Journal of Archaeological Science 38 (2011) 903–912

Contents lists available at ScienceDirect

Journal of Archaeological Science

journal homepage: http://www.elsevier.com/locate/jas

Heat, smoke and fuel consumption in a high mountain *stállo*-hut, northern Sweden – Experimental burning of fresh birch wood during winter

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ARTICLE INFO

Article history:
Received 22 January 2010
Received in revised form
13 October 2010
Accepted 25 November 2010

Keywords:
Northern Sweden
Experimental archaeology
Hearths
Firewood
Forest history
Sami

ABSTRACT

The overall aim of this study was to investigate in situ, the use of an open fire for heating a traditional mountain Sami *stállo*-hut during winter using fresh mountain birch as fuel. The study took the form of repeated actualistic experimentation and the following parameters were recorded: fuel consumption and logistics, indoor temperature, CO-levels inside the hut and temperature in both the hut and the traditional Sami stone-lined hearth with a stone filling of flat stones. Our results show that fresh birch is an effective fuel and that about 3.6 kg (dry weight) of wood was used per hour; it took a few hours of work per day to obtain the firewood required. The highest temperature recorded beneath the stone filling in the hearth was 437.7 °C. The hearth stored a lot of heat but this did not affect the indoor temperature during the night. The highest indoor temperature indoor was +26.9 °C, but it was generally much lower and varied considerably during the day and in relation to the outdoor temperature. The CO-levels reached 112 ppm at floor level and co-varied with the smokiness experienced inside the hut.

1. Introduction

One of the most critical aspects of surviving in northern boreal and subarctic environments is how to stay warm during the long winters. Globally, at latitudes around 60° N, the winter is usually more than six months and temperatures can fall below −25 °C for extended periods of time; these are Dfc to ET climates according to the Köppen-Heigen system of climate classification (Geiger and Pohl, 1953). Access to fuel (i.e. firewood), the methods and logistics for using available firewood and constructing dwellings that can withstand the cold climate are crucial components for survival under these conditions.

Earlier studies of prehistoric pyro-technology have mostly focussed on particular aspects of producing heat, for example the ancient use of preheated stones and the waste material created by this process (Brink and Dave, 2003; Backhouse et al., 2005). Different types of hearths, and wood from different species of trees were studied experimentally by March (1992). He concluded that fire temperature and fire longevity was highly dependent on the type of wood used and the construction of the hearth. The effectiveness of the burning process, as measured by the remaining charcoal, was also largely dependent on the hearth construction.

Relatively few papers describe experiments designed to study prehistoric living conditions in different kinds of buildings, especially for the winter months. One early example involved experiments with one of the reconstructed houses at the great stronghold of Eketorp in southern Sweden (Näsman, 1983; Herschend, 1982). The experiments illuminated the difficulties with and complexity of using ancient firing technology, but also suggested ways that this could be achieved through appropriate construction. Another experiment, conducted in one of the large reconstructed houses in Gene, northern Sweden (Edblom, 2004), involved measuring heat output, fuel consumption, carbon monoxide, ventilation, etc.

Both of the aforementioned experiments were carried out during winter, in large, Nordic, permanent Iron Age houses. The main problem encountered during both experiments was inflow and outflow of air, which caused smoky conditions indoors. In some studies, the living conditions in really harsh environments during the Arctic winter have been discussed (Odgaard, 2001). Firing experiments with seal blubber showed that to keep an indoor temperature of about 8 °C in a tented hut covered with reindeer hides (at −30 °C outdoors), about 175 kg of seal blubber was needed to keep a lamp burning 24 h a day during the two dark months (Odgaard, 2001: 127). Actual indoor temperatures, in an Eskimo igloo warmed by oil lamps, were reported to be −5 to 3.3 °C while the outside temperature was −31.6 °C (Hough, 1898: 1030). Kennan, during travels in the land of the Koryaks in Kamchatka in the late 19th century, recorded that the temperature in a winter

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doi:10.1016/j.jas.2010.11.020

tent was seldom warmer than −4 to −7 °C (Kennan, 1986: 174p). He also noted that smoke coming from the hearth situated on the floor caused problems by polluting the air and restricting the visibility indoors.

The overall aim of this study was to investigate the use of an open fire for heating a traditional mountain Sami *stállo*-hut during winter *in situ*. The study took the form of a repeated actualistic experiment and the following parameters were recorded: firewood consumption and logistics, temperature (indoors, outdoors and in the hearth), and CO-concentrations in the hut. The specific questions we wanted to address were:

1. How does unseasoned mountain birch (*Betula pubescens ssp. Czerepanovii* (N.I. Orlova) Hämet-Ahti) function as fuel in a Sami *stállo*-hut?
2. How much fuel is consumed per time-unit under different temperature conditions?
3. What is the level of comfort inside a hut in terms of warmth and smoke?
4. How does the temperature vary at different depths under a hearth?
5. What is the function of the stone packing in the hearth?
6. What are the concentrations of carbon monoxide in the hut during and after using the hearth?

2. Background

The nomadic mountain Sami groups in northern Sweden, many living north of the Arctic Circle, survived on reindeer meat, and lived in tents the whole year round (Graan, 1983:45; Rheen, 1983:15, Schefferus, 1956:224; Högström, 1980:100, Öhrling, 1970:10).

When staying in the mountain forest the Sami usually used fresh birch wood for making fire in their huts (Ryd, 2005:7). At higher altitudes, above the tree-line, they used dwarf birch (*Betula nana* L.), shrubs (*Salix* sp.), heather (*Calluna vulgaris*),and juniper (*Juniperus communis*) (Læstadius, 1977:226; Pettersson, 1979:215; von Düben, 1977:38). Leem's (1975:102) detailed descriptions from the 18th century show that the amount of fuel collected during winter, on each occasion, was intended to last for one day. The trees were transported as they were, with twigs and stems, to the hut. The twigs were then cut from the stem and the stems chopped into smaller pieces. Subsequently, the twigs were also cut into smaller pieces. Long into the 20th century, the axe was the only tool used for chopping wood (Ryd, 2005:30).

The fire was ignited by the use of pieces of birch bark and smaller twigs. Thicker branches and stems were then added. According to Leem a large amount of smoke was produced initially (Leem, 1975:102, 103) but later, when the fire was burning steadily, the amount of smoke decreased. Düben (1977:38, 42) noted that the Sami took birch bark and pine-sticks from the coniferous forest with them as kindling when going to the mountains.

The problem with smoke in Sami huts was observed by many travellers in Lapland during the 17th century and after (Ehrenmalm, 1743:138; Linné, 2003:122; Stockfledt, 1868:101). It has been suggested that the people visiting Sami huts were generally not used to smoke and that the problem was not so great for people accustomed to these circumstances (Ryd, 2005:367pp).

Most visitors described the temperature in the hut or tent as relatively comfortable and sometimes as hot (Graan, 1983:47, footnote; Högström, 1980:102; von Düben, 1977:120).Tornæus

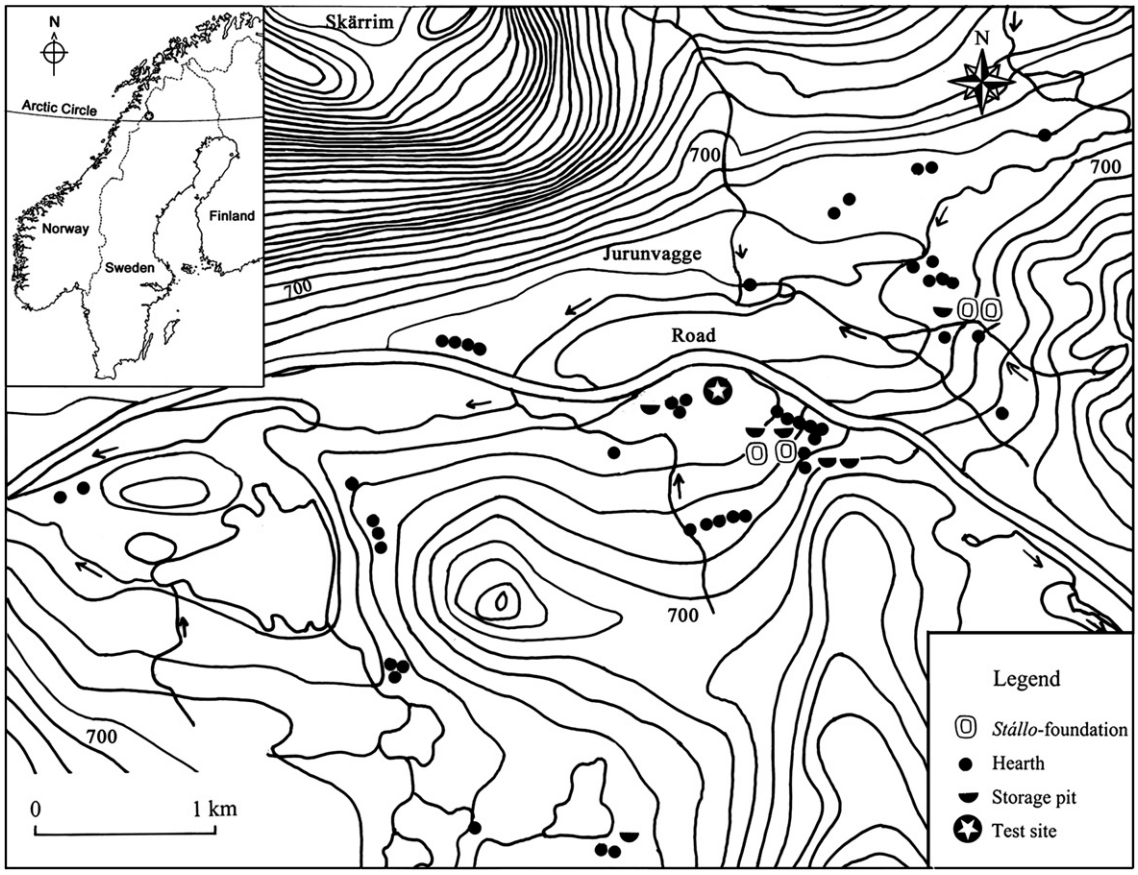

Fig. 1. Map of the experimental area, which is close to the Norwegian border and has registered ancient monuments in the vicinity.