FIRE-CRACKED ROCKS AT ALM SHELTER (48BH3457): AN EXPERIMENTAL STUDY

Erin R. Kelley

Department of Anthropology, University of Wyoming, Laramie WY 82072
(ekelley3@uwyo.edu)

Under the advisement of Dr. Robert L. Kelly
Department of Anthropology, University of Wyoming, Laramie WY 82072
(RLKelly@uwyo.edu)

Abstract

Fire-cracked rocks are a common but rarely analyzed feature of archaeological sites. These stones can fracture due to use as hearth stones, use in “stone-boiling,” or through natural stone decay processes. Several concentrated collections of fire-cracked rocks (FCR) were uncovered at Alm Shelter (48BH3457), a well-stratified rock-shelter in northern Wyoming. Knowing what caused the fractures of these stones helps to understand how use of the site might have changed over time. To help determine potential use at Alm, two tests were conducted, stone boiling and heating as hearth stones, to see if the archaeological features could be replicated. These experiments were inconclusive. The patterns analyzed in these tests were closest to those of hearth stones, but the characteristics of the archaeological specimens may have been produced largely through natural decay.

Keywords: Fire-cracked rocks, heat-altered rocks, human behavior, experimental archaeology

Heat-altered rocks, or HAR, are a common but rarely analyzed feature of archaeological sites. HAR can signal a number of different activities; knowing what those activities were help archaeologists reconstruct prehistoric behavior and how that behavior changed over time. Although not as glamorous as projectile points or other tools commonly found in prehistoric sites, HAR can provide critical information on common and important human activities: staying warm and cooking food.

In the course of fieldwork at Alm Shelter (48BH3457; excavated from 2005-2018), a well-stratified rockshelter in northern Wyoming, archaeologists excavated seven hearths that contained HAR. This paper analyzes whether the breakage patterns of HAR found at Alm Shelter provide clues as to how the site was used by the prehistoric people who occupied it.

Rocks can become heat-altered in several ways. For Alm Shelter, the two major ways are by the cooking method of stone-boiling or through use as hearth stones. To determine how these activities affected stones, we conducted two experiments, stone boiling and use of rocks as hearth stones, to determine if different activities produced different breakage evidence. The stones uncovered at the site were also analyzed for the potential of fractures created due to natural decomposition of the stones. The data analyzed here suggest the HAR excavated at Alm were used as hearth stones.

Alm Shelter

Alm Shelter (48BH3457) is a well-stratified prehistoric rockshelter located at the mouth of Paint Rock Canyon on the west side of the Big Horn Mountains in Northern Wyoming (Figure 1). The site lies at the base of an east-facing cliff, and the modern-day dripline, the dry part of the site, encompasses an area of about 60 m^2; the majority of excavations conducted at this site took place behind the dripline. This was an ideal location for prehistoric peoples because the site receives morning sun and afternoon shade. Paint Rock Creek also runs approximately 100-meters south of the site which would have provided occupants with water year-round and even through serious droughts. Alm Shelter also sits on a prime route from the Bighorn Basin to the highest elevations of the Bighorn Mountains, which could have made it an ideal stopping point between the two locations.

Dr. Robert L. Kelly has been conducting research at Alm Shelter since 2005, and the site has been used as a location for the University of Wyoming summer field school for the past five field seasons (2014-2018). The first test pit was dug in 2005, with Dr. Kelly returning to the site in 2009 to excavate two more test pits. During the first season of the field school in 2014, the excavation was expanded to include a 2 x 3 m excavation block connecting the three initial test units. Work continued at the site through the 2018 field season. The site provides evidence for a continuous, undisturbed record of human occupation from the Late Paleoindian (~12,000 years ago) through the historic era (the ranch on whose property the site is located was homesteaded in 1880). The site was excavated in 50 x 50 cm units, in no more than 5 cm levels, using a total station to obtain provenience data (at ± 3 mm) on all finds >2 cm in maximum dimension. Unusually, the site's sediments are nearly undisturbed by burrowing animals. This affords the possibility of examining temporal changes in human behavior, as they are recorded in material remains, in detail. Combined with existing knowledge of past environments and changing population size, Alm Shelter provides a unique opportunity to study the relationship between human behavior, population density, and environmental change at one location in detail.

Alm Shelter likely housed small hunting or foraging parties, and possibly small residential parties. Research at the site aims to understand how people used this shelter in order to understand prehistoric hunter-gatherer mobility patterns in the region. This, in turn, helps expand our understanding of how hunter-gatherers used nomadic movement as a way to solve problems in getting food to people (or vice versa). This matters because studies show that changes in hunter-gatherer mobility have significant implications for social and political organization (Kelly 2013).

What Are Heat-altered Rocks?

Heat-altered rocks include those used in stone boiling, as griddles, in earth ovens (also known as pit-baking), and as hearth stones (Neubauer 2019). They primarily reflect cooking activities, but stones can be heated for activities such as body warmth and for use in sweat lodges, among others (Buckelew 1911; Driver 1952; Hough 1926; Neubauer 2019), although cooking is by far the most studied aspect of HAR. The most commonly studied of these cooking techniques are stone boiling and rock griddles. Stone boiling was used to indirectly cook vegetables, meats, or liquids by heating water to a boil. Rock griddles were used to cook meats to cure or dry them out in order to preserve them. It is also important to note that HAR can be created in non-cultural settings, primarily natural fires (Neubauer 2019). HAR include fire-cracked rocks (FCR), but these are rocks have already fractured. At Alm Shelter, we encountered both fractured and un-fractured rocks, therefore “heat-altered rocks” is more applicable to this study.

How Do Rocks Break?

Very little literature or research exists on breakage patterns of granitic rock in thermal environments. This is unfortunate because the majority of the heat-treated rocks found at Alm Shelter are granite and granodiorite. Much of the existing literature focuses on quartz and quartzites, therefore, I treat the breakage patterns found on Alm's rocks as the same or similar to the breakage patterns recorded in existing research.

There are several indicators that suggest a rock has been heat altered, the first of which is color change. Heating can increase the luster, or sheen, of the rock; this is especially true of cherts but can also be true of quartzites. This change in luster can also be accompanied by a change in color, sometimes a dramatic change. This change in color and luster is commonly an example of intentional heat-treatment, done to make a stone easier to work when knapping into a tool (Neubauer 2019). Such intentional heat treatment is not of concern here. Heat alteration also appears as sooting, or blackening, of the rock surface (Custer 2017), and some rocks may even exhibit evidence of oxidation, or reddening of the cortex, the stone's weathered exterior surface (Neubauer 2019). This is generally evidence of direct exposure to flame, where color/luster change associated with the heat treatment of stone is associated with stones buried beneath a fire, and not directly exposed to flame. Sooting is the most common color change seen at Alm Shelter.

Cracks, a second indicator of heat treatment, are present when a rock exhibits fissures but has not broken into separate pieces (Custer 2017). Two types of cracking can occur with heat-treated rocks, fine-crazing and deep surface cracking. Fine-crazing is "a delicate network of very shallow surface cracks comprised of fine, non-linear or latticed cracks macroscopically visible on the surface" of a rock (Neubauer 2019:12). Neubauer (2019) suggests this type of cracking is caused by different types of expansion or contraction during the heating/cooling process. It is likely that deep surface cracks would eventually become fractures, either naturally or through reuse in fire activities (Neubauer 2019).

Fractures are present if the rock has broken into two or more separate pieces (Custer 2017). Multiple types of fractures can be created in HAR, the first of which are pot-lids. These are a common indicator or heat-treatment and are “small round pot-lid ‘flakes’ that pop off the surface of the rock” (Neubauer 2019:14). These fractures leave a circular pit, or negative, scar on the surface of the stone. These fractures are created likely due to a sudden change in pressure, or its release, from the inside of a rock as a result of the rapid heating, vaporization, and expansion of water contained in the rock (Neubauer 2019). There is no clear evidence of these kinds of fractures at Alm Shelter as they predominantly occur on materials such as chert and quartzite rather than granite and granodiorite.

Several techniques can cause rocks to fracture in fire, the first of which is stone boiling, known in the literature as “wet heat.” Stone boiling involves the heating of rocks in a fire and then placing them in a water-filled container (prehistorically this might be a tightly woven basket, or a skin-lined pit) to raise the temperature of the liquid without the container coming into contact with the fire. This method is most common in societies who do not use ceramics (Custer 2017). Rock size in this technique was limited due to the necessity of rocks needing to fit in their designated containers, and anywhere from 10 to 50 rocks were used on each occasion (Custer 2017). Rocks used in stone boiling were generally left to sit in the fire for a few hours allowing them to heat, and then were placed in the liquid. There are generally two different techniques used in stone boiling: rocks used to boil the water before food is placed in liquid, or rocks that are added one by one to gradually raise the temperature of the liquid (Custer 2017). Literature does not explain how to tell the difference between the two methods based on HAR alone, and it is likely that the two methods produce no discernible differences. These techniques were likely used for more than just food preparation, but cooking is the main focus of stone boiling literature.

The second cooking activity that causes rocks to fracture in fire are earth ovens. These ovens were common around the world and used to cook a variety of plants and animal food products (Custer 2017). This technique was used for varying periods of time, but usually long (24 hours or more), to bake foods in a sealed pit (Neubauer 2019). Earth ovens allowed foods to cook or steam from all sides (Milburn 2009). Recent studies on HAR created in earth ovens have mainly been done by archaeologists in the western United States (Custer 2017). There is no evidence of earth ovens at Alm Shelter.

Another technique known to cause heat-induced fractures is use as hearth stones, a technique intended to enhance a fire's ability to heat a human sitting or sleeping nearby. This kind of heating is known as "dry heat." Very little literature exists on this specific activity, but it could produce fractures similar to those found on rock griddles. Rock griddles were used as cooking surfaces, and were flat stones elevated over a fire by several stones that served as legs. Their intention was normally to dry cook foods to reduce water content (Neubauer 2019) and increase preservation. Dry heating creates both heat fractures and exfoliation. Heat fractures are complete fractures that initiate from within the rock and leave the rock in at least two separate pieces. Exfoliation will be discussed below (Neubauer 2019). Whether fractures were produced due to use as rock griddles or as heath stones is difficult to know without testing for residue. Both of these fractures, heat fracture and exfoliation, have been found at Alm Shelter. However, the heat-altered stones at Alm Shelter are round river cobbles, not the flat stones we expect to see used as griddles.

Several experimental studies find that, depending on how long rocks are exposed to fire or the way in which they were used, can be discerned macroscopically, in their use-alteration. Neubauer (2019:17) writes,

> rocks heated experimentally to 800ºC and cooled gradually for 48 hours to simulate earth-oven cooking exhibited intense use-alteration compared to the moderate use-alteration of stones heated similarly and cooled gradually for 24 hours to simulate hot-rock griddle cooking in an oven hearth. In contrast, rocks heated to 800ºC and cooled quickly by immersion in water simulate stone boiling cooking exhibited far less use-alteration than those cooled gradually.

Based on the lack of evidence for earth ovens but the heavy heat-alteration patterns found at Alm, it is likely the Alm fractures were created during dry heating activities. McFadden et al. (2005) claim that fractures created by fire tend to be parallel to the surface of the rock, rather than perpendicular ones caused by natural sun exposure (McFadden et al. 2005). However, exfoliation is what we observed on natural boulders exposed to the sun, but not to fire, near Alm (Fig. 3).

Natural Decomposition

It is possible that some of the fractures from Alm were caused by natural granitic decomposition in addition to, or instead of, human activity. Studies conducted by McFadden et al. (2005) suggest stones can fracture due to long-term exposure to sunlight. Cycles of sun exposure, or diurnal cycles, are known to cause episodes of expansion and contraction. This happens on a smaller scale than that which produces HAR, but when rocks are submitted to sun exposure every day for an extended period of time, cracking and fractures can occur. These fractures can also reach deeper into the rock than those caused by fire (McFadden et al. 2005). When natural processes are in action, cracks created by thermal pressures do occur, but they are often escalated due to other processes, such as chemical weathering, i.e., the effect of salts and freezing.

In the case of cold, dry environments, which describes Alm Shelter's environment, granular disintegration near the surface of the rock is more common than deeply penetrating fractures (McFadden et al. 2005). This type of fracturing, or as Neubauer (2019:13) calls it, "exfoliation," probably reflects the natural decomposition of stones at Alm (Figure 2), possibly exacerbated by heating, although we do not know this for certain. This would suggest that the sun makes the surface of the rock more friable; this will, coupled with cold and any other chemical weathering factors cause the exterior of the rock to sheaf off.

In the area just north of Alm Shelter, near a second site, rocks exhibit this sort of fracturing that have experienced long-term sun exposure (anywhere between months to thousands of years; Figure 3). These rocks indicate how natural decomposition of granitic rock appears in this area.

Stones found in hearths at Alm Shelter were likely collected from either the river or from the base of the cliff face just north of the site. Both are valid options but based on data by McFadden et al. (2005) stones exposed to sunlight could be more friable and therefore, at least from a 21st century point of view, potentially less useful than rocks collected from the river.

Hearths

Teams excavated 61 hearths at Alm. Hearth use spans the length of all occupations of the site, with the oldest appearing roughly 11,778 years before present (BP), and the most recent appearing approximately 377 years BP. These dates, and all dates referenced in this paper, were calculated based on an age-depth model developed by Spencer Pelton, a former University of Wyoming PhD student. Additionally, all hearths found at Alm have a wide spatial distribution across the site, appearing in every excavation unit, except for one. This unit, however, was disturbed by looters in the 1950s and provides no useful prehistoric data for the site.

Seven hearths containing rocks were excavated at Alm and are estimated to have been used over the span of about 4,500 years. The oldest is believed to be approximately 7,776 years old and the youngest 3,186 years old. There is no temporal patterning in this usage, and they only appear in four of the nine excavation units of the site. The number of rocks in each hearth was not recorded during excavations, but this could tell us very little. According to excavation notes, there was at least one hearth *without* rocks excavated between each of the hearths *with* rocks. The maximum number of hearths without rocks between rock hearths during this time period was five, but whether this pattern suggests anything interesting is unknown.

Field Experiment

Test experiments were conducted in the field to identify the cause of fractures found on stones in the hearths. First, rocks were collected from Paint Rock Creek. Each rock was weighed (Table 1) and photographed before it was exposed to the fire (Figure 4). These experiments were intended to provide clues as to how prehistoric peoples may have been using hearths in this site and could help us to understand how the site was being used as a whole.

The first test was stone boiling. Roughly ten stones were used in this test, four of which were collected during the experiment. These additional four rocks were never weighed or photographed prior to exposure to the fire. A large metal pot was filled with five liters of water. The time that each of these rocks were exposed to the heat was not recorded as they were placed in and removed from the fire haphazardly. Before the experiment began, the temperature of the water was 12.3 degrees Celsius.

It took about an hour to get the water to a boil. To speed up the process, the four previously mentioned additional rocks were added to the experiment. The temperature of the water during the final boil (taken with a heat gun) was 83°C, and the boil lasted for approximately five minutes. The heat gun used to take the temperature may not have been as effective as desired, as the boiling point of water at 5000 feet is ~95°C, and Alm Shelter is at ~5600 feet above sea level. The time it took to get the water to boil and the short length of the boil raised questions about the efficacy of stone boiling as a method. However, other experiments have been able to boil water faster and longer (Speth 2015).

Rocks used in other stone boiling experiments were left in the fire for about two hours prior to being placed in the water (Custer 2017). In our experiment, rocks were left in the fire for approximately thirty minutes to heat and then added to the water and returned to the fire. We do not know if the stones acquired more heat in two hours than in 30 minutes. Time in the fire following this first removal was not recorded. This did not allow the rocks to collect as much heat as they may have in the past, and it significantly changed the way the rocks were heated. Research also suggests rocks were dipped in another "pot" of water before they were placed in the cooking pot to keep the cooking water free of ash (Custer 2017). This was not done in our experiments, and the water was black by the time it boiled. This dipping of the stones prior to use in cooking may have also caused more fractures than boiling itself. It is likely the cleaning water was not as warm as the process went on and the initial cold shock to the rock may have caused stresses that could lead to fracture. These differences in technique may have caused errors in our tests.

One of the test rocks – rock six – fractured during our stone boiling tests (Figure 5). The rock was broken into three distinct pieces, and the fractures on this stone were very clean sheared planes. All three pieces were created during the same fracture event, and the origin of the fracture appears to be approximately the center of the rock, suggesting internal stresses, of the kind discussed in most stone boiling research (Driver 1952; Lovick 1983; Neubauer 2019; Thoms 2009).

The second experiment conducted in the field was several long-term heat exposures. Here we aimed to test the possibility that Alm fractures could have been created in a dry heating activity, specifically as hearth stones. The idea here is that stones were placed in a hearth and, as the fire died down during the night, the stones continued to radiate heat for some time after the flames ceased. This test included several parts and was conducted three times. These rocks were weighed and photographed before placement in the fire. Once in the fire, the rocks were left to "cook" and only disturbed as the fire was maintained. After approximately two hours, the rocks were removed from the fire, and their temperature was taken using a heat gun. At the same time, the temperature of a nearby rock that had not been used in the fire was recorded as a control. The rocks were then left to sit overnight, and their temperatures taken intermittently. Even two hours after removal from the fire, the coolest rock was still at least ten degrees warmer than the control rock. The temperature progression of the second heating experiment can be seen in Table 2.

Due to the necessity of fire safety, the rocks were pulled from the fire to let them to cool as naturally as possible; this allowed us to put out the fire before going to bed in the evening. Field work and day-to-day activities prevented us from "cooking" the rocks for extended periods of time, and there was no viable option to do so on returning from the field. This did not allow us to do the experiment as fully as I would have liked, but based on the temperature readings we received, it is certainly evident that stones could be used to prolong the heat of the fire.

None of these stones fractured, but one developed a distinctive deep surface crack that would likely lead to a fracture with more heating events.

Results

The results of our field tests were inconclusive but appear to be more reflective of use as hearth stones than stone boiling. Fracture patterns and size of the stones excavated from Alm are not indicative of stone boiling and there is no evidence for earth ovens. The fine crazing and deep surface cracking reflect breakage described in other literature, and are similar to our test experiments as well as to the stones excavated at Alm Shelter.

Stones near the site display evidence of natural decomposition (Figure 3). These fractures can be seen in some of the stones excavated from the site while *in situ* (Figure 2), which could suggest stones were selected from the base of the cliff north of the site. It is also possible that burning a rock could make it more friable and more susceptible to other forms of weathering, both physical and chemical. The hearth stones could have been left exposed on the surface when prehistoric peoples left the site, and sun exposure caused them to breakdown and fracture similarly to the nearby stones, but at an accelerated rate. However, the hearth stones that surround our camp's fire, where we conducted the experiments, do not exhibit such disintegration, despite being used repeatedly and exposed to the sun for many years.

From the discoloration of the stones collected from the site, it is clear that they were burned in a concentrated fire. In addition, other river cobbles present in the site but found outside of hearths do not exhibit the evidence for decomposition found in the hearth stones (Kelly, per. com. 2019) and, as noted above, it is unlikely that inhabitants chose already decomposing stones for use as hearth stones. Therefore, it is likely that the condition of the stones found in hearths is a product of direct, intense heating and/or heating-induced enhanced decomposition.

The rocks from two of those hearths containing rocks were collected and taken to the lab. One of these collections can be seen in Figure 6. These stones exhibit signs of fine crazing, cracking, sooting, and fracture. The majority of fractures collected seem to be fractured pieces that broke off of rocks, but several unbroken rocks also exhibit evidence of fracture. The surface of these stones is also much more granular or rough than the expected cortex of a rock, especially those collected from the river. The surface texture seen on the rocks excavated from Alm also developed on the rocks used in our tests.

The distribution of the hearths with rocks also shows a clear pattern. Figures 7 and 8 show the distribution by unit of hearths dated between 7,776 and 3,186 BP. These graphs show that more hearths were excavated out of unit 2009-2 both with and without rocks; and of the seven rock hearths found at Alm, four of them were excavated from unit 2009-2. And a fifth hearth containing rocks was excavated from unit A directly to the north of unit 2009-2 (Figure 9). This pattern also reflects the larger pattern of the site as a whole (Figure 10); that is, hearths with or without rocks occur most frequently in unit 2009-2 and Unit A. This distribution was likely caused by the shape of the shelter. The modern-day cliff face provides a small nook (Figure 11) that could have protected occupants from most weather, and if they set the fire away from the wall, they could use the wall as an additional trap for warmth. If people were using stones to maintain heat overnight this would create the best environment for this type of use and would also support the dry heat fracture patterns seen at Alm. Additionally, based on the limited appearance and the distribution of the rock hearths found at the site, it is likely these rock hearth occupations could have occurred during the winter. The time it took for the rocks pulled from the fire to lose their heat in our experiments would suggest that they could help to prolong the heat of the fire through the night.

Conclusion

The likelihood that these fractured stones are unrelated to human activity is small. Evidence including sooting, fine-crazing, cracking, fracture, and rock placement in hearths are too compelling to suggest they all occurred coincidentally. River cobbles did not roll uphill from Paint Rock Creek and aggregate themselves in hearths. However, the possibility that some of these fractures were caused by natural factors like weathering and sun exposure cannot be ruled out.

Although experiments conducted in the field were inconclusive, in comparison to the rocks collected from Alm Shelter and existing research, it is more likely rocks at Alm were used as hearth stones. Fine-crazing, cracking, and the fracture patterns found at the site all suggest breakage due to dry heating and subsequent enhanced decomposition, and the placement of these stone-filled hearths relative to the modern-day cliff face supports this possibility.

It is important to note that errors likely occurred during this study. Our field experiments were limited, and therefore cannot fully support any conclusions. Our inability to leave the rocks in the fire overnight and allow the fire to burn down naturally also limited the evidence for conclusions drawn here. And lastly, the errors in our stone boiling test prevented us from developing a full understanding of the fractures caused by this activity.

Acknowledgements

Special thanks to Dr. Robert L. Kelly without whom this project would not have been possible! And thank you to the University of Wyoming Anthropology Department and Honors College for supporting this project.

References

Buckelew, Francis M.

1911 *Buckelew, the Indian Captive; or, The Life Story of F.M. Buckelew* [sic] *While a Captive Among the Lipan Indians in the Western Wild of Frontier Texas, as Related by Himself Written by S.E. Banta.* Mason Herald, Mason, Texas.

Driver, Harold

1952 The Acorn in North American Indian Diet. *Proceedings of the Indiana Academy of Science* 62:56-62.

Hough, Walter

1926 *Fire as an Agent in Human Culture.* US National Museum Bulletin 139. Smithsonian Institution, Washington DC.

Lovick, Steven K.

1983 Fire-Cracked Rocks as Tools: Wear Pattern Analysis. *Plains Anthropologist*, 28(99):41-52.

McFadden, L.D., M.C. Eppes, A.R. Gillespie, and B. Hallet

2005 Physical Weathering in Arid Landscapes Due to Diurnal Variation in the Direction of Solar Heating. *GSA Bulletin*, 117(1/2):161-173.

Milburn, Douglas H., Uyen K. Doan, ad Joanna Huckbee

2009 Spatial and Temporal Distributions of Archaeological Heated-Rock Cooking Structures in the Transverse Mountain Ranges: Proposed Markers of Land-Use Shifts Since the Early Holocene. In *Society of California Archaeology Proceedings* 22:1-21.

Neubauer, Fernanda

2019 Use-Alteration Analysis of Fire-Cracked Rocks. *American Antiquity*, 83(4):681-700.

Speth, John

2015 When Did Humans Learn to Boil? *PaleoAnthropology*, 2015:54-67.

Thoms, Alston V.

2009 Rocks of Ages: Propagation of Hot Rock Cookery in Western North America. *Journal of Archaeological Science*, 36:573-591.

Figure 1. Alm Shelter viewed from above facing north.

Figure 2. Hearth feature showing hearth stones found *in situ*.

Figure 3. Examples of natural decomposition of granodiorites just north of Alm Shelter. Note the multiple shearing planes parallel to the surfaces.

Figure 4. Experimental rocks before burning.

Figure 5. Fractured rock from stone boiling field experiment. This was the only rock to fracture in all of our experiments.

Figure 6. HAR from one of two hearths excavated from Alm Shelter and brought back to the lab.

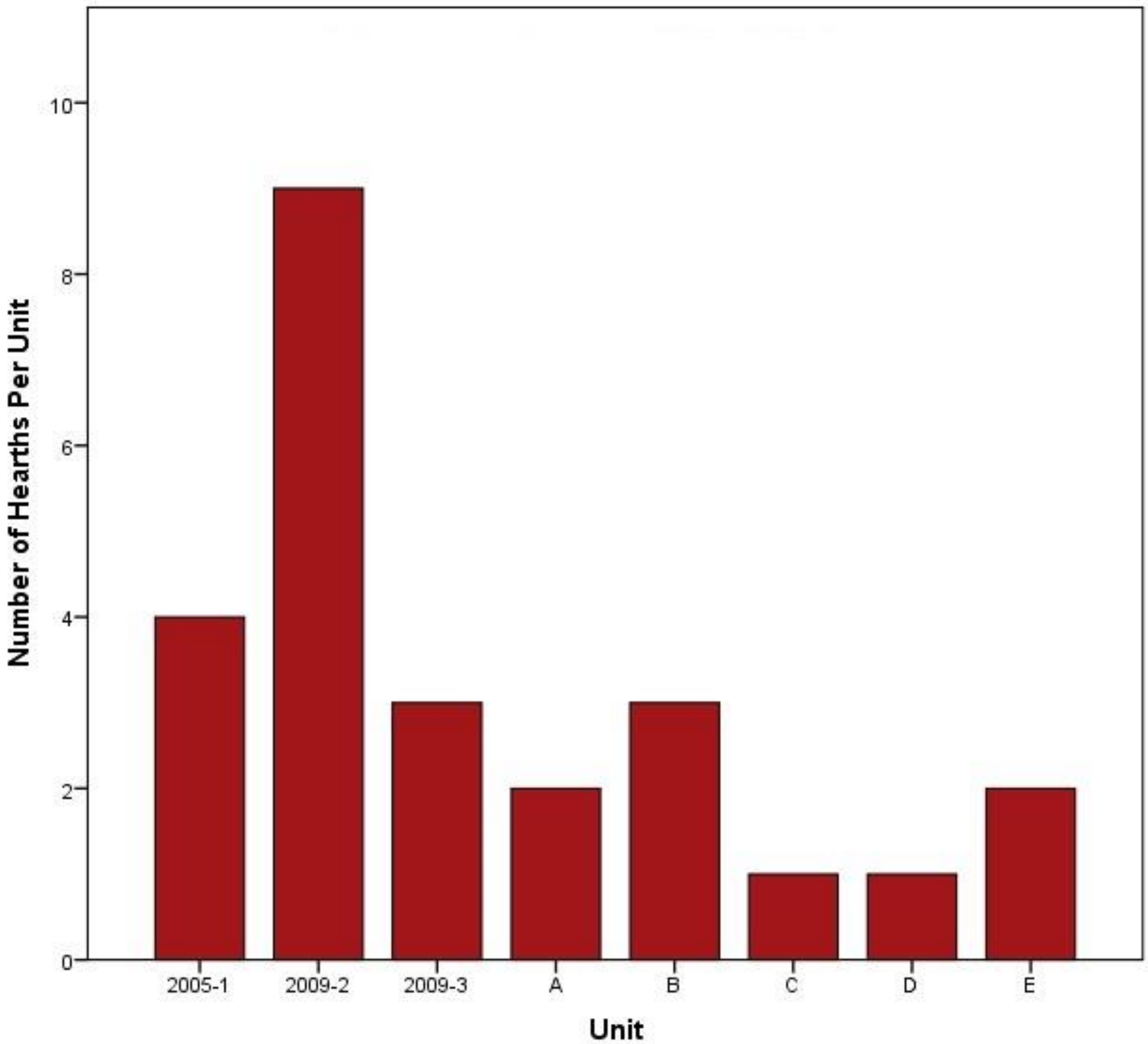

Figure 7. The distribution of hearths by 1 x 1 m excavation unit between 7776 – 3186 BP.

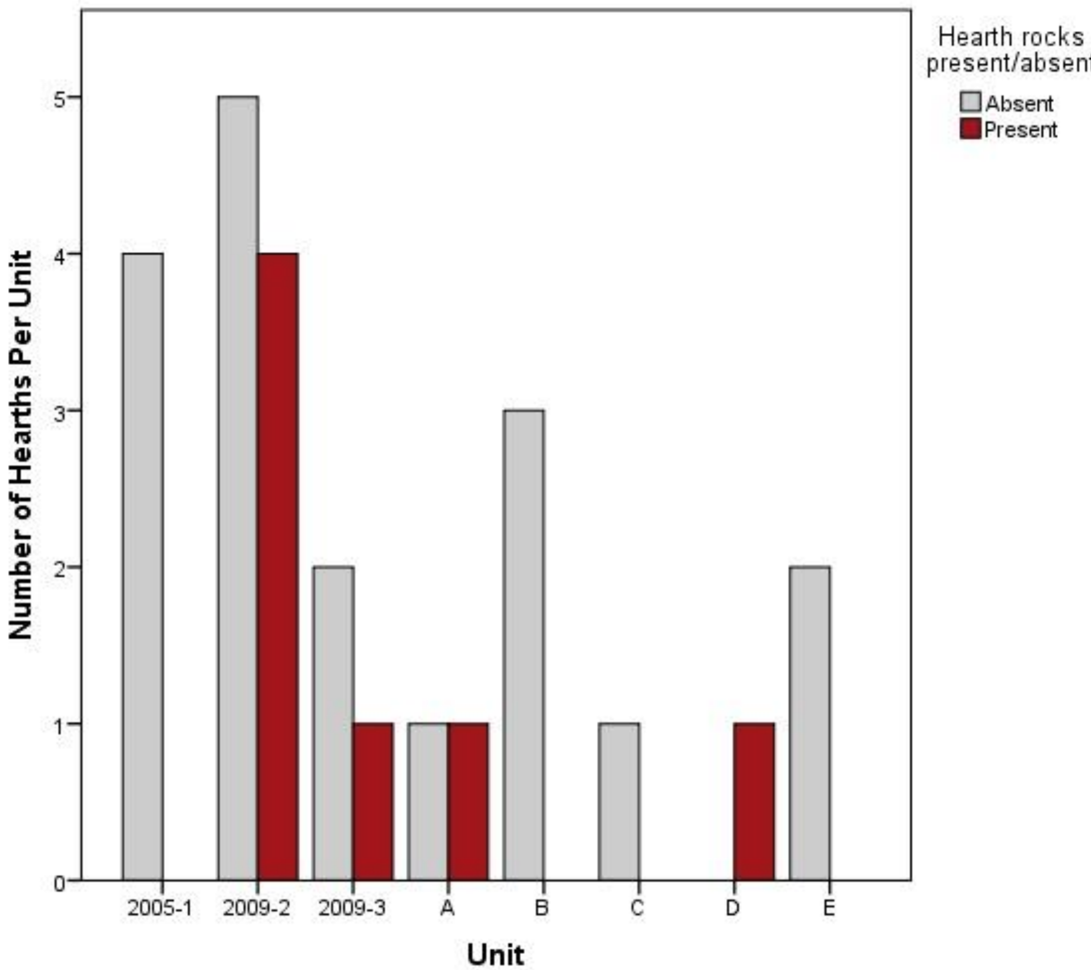

Figure 8. The distribution of hearths with and without rocks.

Figure 9. Alm Shelter at end of excavation showing location of 1 x 1m units 2009-2 and A.

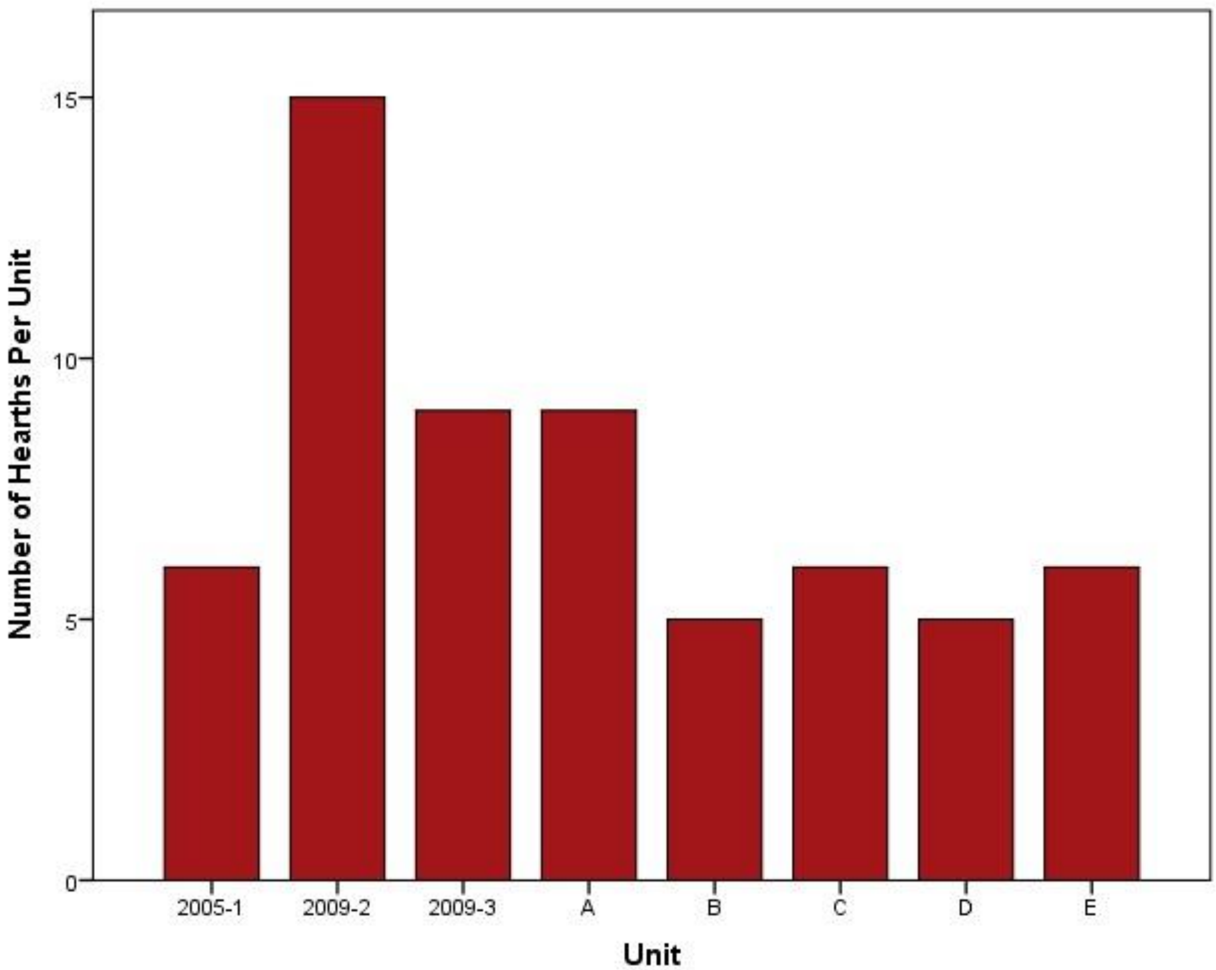

Figure 10. The distribution of all hearths excavated at Alm Shelter by excavation unit.

Figure 11. Unit 2009-2 in context of the rest of the site. The individual in the white shirt and one in a blue jacket are in the nook believed to be ideal for warmth at night.

Rock number	Weight (g)	Rock number	Weight (g)
1	122.7	10	850
2	231.8	11	1200
3	307.9	12	1050
4	418.1	13	1600
5	399.3	14	1200
6	404.9	15	825
7	526.2	16	800
8	620	17	1250
9	950		

Table 1. This table shows the weights of each rock used in our field experiments

Rock number	Removal from fire (7:30pm) (ºC)	8:00pm (ºC)	8:30pm (ºC)	9:00pm (ºC)	9:30pm (ºC)	1:00am (ºC)
9	323	154	73.8	43	28	17
10	360	197	105	68	45	17
11	250	148	70	48	33	17
12	328	170	83	52	34	17
13	888	215	129	81	55	17
14	888	246	139	87	57	17
15	306	151	75	47	31	17
16	370	195	100	81	42	17

Table 2. This table shows the decrease in temperature of the heated rocks from the second heating experiment for tests as hearth stones.