag-collecting pit beneath a furnace whose superstructure has disappeared – rather than a pit furnace, as Nielsen thought – its construction and size would find its closest parallels far earlier, in the Norwegian Early Iron Age (*c.* 350 BC–AD 500).[44]

41 *Landnámabók I–III: Hauksbók. Sturlubók. Melabók.* Manuscripts Udgevet af det Kongelige nordiske oldskrift-selskab, ed. Finnur Jónsson (Copenhagen, 1900).

42 On the archaeological record of Nordic bloomery iron production, see, for example, Martens, "The Norwegian Bloomery Furnaces"; Lars F. Stenvik, "Iron Production and Economic 'Booms,'" in *Bloomery Ironmaking*, vol. I, pp. 100–115; Arne Espelund, "A Retrospective View" and "The Mellager Site in Trondheim – a Complex of Metal Workshops and its Role in Medieval Iron Metallurgy," both in *Bloomery Ironmaking*, vol. II, pp. 93–114; Perry Rolfsen, "Iron Production in the Upper Part of the Valley of Setesdal, Norway," in *Bloomery Ironmaking*, vol. II, pp. 79–88; and Arne Espelund and Lars F. Stenvik, "Ironmaking During the Roman Iron Age in Mid-Norway: The Bloomery Site Storbekken I in Budalen," in *Bloomery Ironmaking*, vol. III, pp. 123–48.

43 Niels Nielsen, "Jærnudvindingen paa Island i Fordums Tider," *Aarbøger for Nordisk Oldkyndighed og Historie* (1926), pp. 129–74.

44 This is not to suggest that Nielsen's furnace at Belgsá constitutes evidence of Early Iron Age settlement in Iceland. It may reflect the resurrection of earlier furnace

In the 1970s, Guðmundur Ólafsson excavated the bases of what appear to be two small Viking Age smelting furnaces at the tenth-century site of Grelutóttir, in north-western Iceland. Each was represented only by a shallow depression associated with small amounts of slag, located off-center in small turf-walled houses built within the confines of a Viking Age farm's homefield. The amount of slag recovered from the site suggests that these smelters were used to produce only 20–50 kg of raw iron blooms, at most, presumably for home use.[45] A furnace hut with somewhat similar layout, excavated at L'Anse aux Meadows, Newfoundland, also appears to have been used for the production of just a few kilograms of iron.[46]

Thorbjörn Fridriksson and Margrét Hermanns-Auðardóttir briefly describe the excavation of a similar furnace at Ormsstaðir, northern Iceland, apparently constructed inside a turf-walled structure 7.5 m long and 2 m wide.[47] Nothing remained of the furnace itself but a sub-rectangular pit in the structure's floor, roughly 60 cm wide, 80 cm long, and 40 cm deep, containing three superimposed layers of slag and bog ore. Fridriksson and Hermanns-Auðardóttir interpreted the pit as a slagging basin beneath a furnace built of humic floor material packed around a charge of ore and charcoal, held in place by turf blocks supported by sticks or planks.[48] Unfortunately, no information has been published concerning the dating of the site or the amount of slag recovered at Ormsstaðir, making it difficult to estimate its age or productivity.

No traces of ceramic furnace linings, constructed clay furnace walls, tuyéres, or *in situ* furnace bases were reported from these sites, but, as at Háls, both Ormsstaðir and Grelutóttir yielded evidence for both the storage of bog ore and

types by Viking Age or later iron smelters in Iceland or technological experimentation in Iceland that was uninformed by Early Iron Age prototypes. It may belong to the later medieval period – pit furnaces were known in late and post-Medieval Norway, as evidenced by Ole Evenstad's description of such furnaces from 1782 and excavations of such furnaces in western Norway at sites dating from 1400–1800 (see Espelund, "A Retrospective View"). Concerning the age of shaft furnaces with sub-hearth slagging pits, see, for example, Martens, "The Norwegian Bloomery Furnaces", pp. 119–20; Oddmunn Farbregd, Lil Gustafson and Lars F. Stenvik, "Tidlig Jernproduksjon i Trøndelag. Undersøkelsene på Heglesvollen," *Viking* 48 (1985), pp. 103–29; and Peter Hambro Mikkelsen, "Slag – With an Impression of Agricultural Practices," in *Prehistoric and Medieval Direct Smelting*, pp. 43–8.

45 Guðmundur Ólafsson, "Grelutóttir. Landnámsbær á Eyri við Arnarfjörð," *Árbók hins Íslenzka Fornleifafélags 1979* (1980), pp. 25–73.

46 Eldjarn, "Investigations," pp. 87–96; Wallace, "L'Anse aux Meadows," pp. 185–6.

47 Fridriksson and Hermanns-Auðardóttir, "Ironmaking in Iceland," pp. 7–8 and Fig. 3.

48 Unfortunately, the excavators provide no detailed information on how they developed their reconstruction of this furnace, noting that "the fact stared us in the face that there were no traces of the furnaces whatsoever … instead of a beautifully built furnace only an inconspicuous depression in the floor seemed to identify the smithy as a rauðasmidja [ironmaking smithy]," and further that "when the smithy at Ormsstadir was excavated … all there was to be seen was a miserable depression" (Fridriksson and Hermanns-Auðardóttir, "Ironmaking in Iceland," p. 7).

smithing near the furnaces. Poor preservation conditions at both Ormsstaðir and Grelutóttir preclude definitive reconstructions of the furnaces, yet each appears to have been provided with a shallow sub-furnace slagging pit, unlike known Viking Age low- and mid-shaft bloomery furnaces from mainland Scandinavia.[49] In addition, the furnaces at all of these locations, with the exception, perhaps, of Belgsá, appear to have been enclosed within small turf-walled structures, and were unassociated with other production features, such as charcoal-burning pits.

The iron production complex at Háls differs in several significant ways from these other sites. For example, no evidence has been recovered to indicate that a semi-permanent roofed structure was ever built over the furnace at Háls, and rather than being in proximity to a farm or major residential complex (as at Grelutóttir and L'Anse aux Meadows), the complex at Háls appears to have been seasonally used and far enough distant from a residential site to have required the construction and maintenance of pit-houses there for temporary occupation. The evidence for both intensive use of the site in sequential iron-production campaigns and for returns to the site after episodes of disuse also imply long-term investments in the location that differ from the other sites described to date. The scale of production at Háls also appears to have been larger by an order of magnitude than has been inferred for other Icelandic sites. Although not huge by medieval industrial standards, Háls does stand out as a large metallurgical site in comparison with other known Icelandic sites, and one that existed on its own for the production of iron, rather than being an ancillary structure on an established farmstead.

These aspects of the site, plus the size and shape of the furnace bases and the suite of surrounding production features uncovered at Háls, correspond well with contemporaneous open-air, large- to medium-scale Viking Age bloomery iron production sites in mainland Scandinavia, especially Marten's Group 1BI sites from Møsstrond, south-eastern Norway, which are dated to the period AD 800–950.[50] The only significant difference from these Norwegian sites is that the furnace shafts at Háls were not built from clay. The indications at Háls of a turf-built, clay-and-stone-lined furnace with a surrounding wood-framed enclosure suggest an innovative solution developed early in the Icelandic settlement period to solve problems faced in adapting well-known Nordic techniques of iron production to a country with few supplies of usable clay. Fridriksson and Hermanns-Auðardóttir's somewhat similar reconstruction of the furnace at Ormsstaðir[51] suggests that the design may have been present in distant parts of the island and had enduring value. Further, Jan Henning Larsen's description of low-

49 Jan Henning Larsen, "Iron Production at Dokkfløy in Oppland, Norway," in *Bloomery Ironmaking*, vol. II, pp. 70–71; also, Rolfsen, "Iron Production."

50 These sites (Group 1BI) are defined as open-air sites characterized by slag heaps not more than 6–8 m in diameter, with shaft furnaces and without ore-pits or surface-built houses (Martens, "Iron Extraction," pp. 69–80, esp. pp. 71–3).

51 Fridriksson and Hermanns-Auðardóttir, "Ironmaking in Iceland," p. 15, Fig. 4.

shaft furnaces from Setesdal, Norway, dating to the period AD 900–1450, with frames of turf, silt and small stones insulating and supporting clay-and-stone-lined furnace shafts suggests that prototypes similar to the Háls furnace may have existed in Viking Age or Early Medieval Norway.[52]

It is therefore tempting to wonder whether an adaptation of this south-eastern Norwegian design was the creative solution for which Rauða-Björn was memorialized in *Landnámabók*. Despite small sample sizes and poor preservation, the apparent diversity of furnace types, sizes and settings reported so far from Viking Age Iceland suggests that the first centuries after settlement witnessed considerable variation and experimentation in this technological realm. Similar diversity and experimentation has been noted before as a characteristic feature of this colonizing society's subsistence systems, architecture, settlement patterns and approaches to personal adornment.[53]

Conclusion

Evidence for smelting (iron production) and smithing/forging (ironworking), or both, is not uncommon in Iceland. Fridriksson and Hermanns-Auðardóttir, for example, located records for more than 120 sites that have produced traces of smelting or smithing.[54] However, few of these sites have been tested, fewer still have been dated, and none but Háls has been systematically sampled volumetrically to allow the scale and organization of production to be estimated. Despite these problems, some patterns are nevertheless evident and important for considering the roles that smelting and smithing played in the Viking Age and Early Medieval Icelandic economy. Figure 11.8 shows the distribution of excavated Icelandic Viking Age and Early Medieval sites with traces of iron production or smithing. Larger smelting sites, like Háls, are few in number and are known, so far, only from the interior. A few smaller smelting sites, with slag heaps of just a few hundred kilograms or less, appear to reflect household-level, short-term production and are known from a small number of coastal sites. Sites with evidence for smithing, but not smelting, are more common. More abundant still are sites without reported evidence for smelting or smithing, but with iron tools or tool fragments implying the use and consumption, but not the production or maintenance, of iron objects at these locations.

52 Larsen, "Iron Production at Dokkfløy," p. 82. Even the clay-built, low-shaft furnaces from Møsstrond and Heglesvollen were enclosed in earth-filled, slab-built supporting structures, implying that the larger timber-framed surround at Háls most likely represents just a modification of existing technological solutions in Nordic bloomery iron production.

53 Concerning views on diversity in these different cultural realms within Iceland's early settlement and burial sites, see Smith, "Landnám"; Vésteinsson, "Patterns of Settlement"; Vésteinsson et al., "Enduring Impacts"; and Hayeur Smith, "Social Analysis of Jewellery."

54 Fridriksson and Hermanns-Auðardóttir, "Ironmaking in Iceland," p. 15, Fig. 5.

This evidence contradicts the expectations of the self-supporting household model and implies that there may have been considerable diversity across the island in the size, scale, and goals of iron-production and ironworking sites operating during the Viking Age and Early Medieval periods. None of the iron-production facilities known, to date, are located on sites identified in medieval sources or through archaeological correlates as having been the seats or property of Icelandic elites. Although future excavations may well show that elite households maintained significant iron-production facilities, the observations that some smaller farmsteads had small-scale smelters and that more have evidence of smithing suggest that iron production and ironworking were beyond the control of Iceland's emergent elites. Saga descriptions of blacksmiths and others involved in related activities (charcoal production, smelting) similarly include both non-elite and elite men.[55] This implies, at least, that the thirteenth- and fourteenth-century authors and audiences of the sagas understood iron production and smithing to be decentralized aspects of the economy in their own times – under elite control where possible, but more often a part-time specialization and household, or cottage, industry. This accords well with existing archaeological data from the Viking and Early Medieval periods.

At the same time, the uneven distribution of iron-production and ironworking sites within districts suggests that smelting and smithing were skills unevenly distributed across the social landscape. The Early Medieval farm that was founded at Háls after AD 1000, for example, had no associated smithy throughout its nearly 300-year existence, despite the earlier production of iron there, and must have relied completely on other farms for the production, manufacture, and repair of its iron tools and equipment. The early thirteenth-century *Heiðarvíga saga*, set in the same district, describes farmers traveling 6–12 km, each way, to visit farms that had the facilities, resources and skills to operate smithies or smelters.[56] Rather than each farm having its own smithy, this conjunction of archaeological data and documentary sources implies that the socio-economic landscapes of Viking Age and Early Medieval Iceland were characterized by networks of economic exchange and obligations that linked households in relations of mutual or commercial interaction, if not economic asymmetry and dependence. These views are far removed from traditional models emphasizing household self-sufficiency and economic independence. Opening this window provides a suitable vantage point for viewing the economic basis of Icelandic Viking Age and Early Medieval social structures in a new light.

[55] For example, *Heiðarvíga saga, Íslenzk Fornrít* 3 (Borgfirðinga sögur), ed. Sigurður Nordal and Guðni Jónsson (Reykjavík, 1938), pp. 288–94; *The Saga of Gisli*, trans. and ed. George Johnston (Toronto, 1962), p. 114; *Laxdæla Saga*, trans. and ed. Magnús Magnússon and Hermann Pálsson (Harmondsworth, 1969), pp. 101, 230–33; and "Ale-Hood," in *Hrafnkel's Saga and Other Stories*, trans. and ed. Hermann Pálsson (Harmondsworth, 1971), p. 82. Hall, "Viking Age Ironworking," provides examples from *Landnámabók* of non-elite householders involved in iron production and describes a Danish runestone commissioned by a freed slave who at one time had been a smith.

[56] *Heiðarvíga saga*, pp. 288–94.

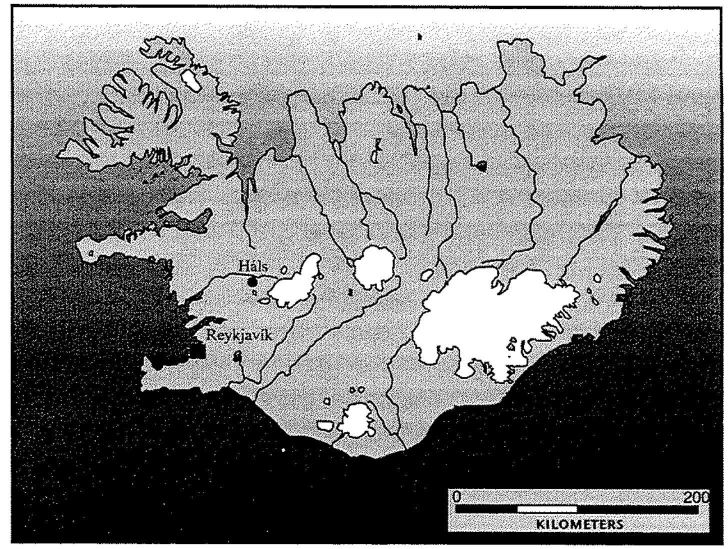

Figure 11.1 Iceland, showing the location of Háls.

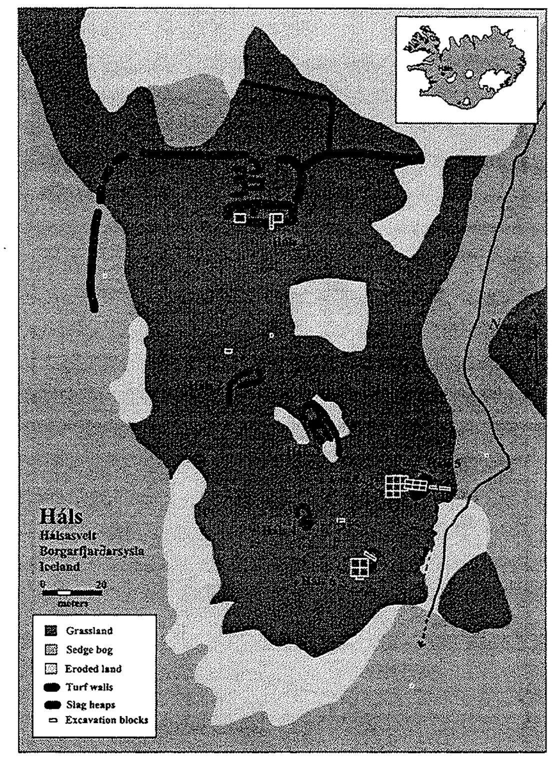

Figure 11.2 Map of Háls 5 and 6, showing the distribution of known iron production and features and deposits at the site.

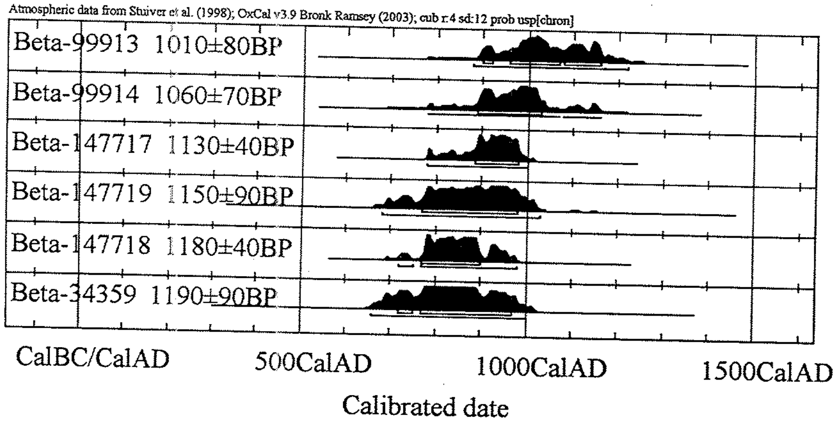

Figure 11.3 Calibrated radiocarbon dates from iron production contexts at Háls, 1989–2000 seasons. Vertical line at approximately AD 871 represents the "*landnám* tephra," which underlies all of the dated deposits.

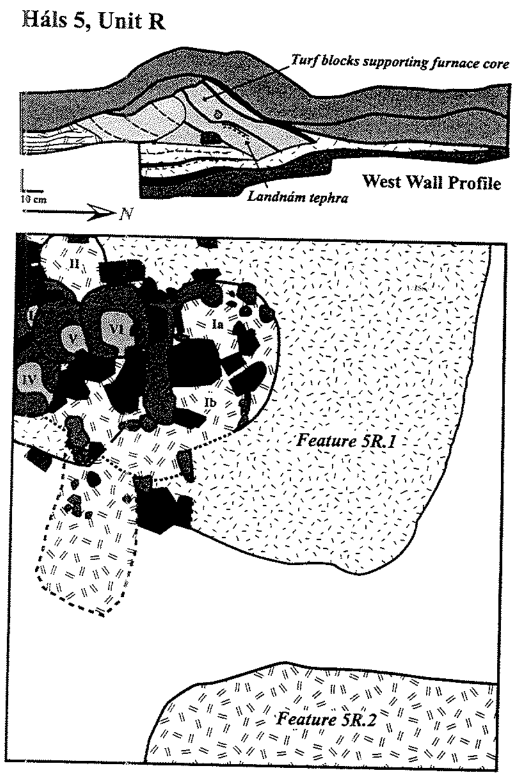

Figure 11.4 Plan and profile views of furnace bases excavated in 2000 at Háls 5.

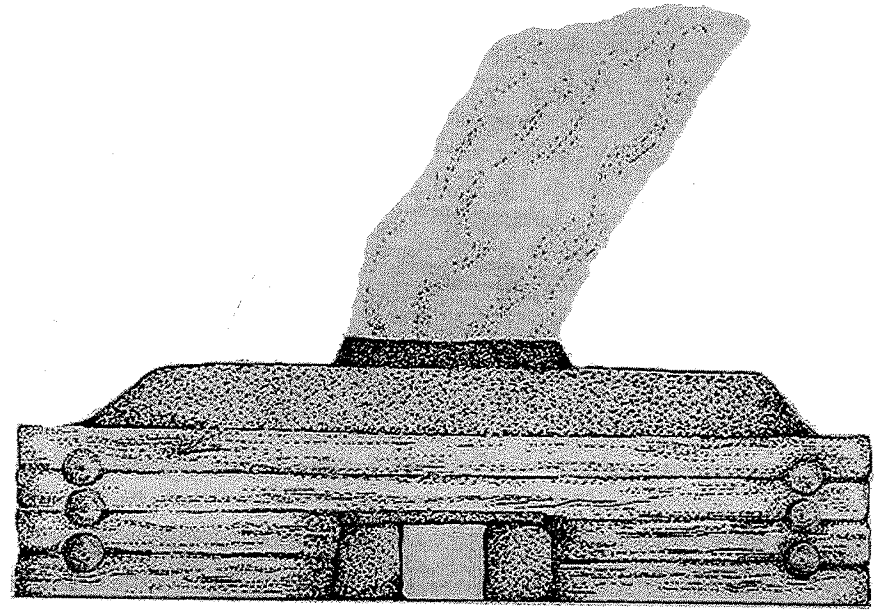

Figure 11.5 Preliminary reconstruction of a Viking Age blooomery furnace excavated in 2000 at Háls (illustration: Michèle Hayeur Smith).

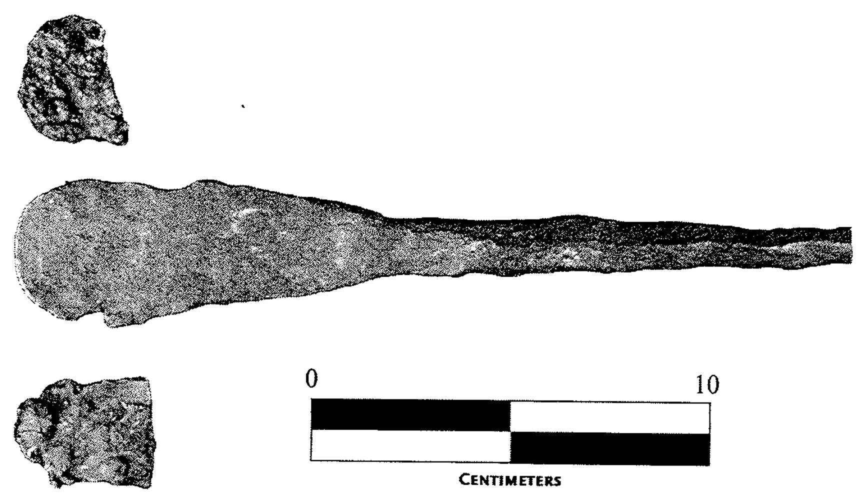

Figure 11.6 Spatulate end fragments of iron objects from Háls 6, compared to a Viking Age currency bar (center: Buffalo Museum of Science, Kn718).

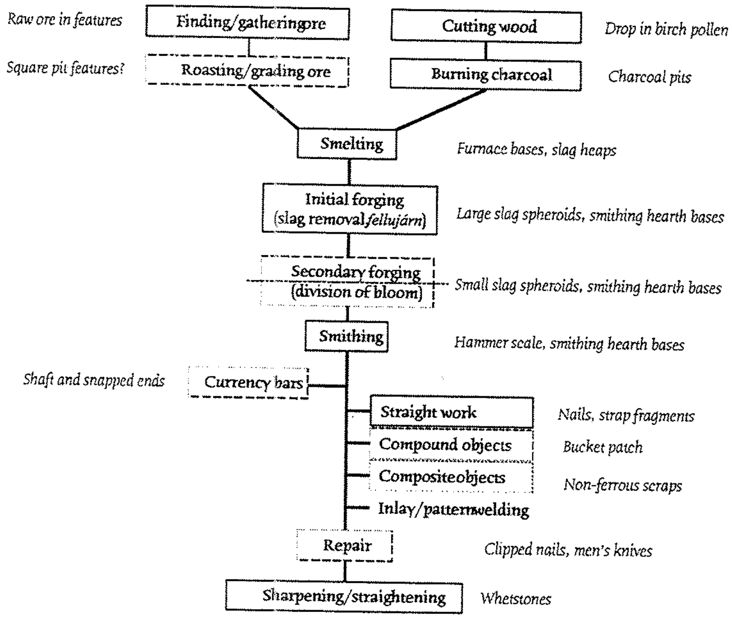

Figure 11.7 Stages in bloomery iron production from raw material to finished tools. Solid boxes indentify processes documented directly at Háls 5/6 through material remains of the process itself. Dashed borders identify processes documented through material remains derived from the process. Dotted borders identify processes and products inferred for the site from less immediately linked residues.

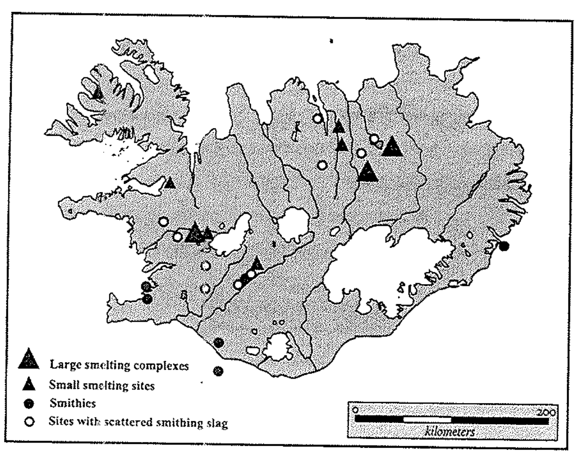

Figure 11.8 Distribution of excavated and/or published Icelandic Viking Age or Early Medieval sites with clearly defined evidence for iron smelting and smithing.

Chapter 12

What's the Point? A Metallurgical Insight into Medieval Arrowheads*

David Starley

Many aspects of archers and archery in medieval European warfare have been thoroughly researched: the training of bowmen, deployment on the battlefield, even the legislation to provide an adequate supply of bowstaves. By contrast, the projectiles themselves have received relatively little attention. Although arrow shafts survive only under extremely rare circumstances, arrowheads are not uncommon archaeological finds. With the exception of two notable stylistic typologies,[1] there has been little detailed study, or even publication of finds beyond those from individual sites. In the absence of investigative work, many "facts" are reiterated from text to text without question, until the original source becomes obscure. The purpose of this paper is to investigate the technology of arrowheads by studying the artefacts themselves, and to use this to understand more clearly the purpose of individual types of arrowheads. Previously published and unpublished material from various European sources along with further new metallographic investigations will expand this database and our understanding of this important medieval military technology.

This study sheds light on current differences of opinion for the types of arrowheads used in battle, as well as their effectiveness against armored opponents. In particular, I hope to determine the role of the long, narrow heads known as bodkin points and classified as Type 7 in the London Museums Catalogue (Fig. 12.1, lower.)[2] For this type, there are two opinions, the first being that they were primarily intended for use against armor.[3] The reasoning used to justify this is that its narrow point delivers energy to the minimum area and is

* The author is grateful to John Waller for supplying the eight arrowheads for sampling. Thanks also to AVISTA for the invitation to participate in the "De Re Metallica" program, and to the Kress Foundation for their generous contribution towards the costs of attending the International Medieval Congress, Kalamazoo, MI, 2002.

1 J. B. Ward Perkins, *London Museum Medieval Catalogue* (London, 1940), pp. 65–73; and Oliver Jessop, "A New Artefact Typology for the Study of Medieval Arrowheads," *Medieval Archaeology* 40 (1996), pp. 192–205.

2 Ward Perkins, *London Museum Medieval Catalogue*, pp. 65–73.

3 Peter N. Jones, "The Attack of Plate Armour by Longbow Arrows," *Château Galliard* 11 (1983), pp. 167–8.

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