TOOTH-TOOL USE AND YARN PRODUCTION IN NORSE GREENLAND

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ABSTRACT

During a dental study of medieval Norse skeletons from Greenland, Iceland, and Norway, a distinct pattern of wear was observed on twenty-two anterior teeth of twelve Greenlanders. Further examination revealed that cultural notches were limited almost exclusively to settlement-period Greenlandic females interred at Thjodhild's church (AD 1000–1150). The most likely explanation for this patterned wear revolves around the manner in which females manipulated woolen thread on their maxillary incisors and canines during the production of a coarse woolen cloth (frieze) that was generated in large amounts during the early medieval period for local consumption and export to Europe.

KEYWORDS: teeth, abrasion, wool

INTRODUCTION

Anthropologists have long studied normal crown wear to evaluate the diet and dietary behavior of earlier human populations (Hinton 1981, 1982; Kieser et al. 2001; Molnar 1971, 1972; Molnar et al. 1983; Walker 1978; Walker and Erlandson 1986). Several methods have been developed to score such wear (Brothwell 1963; Dreier 1994; Murphy 1959; Scott 1979; Smith 1984) with the primary emphasis on pattern of dentine exposure. When crown wear is a long-term product of normal food mastication, the occluding surfaces of the upper and lower anterior teeth and premolars are often worn flat, with cupping on the cusp tips where the wear breaks through the hard enamel into the softer dentine. The molars sometimes show a buccal to lingual gradient of wear in the upper molars and a lingual to buccal wear gradient in the lower molars due to a side-to-side rotary chewing motion (Smith 1986). However, whether normal wear is flat or angled, it is normally evident that it is primarily a result of normal mastication, with varying contributions of attrition (tooth-on-tooth contact) and abrasion (foreign particles in food) (Hillson 1996; Scott and Turner 1988).

As the most directly visible aspect of the skeletal system, teeth are also subject to the vagaries of human cultural behavior (cf. Milner and Larsen 1991). For that reason, they are useful in bioarchaeological research for making inferences on the behavior of past human populations. Behaviorally induced alterations fall under four general categories: (1) intentional mutilation; (2) unintentional modification from objects in mouth; (3) oral hygiene; and (4) occupational behavior.

The most common form of dental alteration falls under the category of intentional modification. In Africa, this custom goes back at least fifteen hundred years to the early Iron Age (Van Reenan 1977). Mutilation is often accomplished through chipping or filing (Pindborg 1969; Singer 1953; Van Reenan 1986; Van Reenan and Briedenhann 1986), with tooth removal (ablation) another frequent practice (Singer 1953). Motivations vary, but in some cases modifications take on very specific forms that provide a visual signal of tribal identity (Van Reenan 1986). When Africans were forcibly removed from their homes and taken to the New World, dental modification was not

abandoned altogether as African-type tooth mutilations have been found in the Caribbean and North America (Corruccini et al. 1982; Handler et al. 1982; Ortner 1966; Stewart 1942; Stewart and Groome 1968).

Another center of dental modification was Mesoamerica, where anterior teeth were not only chipped and filed but also incised, banded, and inlaid with precious metals or gems (De La Borbolla 1940; Romero 1970). In South America, dental deformation was not as common in prehistoric times and more often took the form of filing and inlays (Saville 1913; Stewart 1963). In historic times, chipped and filed teeth became more common in South America after this practice was introduced by African slaves (Stewart 1963). North of Mexico, there are sporadic cases of dental modification in the American Southwest and along the Mississippi, where the practice was presumably introduced directly or indirectly from Mesoamerica (Autry 1991; Holder and Stewart 1958; Stewart and Titterington 1944; Turner and Turner 1999; Willey and Ubelaker 1976).

Dental modifications involving insets, blackening, filing, ablation, and cross-hatching are also common practices in Southeast Asia and the Pacific (Ikehara-Quebral and Douglas 1997; A. Jones 2001; Scott and Turner 1997). These practices were far less common in Europe, although Arcini (2005) has reported carefully filed labial surfaces of the maxillary incisors and canines in twenty-four Viking Age males from Sweden and Denmark.

In addition to intentional cultural modifications, other practices produce patterned crown wear distinct from that generated by normal mastication. Unintended alterations can result from habitually holding and/or manipulating nonfood objects in the mouth, such as pipes, bobby pins, nails, and the like (Blakely and Beck 1984; Hillson 1996; Lous 1970; Lukacs and Pastor 1988; Morris 1988; Schour and Sarnat 1942; Ubelaker 1996). Labrets worn in the cheeks or lips also produce unintended wear facets on the buccal or labial surfaces of the teeth that could not possibly be produced through tooth-on-tooth wear (Cybulski 1974; Scott and Turner 1997; Torres-Rouff 2003).

Interproximal tooth grooves may reflect early attempts at dental hygiene where food debris between the teeth would be removed by objects similar to toothpicks (Berryman et al. 1979; Formicola 1988; Frayer 1991; Ubelaker et al. 1969). Such grooves were relatively frequent in fossil hominids from Atapuerca and Krapina where the focus was on the cheek teeth (Bermudez de Castro et al. 1997; Frayer and Russell 1987). Not all favor a "toothpick" interpretation of interproximal grooves. Brown and Molnar (1990) found that grooved teeth were very common (41 percent) in nineteenth-century Australian aboriginal skulls. With but few exceptions, the grooved teeth were premolars and molars. Overall, males were more than twice as likely to express grooved teeth, with most grooves on the mesial rather than distal surface (93 of 98). These authors prefer task activity to the use of a palliative probe to explain this pattern.

Of the different types of tooth modification, occupational behavior has received the least attention. Schulz (1977) found occlusal and approximal grooves in a small sample of prehistoric California Indians. The foci for both types of grooving were the anterior teeth of the lower jaw, where task activity, involving fibrous materials (for baskets, nets, mats, etc.) was considered the likely cause. In a much larger sample (n = 171) from the Great Basin, Larsen (1985) found 16 of 1,931 teeth exhibited transverse grooves on the occlusal surfaces of the teeth of five older adult males. Given the emphasis on tools made from plant materials in the Great Basin, task activity aimed at producing nets, baskets, and footwear was considered the likely explanation for these occlusal grooves.

Cruwys et al. (1992) distinguish three types of notched teeth. Occupational notches are produced when hard objects are held by the teeth during an activity that requires the use of both hands (see Turner and Anderson [2003] for dramatic example of this type of wear, likely caused by habitually holding square iron nails between the anterior teeth). Habitual notches refer to nonoccupational behaviors such as pipe smoking. Finally, cultural notches are those that relate to specific task activities, such as stripping sinew or producing and manipulating fiber cordage. The authors note that occupational and cultural notches overlap in the sense that both are tied to task activities. The difference is in geographic distribution, with cultural notches more common and widely distributed.

In a study of 1,029 British skulls from the Neolithic to late medieval periods, Cruwys et al. (1992) found cultural notches on the teeth of eight individuals, all of which dated to the Anglo-Saxon period (AD 410–1066). Notches were limited to the anterior teeth and each jaw was equally affected (thirteen notched teeth in both the maxilla and mandible). All eight individuals with notches were males. Although reluctant to speculate, the authors note "the notches may well have been caused by some habitual activity involving the teeth and an abrasive material, not metal

or stone, but wood or fibres, producing these small oval notches" (Cruwys et al. 1992:219).

Bonfiglioli et al. (2004) operationally define three grades of cultural notches that run from slight indentations on the enamel to deep and wide depressions with heavily worn dentine. In a twentieth-century skeletal collection from Italy, Bonfiglioli (in Bonfiglioli et al. 2004) found a number of notched teeth. For certain occupations, such as carpenters and shoemakers, these notches were observed primarily in males (six out of seven). Tailors showed the opposite pattern where three of four individuals were female.

Originally, research on Greenlandic, Icelandic, and Norwegian populations focused on diet-related tooth crown wear, chipping, linear enamel hypoplasia, and dental pathologies, along with tooth size and morphology (Scott et al. 1992). Cultural notches, which had not been anticipated, were common enough to warrant a follow-up survey.

MATERIALS AND METHODS

Focus is on a type of unintended tooth wear manifested on the occlusal surfaces of the anterior teeth of medieval Norse Greenlanders. This wear pattern varied between a U-shaped and V-shaped notch and occurred primarily on the upper incisors and canines (see Fig. 1). During the initial set of observations on the Greenlanders, only marginal notations were made on cultural wear. During the reexamination, the presence or absence of cultural wear was recorded for all maxillary and mandibular anterior teeth. Exceptions were made for children (<10 years) and older individuals who exhibited advanced attrition. In the latter case, cultural notches might have been eliminated by subsequent wear. Although the advantage of scoring these notches on a ranked scale is now evident, they were only recorded as present or absent. Slight notching might have been overlooked so the values reported should be considered conservative.

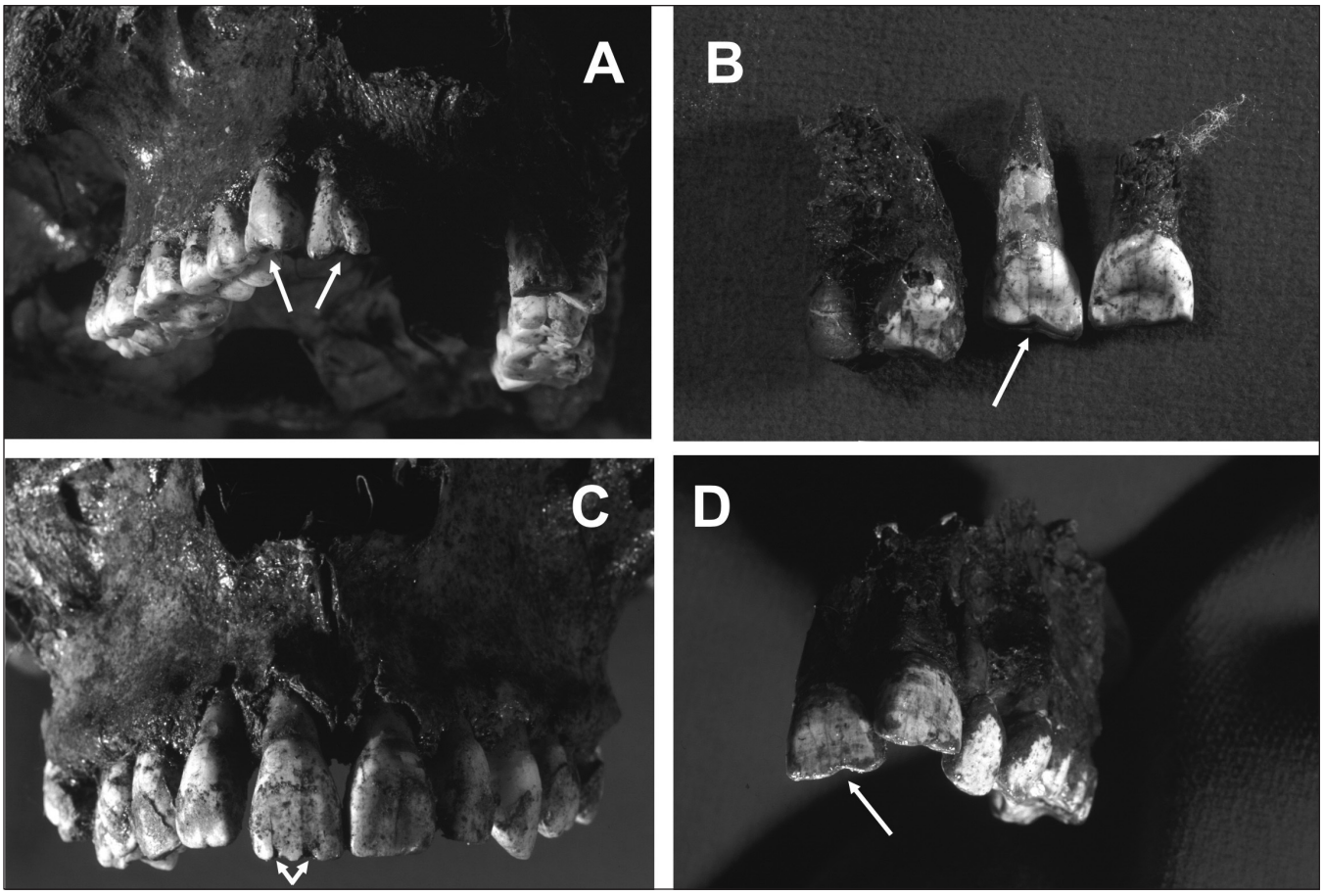

Figure 1. Four examples of notched teeth in settlement-period Greenlanders from Thjodhild's Church: (A) T.C. 66, female, 20–30; (B) T.C. 46, female, 20–30; (C) T.C. 63, female, 20–25; (D) T.C. 2, female, 20–25.

All Greenlandic Norse skeletons excavated are housed at the Panum Institute, University of Copenhagen. Remains come from two regions referred to as the Eastern and Western Settlements (Krogh 1967). There is variation across sites in terms of age and preservation. The oldest site, Thjodhild's Church, dates to the settlement period in Greenland, spanning the time from about AD 1000 to 1150 (Arneborg et al. 1999). Skeletal preservation was fair to good at this site. The latest site was Herjolfnes, where the cemetery dates from the fourteenth and fifteenth centuries. Although bone preservation was poor due to acidic soils, woolen textiles were well preserved. Between these early and late sites, there is a small sample from the bishop's compound at Gardar and another from the cemetery at the Benedictine convent. The direct dating of skeletal remains puts these samples in the range of AD 1200–1400 (Arneborg et al. 1999). The Western Settlement sites of Sandnes and Anavik, where preservation was generally good, also date to this time range (see Scott et al. 1992 for more details on samples). We employ the same temporal designators that were used in earlier studies: Eastern Early (Thjodhild's Church), Eastern Middle-Late (Gardar, Benedictine convent, Herjolfnes), and Western (Sandnes, Anavik) (Halffman et al. 1992; Scott et al. 1992).

RESULTS

Most studies of cultural wear focus on individual cases rather than entire samples, but the pattern observed in the Greenlanders was relatively common. Table 1 shows the individuals who exhibited one or more cultural notches on their anterior teeth. The initial impression of cultural wear was that it affected the upper anterior teeth of females. Upon closer examination, we had to expand this characterization but only to a minor extent. Two males from Thjodhild's Church exhibit cultural wear on the left upper canine and right lower central incisor, respectively. Two individuals of unknown sex also exhibited notches. Eight of the twelve individuals who exhibited notches were females. With but two exceptions, they fall in the age range of twenty to thirty years (young adult category). Two females and both males from Thjodhild's Church were over the age of thirty while an individual of unknown sex was twelve to sixteen years old.

Table 2 provides a more detailed summary of cultural notches by sample, sex, and jaw. In many instances, skeletons were represented by both upper and lower jaws. In some cases, however, an individual might have only one jaw. That explains why there is not a one-to-one relationship between individual samples for the upper and lower jaws. The Eastern Early sample was represented by the greatest number of jaws (50 maxillae and 48 mandibles) and teeth (156 maxillary and 173 mandibular). This sample also exhibited the highest frequencies of cultural notches by individual (18.0/6.3) and tooth (9.6/1.7). While the maxillary teeth in this sample show much more notching than the mandibular teeth, this pattern does not hold in the Eastern Middle-Late sample where the frequencies by individual (6.3/7.7) and tooth (2.4/3.4) are about the same in the two jaws. Overall, the Eastern Early sample has a distinctly higher frequency of notches by individual (12.2 percent) and by tooth (5.5 percent) than the Eastern Middle-Late sample where the overall frequencies were 7.1 percent for individuals and 3.2 percent by tooth. The major contrast, however, is to the Western Settlement, where 118 anterior teeth in 50 jaws

Table 1. Individuals exhibiting one or more cultural notches.

Sample	Individual No.	Sex	Age category	Tooth affected*
Thjodhild's Church	T.C. 2	Female	20–25	R-UI1, R-UC, R-LI1
	T.C. 14	Female	20–25	R-UI1
	T.C. 46	Female	20–30	L-UI1, R-UC
	T.C. 62	Female	30–40	L-UI1, R-UI1
	T.C. 63	Female	20–25	R-UI1
	T.C. 66	Female	20–30	R-UI1, R-UC
	T.C. 70	Female	30–40	L-UI1, R-UI1, L-UC, R-LC
	T.C. 83	Male	30–40	L-UC
	T.C. 134	Male	35–45	R-LI1
	T.C. F5	Unknown	12–16	R-UII2
Benedictine convent	A.S. 129	Female	20–25	L-LI1, R-LI1
	A.S. 137	Unknown	20–25	R-UC, R-LC

*Side (R, L) Jaw (U, L), Tooth (I: incisor, C: canine), number (1: central, 2: lateral)

failed to exhibit one instance of cultural notching. In general, cultural modifications focused on females, maxillary teeth, and settlement-period Greenlanders.

DISCUSSION

Southwest Greenland was colonized by Icelanders in AD 986. At that time, the climate was milder than it is now, and there were no resident Inuit in the area to impede Norse settlement of the inner fjords. Erik the Red and his fellow colonists introduced a classic Scandinavian economy into Greenland, bringing with them cows, horses, sheep, and goats. Although grain production was a significant problem in this subarctic setting, their pastoral economy was adequate to meet protein and caloric needs, especially when supplemented by hunting caribou, seals, and walrus (G. Jones 1986; Krogh 1967).

In their early years of life in Greenland, the Norse maintained contact with Icelanders and Norwegians and were occasionally mentioned in European accounts (e.g., King's Mirror). Leif Eiriksson brought Christianity to Greenland in AD 1000, ultimately leading to the construction of at least nineteen stone and turf churches (Arneborg 2000). As an extreme outpost of Christianity, the Greenlanders were given their own bishopric at Gardar. Religious developments in this new land generated a constant set of obligations to the church in the form of tithes. For purposes of both trading and tithing, the Norse exploited the unique bounty available in Greenland in the form of walrus hides (for rope) and tusks (for ivory), with Greenlandic gyrfalcons and live polar bears as prized trade or gift items (Seaver 1996). There was also a market for caribou skins and blubber. In addition, the Greenlanders produced large amounts of frieze, a coarse woolen cloth, which served as a valuable trade item as well as a staple of the Greenlandic clothing industry (Ryder 1983).

Several issues have to be addressed regarding the manifestation of cultural notches in the Greenlanders. First, were the notches produced intentionally or were they a by-product of occupational behavior? Second, there is a noteworthy sex difference in the occurrence of cultural notches in the Greenlanders. What culturally prescribed activities might account for this distinction? Third, there is a marked temporal difference in the presence of notches. They are relatively common around the time of initial settlement, but two hundred to three hundred years later, few individuals developed these notches.

Intentional modification can be ruled out based on the location, nature, and orientation of the notches. They arise through a gradual and long-term process on the incisal surfaces of the anterior teeth following a labiolingual axis. They match the illustrations and descriptions of cultural notches provided by Cruwys et al. (1992) and Bonfiglioli et al. (2004) and resemble in no way the intentionally modified anterior teeth that Arcini (2005) found in Vikings. While some individuals have more than one notch, they are never exhibited in the manner that characterizes purposeful dental modification. They are a by-product of behavior but one that is unintended.

What habitual behaviors of the Greenlanders might be responsible for notched anterior teeth? We feel the difference between males and females provides the biggest clue. That is, the production of textiles was a task activity that fell primarily on females. Ethnographic accounts and descriptions bear testimony to this distinction:

Table 2. Frequency of cultural notches in teeth and individuals by sample, sex, and jaw.

		Upper Jaw				Lower Jaw			
Sample	Sex	Tooth Frequency	(affected/ total)	Individual Frequency	(affected/ total)	Tooth Frequency	(affected/ total)	Individual Frequency	(affected/ total)
Eastern Early (Thjodhild's Church)	M	1.3	(1/76)	3.8	(1/26)	1.0	(1/97)	3.4	(1/29)
	F	23.6	(13/55)	50.0	(7/14)	3.8	(2/53)	15.4	(2/13)
	?	4.0	(1/25)	10.0	(1/10)	0.0	(0/23)	0.0	(0/6)
	Total	9.6	(15/156)	18.0	(9/50)	1.7	(3/173)	6.3	(3/48)
Eastern Middle-Late (Benedictine convent, Gardar, Herjolfsnes)	M	0.0	(0/10)	0.0	(0/3)	0.0	(0/17)	0.0	(0/5)
	F	0.0	(0/17)	0.0	(0/8)	4.1	(2/49)	6.7	(1/15)
	?	6.7	(1/15)	20.0	(1/5)	4.5	(1/22)	16.7	(1/6)
	Total	2.4	(1/42)	6.3	(1/16)	3.4	(3/88)	7.7	(2/26)
Western	M	0.0	(0/4)	0.0	(0/2)	0.0	(0/1)	0.0	(0/1)
	F	0.0	(0/23)	0.0	(0/13)	0.0	(0/43)	0.0	(0/12)
	?	0.0	(0/21)	0.0	(0/9)	0.0	(0/26)	0.0	(0/13)
	Total	0.0	(0/48)	0.0	(0/24)	0.0	(0/70)	0.0	(0/26)

> The Greenland farms were each a unit, self-supplying not only as regards food and drink, the production of implements for agricultural work and for hunting and fishing, and of domestic utensils, but also as regards the making of clothes from the farm's own products. On every single farm wool was carded, spun, and woven into frieze. The looms were very busy both summer and winter. The young girls had to make their own bridal clothes, and the housewife had to renew her store of textiles, and Greenland frieze was in demand as an article of commerce. In exchange for the rolls of cloth many exciting and useful things could be bought when the trading vessels arrived. All day long the women spun or wove. From the tuft of carded wool the thread was pulled between the women's fingers on to the little whirring wooden spindle which was spun by the small soapstone whorls. The ruins teem with spindles with their small round whorls, and big loom weights for the upright looms—all evidence of this work. (Krogh 1967: 71)

Many textile experts feel the term wadmal (or vaðmál) is more specific to the type of frieze cloth that Norse Greenlanders were making and using (Arneborg and Østergård 1993; Østergård 2004; Tortora and Merkel 2000:619). Wadmal was a coarse and stout fabric created all over Scandinavia and Great Britain in medieval times (Carmichael et al. 1947). Woolen yarn was used to make wadmal. Following Emery (1994:10), "yarn" is taken to mean an "assemblage of fibers or filaments which has been put together in a continuous strand suitable for weaving." Wadmal was woven on a warp-weighted loom using woolen yarns in a plain tabby or 2/2 twill structure (Carmichael et al. 1947; Hoffman 1974:194–195), although other twill varieties have been noted. "Vað" translates to "cloth," and the Norse Greenlanders wove many types of cloth such as bragðarvað and smávaðmál, depending on the intended use (Østergård 2004:61–63). Wadmal, literally translating to "cloth measure," was used as a form of currency and was an important trading good. Indeed, until the fourteenth century, wadmal was the most important item exported from Greenland (Damsholt 1984:81). In domestic contexts, Norse Greenlanders used wadmal for everything from clothing to bed curtains and ship sails (Andersson 2003:50).

Along with highly prized cattle and horses, the Greenlanders reared goats and sheep for their milk, meat, hair, and wool. The fibers harvested from their livestock were of no less importance than the meat. The Greenlanders processed a variety of animal and plant fibers, aside from those obtained from goat (*Capra hircus*) and sheep (*Ovis aries*), such as arctic hare (*Lepus arcticus*) and flax (*Linum usitatissimum*). Yet, archaeological evidence and historic documents indicate that the majority of textiles preserved are mainly woven from sheep's wool. The breed of sheep used by medieval Norse Greenlanders, the Icelandic Northern short tail, is still in existence and has changed little in the last five hundred years (Østergård 2005; Ryder 1983).

Østergård (2004) estimates conservatively that the amount of wool needed in the production of wadmal per person, per capita, in medieval Norse Greenland was 5 kg. This quantity covers personal use, but does not include the amount needed to pay taxes or church tithes, or for trade. Given the prominence of wadmal in Norse Greenlandic life, a huge amount of time and effort went into processing fibers and weaving cloth. Women in Norse Greenland were primarily responsible for the manufacture of woven goods and the products made from the cloth, and so fiber-related tasks presumably consumed a great portion of their waking hours. Indeed, Barber (1991) notes that before the industrial revolution, women in Europe spent almost every available moment spinning, weaving, and sewing. Occasionally, men and boys contributed to textile production by gathering raw materials or producing weaving implements.

The morphology of wool fiber easily distinguishes it from silk, mineral, or plant-derived fibers. For example, many plant-derived fibers and silk look smooth under magnification while wool is rough and scaly (Emery 1994). A single wool fiber is composed of three layers. The first layer is the medulla, which is overlaid with cortical tissue, all of which is covered with the outermost epidermal layer of horn tissue (Matthews 1924). Horn tissue consists of flattened cells that look like scales, whose ends overlap each other in a serrated manner (Fig. 2). Generally, older breeds of sheep have more prominent scales on the epidermis of the wool fiber. Correspondingly, Greenlandic sheep are an old and archaic breed with pronounced epidermal scales (Ryder 2005). Additionally, different body parts of sheep yield different degrees of wool coarseness. For example, the wool on the shoulders is finest while the wool on the hind legs is coarsest (Kroll 1981).

After shearing or plucking the wool from the sheep, and before spinning, Norse Greenlanders washed the wool with a mixture that included stale urine (Østergård 2004). Urine is useful in removing excess grease trapped in wool. Stale urine is alkaline and treating wool with an alka-

line compound has the effect of making the wool fibers' epidermal scales swell and become even more prominent (Matthews 1924) and, thus, more abrasive. The natural lanolin in a sheep's wool protects the epidermal scales, but washing the wool with hot water has the effect of corroding the epidermal scales. Washing wool, however, only removes some of the accumulated dirt and grease from the fleece, but not all foreign particles. Given the fineness of some of the loess soils in Greenland, some abrasives would have remained in the wool.

After the wool was washed and combed or carded, the next task facing the Norse Greenlandic women was to spin the wool into a yarn suitable for weaving on their warp-weighted looms. Spinning refers to the process of drawing out and twisting raw fibers of finite length into a thread of continuous length (Emery 1994). While spinning can be accomplished with no tools but the hands, medieval Norse Greenlanders used spindle whorls and distaffs to make the process easier and more efficient (Arneborg and Østergård 1993). A distaff is a rod on which raw fibers about to be spun are placed. In spinning with a distaff, some of the fiber about to be spun is taken from the distaff and placed on a stick, called a spindle, which is twirled in one direction, causing the fiber to twist tightly. To make the spindle heavier, and therefore spin faster to produce a tighter yarn, a weight is sometimes added to the spindle. This weight is called a spindle whorl.

Imperfections in the wool, such as hair, dirt, and so forth, need to be picked out before the yarn is spun because imperfections cause the finished yarn to be uneven and difficult to work with. Although there is no documentary evidence for women using their teeth in the production of wool in Greenland, women in central Europe used their teeth to pick out imperfections in their wool until a generation ago (Sigrid Piroch, personal communication). Spinners would hold the fiber about to be spun from the distaff in one hand, while the other hand held the spindle and whorl. Only the teeth were free to pick out the imperfections like short, useless fibers and snarls; otherwise the spinner would have to put down her spindle or the distaff and pick out the imperfections by hand, which would have considerably slowed down the spinning process. Even when the distaff was secured so that the hands were free (such as tying it to a belt), it was often easier to use one's teeth to pick out the imperfections. The spinner would bite down on the section of the wool yarn that contained the imperfection and simultaneously pull up on the yarn through the teeth to remove the offending

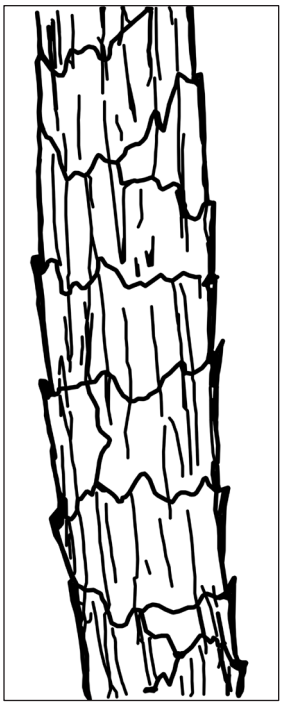

Figure 2. Illustration of a single wool fiber under x500 magnification. Note the scaly, roughened surface (adapted from Matthews [1924:Figure 47]).

imperfection. The manner of biting and angling up while pulling the thread accounts for why there is often only wear on the upper teeth and not the corresponding lower teeth as well. As master handweaver Sigrid Piroch notes, "when many women got older and lost too many of their teeth they could no longer spin" (Sigrid Piroch, personal communication)!

Similar physical motions that occur during spinning also occur during the act of sewing. The same pulling and biting actions that spinners use are sometimes employed by sewers as well, but for the purposes of cutting yarn. Many modern sewers do not take the time to pick up a pair of shears when a thread needs to be cut. Rather, they use their teeth to quickly bite and cut the thread. After a lifetime, many devoted sewers remark that this habit leaves a notch in the tooth that acts as impromptu scissors (Margaret Coe, personal communication). Although scissors were found archaeologically with Norse Greenlandic burials, it is reasonable to suggest that medieval Norse Greenlandic spinners and sewers would not have behaved differently than their modern counterparts. The very act of smoothing and dampening thread, by pulling it through the teeth to facilitate threading a needle, would probably cause abrasions to a sewer's dentition.

If yarn production was primarily responsible for the patterned cultural notches in mostly Greenlandic females, this still does not explain the temporal disparity between settlement period and later Greenlanders. The Thjodhild's

Church sample is larger than later samples but only slightly so (e.g., 48–50 individuals for Eastern Early and 40–52 individuals for Eastern Middle-Late and Western). Part of the explanation might be tied to climatic events over the course of the Middle Ages that significantly affected the Norse economic system.

The garments and footwear that preserved so well at Herjolfnes demonstrate that wadmal production continued in Greenland from settlement (tenth century) to abandonment (fifteenth century). However, animal bones from archaeological contexts indicate that with increasingly colder temperatures through the Middle Ages, domestic livestock decreased while the bones from hunted animals (e.g., seal) increased. It is striking that the Western Settlement, about 350 miles north of the Eastern Settlement, had no examples of culturally modified teeth. While we cannot rule out an accident of sampling, the frequency of affected teeth (23.6 percent) and affected individuals (50 percent) in the female sample from Thjodhild's Church suggests that more is involved. There are other possible explanations for this disparity of tooth modification. The Western Settlement, so much further north, was in an even more economically perilous position than the Eastern Settlement. It is conceivable that Western Settlement families traded for cloth because they could not, or did not want to, make their own. Alternatively, women from the Western Settlement could have adopted a tool to facilitate combing impurities out of the wool and not relied on their teeth. Additional possibilities may include more grit in the Eastern Settlement's sheep's wool, or differences in standards of removing grit. Indeed, it is plausible that the Eastern Settlement consisted of a group of related, either physically or socially, women who learned how to process wool in the same manner. This is consistent with other fiber-related arts where the learning patterns are very conservative (i.e., one learns how to spin from one's aunt or grandmother and does not generally deviate from the norm) (Greenfield 2004; Pryor and Carr 1995).

During their first two centuries in Greenland, the Norse population and economy thrived. Significant changes occurred, however, during the thirteenth and fourteenth centuries that threatened the maintenance of a Norse lifestyle. With the onset of the "little ice age," the northern ice pack drifted ever further south, blocking traditional shipping lanes and decreasing contact between Greenland and both Iceland and Europe. Diseases sweeping Europe (e.g., the Black Plague) also limited the Greenlanders' contact with the outside world. It seems likely that textile production was declining along with mean annual temperatures and numbers of domestic livestock on the Greenlandic homesteads. McGovern (2000:333) notes that "[a]s time passed, most farms appear to have followed the route of a very small and poor farm, V48, which reduced the number of cattle, eliminated most domestic animals, and became increasingly dependent on seal meat for survival." Another factor was Greenland's increasing isolation from Europe after AD 1300. Although a negative in many regards, this isolation probably brought some relief from church-imposed tithes, including the production of wadmal beyond the immediate needs of the people.

CONCLUSIONS

Woolen textile manufacture was a constant household task carried out by Norse Greenlandic women. Morphologically, wool is rough and abrasive, as evidenced by the scaly barbs covering each fiber. The breed of sheep raised by the medieval Norse Greenlanders was an archaic one, with rougher wool than other breeds known today. During spinning, the spinner would have used her teeth to pick out imperfections in the rough and coarse wool. Over a lifetime of using teeth as tools for processing wool, textile production would have left its mark in the form of cultural notches on the medieval Norse Greenlander's anterior teeth.

By the mid-fourteenth and early fifteenth centuries, the end was in sight even if the Greenlanders were not aware of it. Around AD 1350, the Western Settlement was abandoned. Encroachment by the Inuit, who were moving southward along the coast, may have been a contributor but climatic factors played a role as well. Around a hundred years later, the Eastern Settlement was abandoned, bringing to an end the Norse chapter in Greenland's history. Many workers have addressed the factors that contributed to the demise of the Greenlandic Norse (Berglund 1986; Diamond 2005; Lynnerup 2000; McGovern 1980, 2000), but the general pattern followed a trajectory of discovery and rapid colonization (AD 986 to 1050), building period and heyday (1050–1300), followed by relatively rapid decline and abandonment/extinction (1350–1450?). Division of labor and economic system may explain why culturally induced notches occurred primarily in young females. A deteriorating environment brought about by climatic change and cultural trends may account for the temporal difference in these unintentionally modified teeth.

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