**Rising from the Ashes: Post-smallpox epidemic technological change among the Hidatsa as measured by ceramic firing regimes on the North American northern Plains**

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**Introduction**

Contact between European and Indigenous peoples occurred relatively late on the northern North American Great Plains compared to other regions. First documented encounters with the French and English took place in the 1730s and 1790s (Fenn 2014; Wood and Thiessen 1985). Native nations often welcomed explorers, and especially traders, as they began to participate in the fur trade. Contact ushered in technological change, but this process was complicated by Indigenous perceptions of exchange and cultural practices (Rogers 1990). Despite what previous models have proposed, European made trade goods were not seen as superior by all groups, and several traditional technologies persisted into the late 19th and possibly early 20th centuries (Hollenback 2012).

Complicating our understandings of technological change in the Contact and Colonial periods were two catastrophic smallpox epidemics. Both the 1781-1782 and 1837-1838 outbreaks had high mortality rates that decimated northern Plains populations (Fenn 2001, 2014; Trimble 1985, 1986; Hanson 1989). In communities recovering from disaster it is not uncommon for surviving craftspeople to modify certain dimensions of technological practice (Hollenback 2012). This is especially true if the disaster results in the death of cultural specialists.

In Hidatsa society craft knowledge was maintained and practiced by those who had purchased the “rights” to such technologies, specific designs, the associated songs and rituals, and related knowledge and skills (Bowers 1992). This was one way in which elders were supported by younger individuals. Skilled adults sold the rights to technologies such as pottery, basketry, arrow-making, eagle trapping, etc. to the next generation.

Of the many traditional technologies manufactured and used by the Hidatsa, ceramics are some of the most durable and abundant in the archaeological record. It is ubiquitous on Plains Village archaeological sites from AD 1200-1850. This study aims to better understand specific dimensions of technological change in culture contact and post-disaster contexts by building on studies of post-epidemic ceramic manufacture (Hollenback 2012). Here, we will examine shifts in the firing temperature of pottery, an often-overlooked attribute of craft production. Firing temperature will be used as a proxy measure for broader changes in group behavior related to new labor demands and loss of skilled craftspersons in the 18th and 19th centuries.

Original firing temperature is insightful because it is directly related to several variables: (1) the skill level of potters (e.g., they must know how to create and hold an adequate firing atmosphere that sufficiently hardens pots without breaking), (2) the amount of labor and time invested in pottery manufacture and firing (e.g., time for pots to adequately dry, labor to collect firewood or other fuels, and time for pots to fire), and (3) the level of stress faced by the population in regard to fuel requirements.

A decrease in overall firing temperatures might reflect less skilled potters who lacked the requisite knowledge but were still trying to maintain traditional practice after the epidemics. As I will discuss later in this paper, every part of the pottery making process, including firing techniques, was kept secret (Bowers 1992; Wilson et al. 1977). The secrecy combined with the fact that most potters were older adult women, an age group disproportionately affected by the epidemics, it is possible the few women who knew how to fire pots properly died before they could pass on their knowledge (Hollenback 2012).

Lower overall firing temperatures may also reflect a decrease in effort and time spent making pottery. After the smallpox epidemics, where significant portions of households died, time and labor demands for survivors must have been dramatic (Hollenback 2012). In earthlodge villages, women were responsible for planting, harvesting, and storing all crops (Bowers 1992). Women also collected the wood for cooking, heating, and firing of pottery which required both labor and time to collect (Bowers 1992). They could offset carrying demands and distance with the use of dog travois, but it was an essential task that largely fell along gendered lines (Bowers 1992). In addition to traditional village tasks, the Hidatsa’s active participation in the fur trade further increased women’s workloads on the northern Plains (Hollimon 2005). Women processed the furs and hides for exchange at trade posts, and with the rise of the bison robe trade, these labor demands were pronounced (Hollimon 2005). Therefore, as women faced increased labor demands in contact and post-epidemic contexts, it is likely they would have conserved their time and labor for tasks other than ceramic firing.

The most important element in firing pottery is fuel. For Hidatsa women, the most common fuel was wood (Wilson et al. 1977). However, demand and competition for fuel is driven by cooking, heating, and other needs. Depletion of local timber was frequently cited as a reason to relocate settlements by earthlodge villagers (Fawcett 1988; Bowers 1992). If a village existed in a place for too long, or its population grew too large, wood could become scarce. Driftwood from rivers was often collected to offset strains on wooded bottomlands. By the time of the 1781-1782 smallpox pandemic, the Knife River had been occupied for at least 200 years by at least two village groups. By 1837-1838, the number of villages increased to 3 Hidatsa and 2 Mandan settlements. Historic documents reflect the stress on local timber reserves, indicating villagers had to move winter villages farther away from the large summer settlements to ensure that people had enough (Fawcett 1988). Wood was a precious resource in post-epidemic contexts, so it is hypothesized that a lower overall firing temperature could indicate the conservation of wood, as well as time and labor.

To test these variables, we combine the techniques of step-wise clay oxidation analysis and magnetic susceptibility (Goodwin and Hollenback 2016) to analyze sherds from the Awatixa Hidatsa pre-epidemic site Lower Hidatsa (32ME10), post-1781 but pre-1837 site Sakakawea (32ME11), post-1837 epidemic site Taylor Bluff (32ME366), and the last traditional earthlodge village site, Like-a-Fishhook (32ML2), in North Dakota. Lower Hidatsa has both pre- and post-European contact components. All other sites were occupied during the fur trade.

**Background: Earthlodge Villagers and Hidatsa Society**

What we refer to as the Hidatsa today were, prior to 1845, made up of three distinct but closely related village groups. These were the Hidatsa-Proper, the Awatixa, and the Awaxawi (Bowers 1992). This study focuses primarily on Awatixa sites, but it is likely that the Awaxawi and Hidatsa-Proper along with the Mandan mixed together at times, especially after the devastating epidemics (Hollenback 2012; Moreau 2009). For example, Like-A-Fishhook (32ML2) village was established by Hidatsa and Mandan survivors in 1845 (Smith 1972). They were joined by Arikara in 1862 (Smith 1972; Metcalf 1963).

*Hidatsa Women*

Gender and ritual permeated most aspects of Hidatsa life. Boys and girls were socialized to occupy strict gendered tasks as adults (for a discussion of alternative genders, such as *miati,* among the Hidatsa see Prine 2000). Men spent time organizing hunts, raids and warfare, as well as addressing ceremonial duties, but women provided the economic foundation on which the complex religious practices of Hidatsa society relied (Peters 1995). They tended large gardens of corn, squash, and beans, which were inherited matrilineally along with the earthlodges only they had the right to construct (Bowers 1992). Though the men had more age-grade societies, the women created the ceremonial dress worn by men, grew, collected, and cooked the food payments necessary to purchase the rights to the societies and/or ceremonial bundles, crafted the vessels in which the food was served, and processed bison hides into robes and other gifts required throughout the process (Bowers 1992; Peters 1995).

The importance of mothers in Hidatsa socialization cannot be understated. What we would consider aunts, both maternal and paternal, were mothers to Hidatsa children (Bowers 1992). The biological mother’s family was responsible for training girls in economic practices and proper social behavior. The father’s family passed on ritualistic knowledge to the boys through the purchase system (Bowers 1992). The maternal grandmother was the primary caretaker of young children too little to help other women in the lodge with work (Peters 1995). Thus, girls received training from all females living in a lodge, but not without proper exchange (Bowers 1992).

The ideas of payment and reciprocity in Hidatsa culture were taught from the very beginning. When a grandmother made her granddaughter toys, it was expected that the latter would do a favor in return (Bowers 1992). Children were even expected to offer small forms of payment for things as simple as stories. As a granddaughter grew older and could make her own toys, a grandmother would teach decorative skills in return for more favors (Bowers 1992). From about the age of eight onward, a girl helped her mother(s) with household tasks to prepare for when she was expected to run her own lodge (Hollenback 2012).

*Knowledge*

There are two types of knowledge among the Hidatsa: everyday hearsay and sacred or ancient knowledge (Peters 1995). Sacred knowledge had to be purchased and could only be taught by those who had inherited or earned the right to teach (Bowers 1992). It was possible for such exchanges to occur outside of one’s lodge, village, or tribe, but ethnographies focusing on the Hidatsa suggested knowledge acquisition took place within the household first and then within the clan (Hollenback 2012). In some cases, learning from family members was non-negotiable: “If, for instance, the mother was a potter and owned particular designs, the daughter was expected to buy the complete rights and continue the designs unique to that female lineage” (Bowers 1963:104). In addition to pottery, earthlodge construction, basket weaving, and tipi construction were other sacred crafts with restricted knowledge (Peters 1995). The teachers were usually older mothers and grandmothers, and the pupils tended to be mature young adults (Wilson et al. 1977). Learning sacred knowledge was a serious endeavor and a privilege. If sacred crafts were produced by individuals who did not have the right to do so, they or their loved ones might fall ill or get hurt (Hollenback 2012). There was a proper way to do things, and deviation was seen as dangerous.

**Hidatsa Pottery Production**

*Ritual*

Pottery was a sacred craft and its knowledge was intimately tied to religion. Pottery was associated with snakes and Old Woman Who Never Dies, the most important female deity (Bowers 1992). Snakes were the original potters and teachers of this sacred craft (Bowers 1992). Additionally, all snakes were thought to be the husbands of Old Woman Who Never Dies (Hollenback 2012). Alfred Bowers (1992:165) summarizes the Hidatsa origin myth concisely:

It was believed by the Hidatsa that only the snakes made pottery in former times. One day the snakes took an old couple out on the prairie where they had been working. They showed this old couple piles of dirt scattered about and explained to them that in making pottery one must mix certain clays with sand or grit produced by crushing certain stones long used around the fires.

The crafting of pottery was part of Hidatsa religion, and each step in the process was ritually and supernaturally defined (Bowers 1992). Furthermore, certain bundles, all associated with Old Woman Who Never Dies, allowed family lineages to make pottery (Bowers 1992; Hollenback 2012). These bundles were the Big Bird, River, and Snake bundles. Each contained two clay pots symbolizing the sacred pots placed on the shore of the Missouri by the snake people and the pots used by Old Woman Who Never Dies to feed her visitors (Bowers 1992; Hollenback 2012). These rights were passed down matrilineally in tandem with patrilineal bundle lines (Bowers 1992). Therefore, rights could either be purchased from a primary owner belonging to a family in possession of a bundle, or a secondary owner who had “ceremonial rights coming to her from snakes” (Bowers 1992:165). The secrecy resulted in only a few households that produced pottery. The rest of the village had to purchase pottery from these women in exchange for other goods and crafts (Bowers 1992). This unfortunately also meant that, being a closed and tightly regulated system of knowledge transmission, disasters, such as the epidemics that took place in the late 18th and early 19th centuries, posed a major threat to both the utilitarian aspects of pottery production and the sacred knowledge on which it rested (Hollenback 2012).

*Firing*

Unfortunately, information regarding the firing of pottery is limited and inconsistent. However, the firing environment was always an open environment, as northern Plains potters did not have kilns or ovens (Hollenback 2012). Several accounts will be discussed, and similarities will be drawn when applicable. In an account provided by a Hidatsa woman known as Buffalo-Bird-Woman, her aunt would wait until she had between two and five pots ready to be fired before she began the process (Wilson et al. 1977). She mentioned that dry bark, likely cottonwood, was placed into a fire all at once and allowed to burn down to coals (Wilson et al. 1977). The pots were set on the coals, and the coals were raked up around the pots (Wilson et al. 1977). Her aunt would then add more bark to the fire without touching the pots, and they were done when they turned bright red (Wilson et al. 1977). They were then allowed to stand in the fire until the coals burned to ashes and the flames went out (Wilson et al. 1977).

In a different account from a Mandan woman called Hides-And-Eats, she mentioned that only one pot was made at a time, so her firing method was conducive to one pot. Like Buffalo-Bird-Woman, she allowed a pile of cottonwood bark to burn down to coals, but instead of placing the pot on the coals, she would use a skillet to gather coals and place them inside the pot sitting in a ring made of wire and cloth (Wilson et al. 1977). The ring would have traditionally been made of willow bark; rings of willow bark were also used to store the pots upright in lodges when not in use (Wilson et al. 1977). Hides-And-Eats would shift the pot around to make sure it was evenly fired, and after ten to fifteen minutes, she would place the pot on the coals and pile the coals around it like Buffalo-Bird-Woman (Wilson et al. 1977). Unlike Buffalo-Bird-Woman, she placed a handful of hay into the mouth of the pot and would remove the pot before it was red hot (Wilson et al. 1977). The coals would be removed from the inside of the vessel after it stood for a few minutes out of the fire (Wilson et al. 1977).

Yet another different account was given by a Hidatsa man, Bear-In-The-Water, who as a boy, had helped his grandmother. Bear-In-The-Water mentioned that once a pot was dry enough to be fired, his grandmother would cover it with charcoal, wood, and earth until baked (Hollenback 2012). This is an example of a reducing atmosphere, as the complete covering of the pot deprives the environment of oxygen. The pottery would have a black finish due to the carbon deposited while firing (Hollenback 2012).

Non-Native sources in regards to firing come from travelers and early ethnographers. The earliest, Prince Maximillian who visited the upper Missouri around 1834, wrote that pots were filled and covered with dry wood shavings then lit (Hollenback 2012). Melvin Gilmore with the Museum of the American Indian observed Arikara women use elm-wood because it burned steadily and quietly (Hollenback 2012). The women allowed the elm-wood to burn down to coals before placing the pots in the coals. Coals were heaped around the pots and placed inside, then more wood was added on and around the pots (Hollenback 2012). Like Buffalo-Bird-Woman, Arikara pots were finished after they were red hot and allowed to sit in the fire until it was out (Hollenback 2012).

The best consensus that can be drawn from the differing sources is that wood or bark, usually cottonwood, was first allowed to burn down to coals. The pots were placed in the coals which were heaped around the pots, and sometimes the coals were placed inside the pots (Hollenback 2012; Wilson et al. 1977). More wood could be stacked around the pots or dry grass and wood shavings could be placed around and in vessels (Hollenback 2012; Wilson et al. 1977). Pots were done firing after becoming red hot or bright red in color and usually allowed to sit in the fire until it had burned down completely (Hollenback 2012: Wilson et al. 1977).

Once pots finished the firing process, they were either greased or treated in some way. Buffalo-Bird-Woman and Wolf Chief noted that a pot was finished when its first boiling of corn was used to grease the interior and exterior (Wilson et al. 1977). Wolf Chief also quoted a prayer that was said by the potter during the boiling: “I pray you try to be strong; to try to last long” (Wilson et al. 1977:103). Hides-And-Eats did not grease her pot with corn, instead she used uncooked suet, which she applied outside and inside a few minutes after firing (Wilson et al. 1977). Both techniques were believed to make the pot last longer and look nicer (Wilson et al. 1977).

**Background: Hidatsa Archaeology and Sites Included in this Study**

*Lower Hidatsa (32ME10): Early Proto-Historic (1710-1750) and Early Historic Phases (1750-1780)*

The site known as today as Lower Hidatsa is thought to be the traditional home of the Awatixa (Ahler and Weston 1981). Ahler and Weston 1981 noted the site was likely never seen by Europeans during its occupation (Ahler and Weston 1981). The site has three main components: A Heart River phase (1680-1710); a protohistoric phase (1710-1750); and a Knife River phase (1750-1780) that ended with the abandonment of the site after the smallpox pandemic of 1781-1782. Only the protohistoric and Knife Rivers phase are of used in this study. Interestingly, Ahler and Weston 1981 briefly mention that ceramic data may indicate an epidemic around the year 1750 (Ahler and Weston 1981). Lower Hidatsa was reported to have fifty-seven lodge depressions; with between eight and twelve people living in a lodge that puts the population between roughly four hundred and seven hundred people (Ahler and Weston 1981). Additionally, middens reached two meters in height in certain portions of the site and there were three possible constructed earthworks (Ahler and Weston 1981). Therefore between 1710 and 1780, Lower Hidatsa was a village of substantial proportions participating actively in both and existing and well-established Indigenous and new intermittent European trade networks.

Smallpox is thought to have reached the northern Plains in the late spring and early summer months of 1781 (Hollenback 2012). Lower Hidatsa was almost immediately abandoned. The Awatixa and Hidatsa-Proper co-established a new settlement known as Rock Village (32ME15) for a few years until conflict led to the dissolution of the community (Hartle 1960). The Awatixa established a new village at the site of Sakakawea sometime between 1790 and 1800 (Ahler and Weston 1981). The Hidatsa-Proper returned to their traditional site, Big Hidatsa (32ME12) on the Knife River. The Awaxawi, who had been living down the Missouri near the Painted Woods, moved to the Knife River area and established Amahami Village where they lived until 1837 (Hollenback 2012).

*Sakakawea (32ME11): Historic Phase (1797-1837)*

The site archaeologists refer to as Sakakawea was where the Awatixa re-established themselves sometime between 1790 and 1800 (Hollenback 2012; Ahler et al. 1980). It was the home of Sacajawea (Sakakawea) and her husband Charbanneau when the Corps of Discovery reached the Knife River in 1804. Ahler et al. (1980) split the occupation into an Early Village, which was briefly occupied and destroyed by fire, and Later Village components. The dividing date is 1804, when there was supposedly an attack, indicated in the archaeological record by burned roof fall, but this evidence is minimal at best. It is more likely the dividing date, which matches the arrival of the Corps of Discovery, is arbitrary (Ahler et al. 1980). That being said, the village was occupied roughly between 1797 and 1837 (Ahler et al. 1980). The village was, however, significantly damaged from a Sioux attack in 1834 according to some sources (Ahler et al. 1980; Ahler et al. 1988). Sakakawea had more than forty earthlodge depressions which indicates a population around four hundred (Ahler et al. 1980). Over time, the frequency of chipped stone tools decreased while the frequency of glass trade beads increased (Ahler et al. 1980). Metal was relatively uniform across the site, and there is evidence that trade materials were intensively recycled (Ahler et al. 1980). In summary, Sakakawea seemed to be relatively prosperous and stable despite likely attacks from the Sioux and other groups.

The smallpox epidemic of 1837 to 1838 spread rapidly due to steamboat transport. It also had higher mortality rates for the Mandan and Hidatsa (Hollenback 2012). The Mandan living at Min-Tutta-Hangkush in immediate proximity to Fort Clark trading post were the first to be infected around July of 1837 (Fenn 2014; Hollenback 2012). Once the three Hidatsa villages along the Knife River were informed it was too late. Half dispersed while the other half remained to care for the sick (Hollenback 2012). Those that fled moved constantly (Hollenback 2012).

Unfortunately, the Mandan and Hidatsa were particularly vulnerable in the months leading up to the summer epidemic due to a decrease in bison that particular hunting season and a cold, rainy spring that created food insecurity and they were therefore nutritionally stressed (Hollenback 2012). The epidemic of 1837 to 1838 took the lives of nearly half the Hidatsa and nearly nine out of every ten Mandan (Bowers 1992).

*Taylor Bluff (32ME366; 1834-1845)*

Taylor Bluff’s, a multicomponent site, primary occupation likely resulted from Awatixa and Awaxawi resettlement after the abandonment of Sakakawea and Amahami villages because of Sioux raids in 1834 or smallpox in 1837 (Ahler et al. 1988). It represents post-1837 adaptations. The village was fortified, with between thirty and forty lodges, and a massive midden-filled borrow pit (Ahler et al. 1988). Interestingly there are no geophysical indications of earthlodge structures accept for one large lodge (DeVore personal communication). It was abandoned in 1845 after the Hidatsa decided to leave the Knife River region (Ahler et al. 1988; Hollenback 2012).

Many Hidatsa and Mandan left the Knife River region in 1845 for a number of reasons. Hollenback (2012) lists a few in descending order of importance: smallpox, conflict and unceasing raids, lack of timber, scarce game, the shifting of fur trade interests due to migration of bison herds west, and traders at Fort Clark desiring to move north (Hollenback 2012). What resulted was an amalgamation of the three Hidatsa groups and the Mandan, who were later joined by the Arikara in 1861 (Hollenback 2012; Smith 1972).

*Like-A-Fishhook (32ML2; 1845-1885)*

In 1845 the last traditional earthlodge village was constructed on the Plains (Bowers 1992:29):

In 1845, because the wood had been largely consumed at the Knife River…The Awatixa, under Four Bears and Missouri, preferred to move to Fishhook Bend and there build a permanent village.

Soon after its establishment, in 1849, Like-A-Fishhook had a population greater than any white settlement in North Dakota. However, occupants experienced raids from hostile groups like the Dakota Sioux (Smith 1972). In 1850, a palisade was constructed around the village in an attempt to protect against subsequent raids (Smith 1972). In 1851, a second fort called Fort Atkinson was built near the village, and when Fort Berthold burned down in 1858, Fort Atkinson renamed itself, becoming Fort Berthold II (Smith 1972). The reservation of the Mandan-Hidatsa-Arikara Nations take its name from this post.

In 1862 the Arikara abandoned Fort Clark after it was destroyed by fire and established Star Village directly across the river from Like-A-Fishhook (Gilman 1987). The Arikara moved into Like-A-Fishhook that same year after they were attacked by the Dakota (Gilman 1987). The United States Military eventually stationed personnel at Fort Berthold II in an effort to protect against the Sioux; this coincided with a number of other changes to village life (Smith 1972; Gilman 1987). Prior to the 1860s, the three Hidatsa groups and the Mandan wintered in separate winter villages, but winters had become increasingly difficult (Bowers 1992). For example, the winter of 1865 was so harsh that Like-A-Fishhook’s palisade was torn down and used as firewood (Smith 1972; Gilman 1987). It is no surprise that the following year, in 1866, Like-A-Fishhook became a year-round settlement (Smith 1972; Gilman 1987). In 1871, Fort Berthold II purchased an earthlodge to scavenge for timber (Gilman 1987). This desperation is demonstrative of the fact that wood was almost non-existent by the 1860s and 1870s, so it is unlikely much was spared for ceramic production.

The remains of Like-A-Fishhook village were destroyed with the construction of the Garrison Dam which flooded significant portions of the reservation in 1953 (Smith 1972; Gilman 1987). The last traditional earthlodge village now lies at the bottom of Lake Sakakawea.

**Methods**

Original firing temperature is an attribute that is not often documented in ceramic analysis. The temperature at which a vessel was fired provides insight into production techniques (e.g., open firing vs. kiln firing), skill level of producers, as well as firing behavior and environment. It is also a proxy for human labor. Individuals must collect fuel, start, and monitor the firing.

Step-wise clay oxidation analysis combined with magnetic susceptibility were used to estimate the original firing temperature of the sherds from the four sites. Step-wise clay oxidation analysis operates on the basic principle that a clay body changes color with exposure to heat and with oxidation (Rice 1987; Shepard 1995). With refiring under controlled conditions in a lab, it is assumed that once the original firing temperature (or the highest temperature the sherd was exposed to in its life history) is passed it will change color again. However, recent error rates in step-wise clay oxidation analysis have shown that alone, this method is difficult because color changes on low-fired clays, clays with lower iron content, and clays fired in reducing atmospheres are difficult to perceive (Rice 1987; Shepard 1995; Rassmusen et al. 2012; Goodwin and Hollenback 2016). When this technique is combined with magnetic susceptibility, or how induced magnetization reacts proportionally to an external magnetic field, estimating the maximum firing temperature has two lines of data to compare (Goodwin and Hollenback 2016). When the iron in the clay body breaks down and then reforms after the maximum firing temperature is passed, the magnetic susceptibility changes (Rassmuesn et al. 2012). For the purposes of this paper, protocols developed by Goodwin and Hollenback (2016) were followed in the re-firing of all sherd samples (Goodwin and Hollenback 2016). In addition to the estimation of maximum firing temperature, loss on ignition (LOI) was also measured. This provides some measure of organic content of sherds.

Sherds were refired from 100o C to 900oC at 100oC temperature intervals. At each, the sample’s mass was measured before and after refiring to track how much organic material was lost and therefore in the clay sediment itself, deposited on the sherd if smudged, and/or absorbed during cooking processes (Johnson et al. 1988). The color of each sample was also recorded according to the Munsell Soil Color System using a Munsell CAPSURE Color Matching Tool.

Base measurements of magnetic susceptibility and mass were taken before the re-firing began. Batches of twenty samples were fired in a Thermo Scientific™ Thermolyne™ Benchtop 1100°C Muffle Furnace and held at each temperature for three hours. In-between each interval, after the samples were safe to remove from the furnace, magnetic susceptibility, mass, and the Munsell color were recorded. Mass specific magnetic susceptibility was calculated, then graphed as a function of temperature. The derivative of this function was squared, and the point at which the magnetic susceptibility deviated from zero (the first positive or negative spike) was the maximum firing temperature (Goodwin and Hollenback 2016).

*Sample*

Samples employed in this analysis were subsampled from sherds analyzed in Hollenback’s (2012) technological study of ceramic change in contact and post-epidemic contexts. All materials were excavated by Dr. Stanley Ahler in the 1970s and 1980s as part of National Park Service sponsored research at the Knife River Indian Villages National Historic Site near Stanton, North Dakota (Ahler et al. 1980; Ahler and Weston 1981; Ahler et al. 1983; Ahler 1988). For this study, samples were included if sherds came from middens located outside earthlodges and could be assigned to certain time periods. A sample of twenty sherds from each of the sites was evaluated. Forty sherds were selected from Lower Hidatsa because of its long-occupation and to ensure pre-contact and protohistoric contexts were represented (Ahler and Weston’s [1981] Early and Late Proto-Historic periods). See Table 1 for all sherds sampled.

Table 1: Sherds sampled

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Site Name** | **Site Number** | **Sherd Numbers** | **Unit(s)** | **Component** | **Date Range** |
| Lower Hidatsa | 32ME10 | LH0091  LH0113  LH0123  LH0124  LH0198  LH0313  LH0406  LH0407  LH0458  LH0469  LH0609  LH0626  LH0706  LH0733  LH0840  LH0954  LH0929  LH1016  LH1105  LH1106 | All sherds from 342NW256 | Early Proto-Historic | 1710 - 1750 |
| Lower Hidatsa | 32ME10 | LH1184  LH1185  LH1190  LH1198  LH1199  LH1201  LH1207  LH1209  LH1210  LH1214  LH1218  LH1222  LH1226  LH1228  LH1233  LH1234  LH1235  LH1248  LH1261  LH1263 | All sherds from 342NW256 | Late Proto-Historic  (Knife River Phase) | 1750 - 1782 |
| Sakakawea  Sakakawea (continued) | 32ME11  32ME11 | SK1024  SK1045  SK1053  SK1058  SK1089  SK1188  SK0826  SK0848  SK0883  SK0979  SK0829  SK0856  SK0872  SK0962  SK0241  SK0252  SK0290  SK0326  SK0407  SK0433 | 226NW234  226NW234  226NW234  226NW234  226NW234  226NW234  235NW341.5  235NW341.5  235NW341.5  235NW341.5  235NW341.5  235NW341.5  235NW341.5  235NW341.5  287NW361  287NW361  287NW361  287NW361  287NW361  287NW361 | Historic  (Plains Village Knife River Phase)  Historic  (Plains Village Knife River Phase) | 1797 – 1834  1797 - 1834 |
| Taylor Bluff | 32ME366 | TB0324  TB0325  TB0326  TB0292  TB0298  TB0295  TB0388  TB0301  TB0288  TB0289  TB0302  TB0287  TB0344  TB0303  TB0304  TB0306  TB0313  TB0315  TB0318  TB0319 | XU4  XU4  XU4  TU5  TU6  TU5  TU5  TU6  TU3  TU3  TU6  TU2  TU4  TU7  TU7  TU7  Trench  TU9  Feature 8  Feature 8 | Historic  (Plains Village Four Bears Phase) | 1834 - 1845 |
| Like-a-Fishhook | 32ML2 | LAF0019  LAF0020  LAF0024  LAF0033  LAF0053  LAF0072  LAF0073  LAF0074  LAF0077  LAF0078  LAF0086  LAF0104  LAF0125  LAF0128  LAF0134  LAF0143  LAF0150  LAF0152  LAF0161  LAF0162 | \*This information is at SMU in the Traditional Technology Lab\* | Historic | 1845 - 1885 |

**Results**

The one hundred samples had the first derivative squared mass-specific low and high frequency magnetic susceptibilities expressed in terms of temperature graphed to pinpoint the first positive or negative change indicating the maximum firing temperature. The Munsell colors were also tracked in a table, and the first changes in color were noted. The estimation of maximum firing temperature proved to be particularly difficult on sherds that were smudged or blackened by the addition of organic material during the firing process or with use. The majority of sherds were fired at lower temperatures, before the temperature at which oxidation occurred. This resulted in many of the graphs having deviations at lower temperatures and then a significant spike between 700°C and 800°C. Similarly, many of the samples experienced two distinct Munsell changes. The first tended to be from black or very dark gray to brown, and the second was brown or light brown to red. Like the magnetic susceptibility, the first significant Munsell change was interpreted as the maximum firing temperature while the second likely resulted from the full oxidation of the clay body.

The following are the results of triangulation between high frequency first derivative squared magnetic susceptibility, low frequency first derivative squared magnetic susceptibility, and Munsell color change. Samples where the magnetic susceptibility and the Munsell data were incompatible were not included in analysis. Additionally, estimates based solely on Munsell changes were analyzed. All samples were used in the Munsell only analysis. Both wielded similar results.

*Triangulation of Magnetic Susceptibility and Step-Wise Clay Oxidation Analysis*

Table 2: Lower Hidatsa 32ME10 (A: Early Proto-Historic) data summarization

|  |  |
| --- | --- |
| Lower Hidatsa (A) |  |
| Mode | between 300 and 400 |
| Median | between 300 and 400 |
| Maximum | 600 |
| Minimum | 200 |
| Range | 400 |
| Approx. Average\* | 383.3 |

|  |  |
| --- | --- |
| Lower Hidatsa (B) |  |
| Mode | between 300 and 400 |
| Median | between 300 and 400 |
| Maximum | 500 |
| Minimum | 100 |
| Range | 400 |
| Approx. Average\* | 338.9 |

Figure 2: Lower Hidatsa 32ME10 (B: late protohistoric) temperature distribution

Figure 1: Lower Hidatsa 32ME10 (A: early protohistoric) temperature distribution

Table 3: Lower Hidatsa 32ME10 (B: late protohistoric) data summarization

Table 4: Sakakawea 32ME11 data summarization

|  |  |
| --- | --- |
| Sakakawea |  |
| Mode | between 300 and 400 |
| Median | between 300 and 400 |
| Maximum | 500 |
| Minimum | 200 |
| Range | 300 |
| Approx. Average\* | 355.9 |

Figure 3: Sakakawea 32ME11 temperature distribution

Table 5: Taylor Bluff 32ME366 data summarization

|  |  |
| --- | --- |
| Taylor Bluff |  |
| Mode | between 200 and 300 |
| Median | between 200 to 300 |
| Maximum | 600 |
| Minimum | 100 |
| Range | 500 |
| Approx. Average\* | 313.2 |

Figure 4: Taylor Bluff 32ME366 temperature distribution

Table 6: Like-A-Fishhook 32ML2 data summarization

|  |  |
| --- | --- |
| Like-A-Fishhook |  |
| Mode | 300 |
| Median | between 300 and 400 |
| Maximum | 500 |
| Minimum | 200 |
| Range | 300 |
| Approx. Average\* | 316.7 |

Figure 5: Like-A-Fishhook 32ML2 temperature distribution

*Step-Wise Clay Oxidation Analysis Only*

Figure 6: Lower Hidatsa 32ME10 (A: early protohistoric) step-wise clay oxidation data only temperature distribution

Table 7: Lower Hidatsa 32ME10 (A: early protohistoric) - step-wise clay oxidation data only

|  |  |
| --- | --- |
| Lower Hidatsa (A) |  |
| Mode | between 300 & 400 |
| Median | between 300 & 400 |
| Maximum | 600 |
| Minimum | 200 |
| Range | 400 |
| Approx. Average | 380 |

Figure 7: Lower Hidatsa 32ME10 (B: late protohistoric) step-wise clay oxidation data only temperature distribution

Table 8: Lower Hidatsa 32ME10 (B: late protohistoric) - step-wise clay oxidation data only

|  |  |
| --- | --- |
| Lower Hidatsa (B) |  |
| Mode | between 300 & 400 |
| Median | between 300 & 400 |
| Maximum | 500 |
| Minimum | 100 |
| Range | 400 |
| Approx. Average | 330 |

Figure 8: Sakakawea 32ME11 step-wise clay oxidation data only temperature distribution

Table 9: Sakakawea 32ME11 - step-wise clay oxidation data only

|  |  |
| --- | --- |
| Sakakawea |  |
| Mode | between 300 & 400 |
| Median | between 300 & 400 |
| Maximum | 900 |
| Minimum | 200 |
| Range | 700 |
| Approx. Average | 385 |
| Approx. Average (without outlier) | 360.5 |

Figure 9: Taylor Bluff 32ME366 step-wise clay oxidation data only temperature distribution

Table 10: Taylor Bluff 32ME366 - step-wise clay oxidation data only

|  |  |
| --- | --- |
| Taylor Bluff |  |
| Mode | between 200 & 300 |
| Median | between 200 & 300 |
| Maximum | 600 |
| Minimum | 100 |
| Range | 500 |
| Approx. Average | 305 |

Figure 10: Like-A-Fishhook 32ML2 step-wise clay oxidation data only temperature distribution

Table 11: Like-A-Fishhook 32ML2 - step-wise clay oxidation data only

|  |  |
| --- | --- |
| Like-A-Fishhook |  |
| Mode | between 250 & 350 |
| Median | between 250 & 350 |
| Maximum | 600 |
| Minimum | 100 |
| Range | 500 |
| Approx. Average | 305 |

*Data Summary*

Table 12: Data summary for all sites (data from step-wise clay oxidation analysis coupled with magnetic susceptibility)

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Magnetic Susceptibility and Step-Wise Clay Oxidation Analysis** | | | | | | |
| Site | Time period | Mode Temp | Min. Temp | Max. Temp | Range | Approx. Average |
| Lower Hidatsa (A) | 1710 - 1750 | 300 to 400 | 200 | 600 | 400 | 388.3 |
| Lower Hidatsa (B) | 1750 - 1782 | 300 to 400 | 100 | 500 | 400 | 338.9 |
| Sakakawea | 1797 - 1834 | 300 to 400 | 200 | 500 | 300 | 355.9 |
| Taylor Bluff | 1834 - 1845 | 200 to 300 | 100 | 600 | 500 | 313.2 |
| Like-A-Fishhhook | 1845 - 1885 | 250 to 350 | 200 | 500 | 300 | 316.7 |

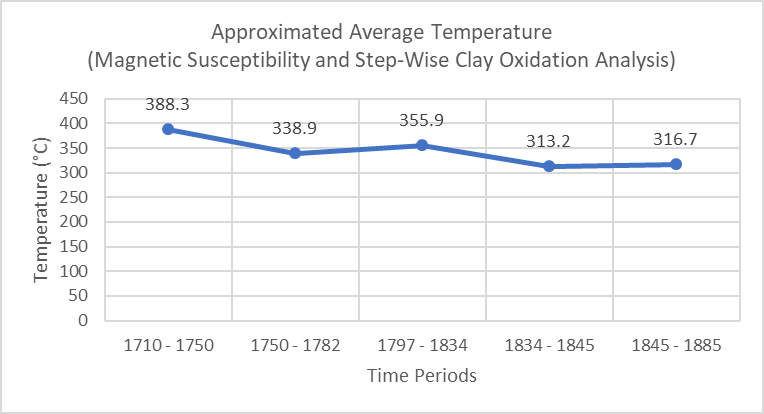


Figure 11: Approximated average temperature graphed for each site. Dashed lines represent epidemics.

Table 13: Data summary for all sites (data from step-wise clay oxidation analysis only)

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Step-Wise Clay Oxidation Analysis Only** | | | | | | |
| Site | Time period | Mode Temp | Min. Temp | Max. Temp | Range | Approx. Average |
| Lower Hidatsa (A) | 1710 - 1750 | 300 to 400 | 200 | 600 | 400 | 380 |
| Lower Hidatsa (B) | 1750 - 1782 | 300 to 400 | 100 | 500 | 400 | 330 |
| Sakakawea | 1797 - 1834 | 300 to 400 | 200 | 500 | 300 | 360.5 |
| Taylor Bluff | 1834 - 1845 | 200 to 300 | 100 | 600 | 500 | 305 |
| Like-A-Fishhhook | 1845 - 1885 | 250 to 350 | 100 | 600 | 500 | 305 |

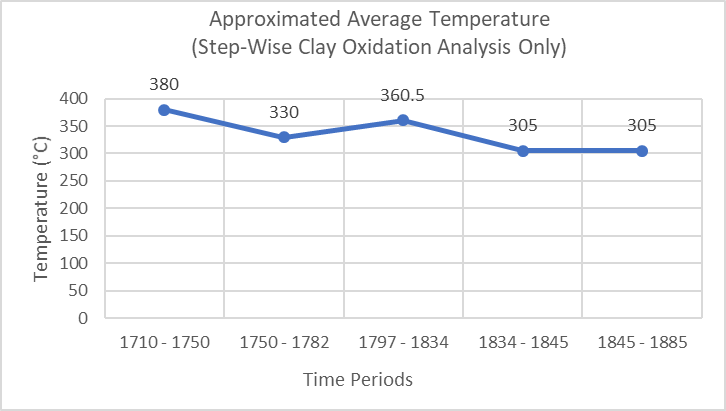


Figure 12: Approximated average temperature graphed for each site. Dashed lines represent epidemics. (Only step-wise clay oxidation data used)

**Discussion**

*Initial decrease in temperature at Lower Hidatsa (32ME10)*

There is a decrease in firing temperature at Lower Hidatsa between AD 1710-1750 and 1750-1780. This supports Ahler and Weston’s (1981) speculation that there may have been earlier, undocumented epidemics in the region, or at least, some kind of change in technological practice around 1750. The notion that an epidemic prior to 1781-1782 is also supported by Truteau’s account that claimed the Arikara had experienced three major epidemics by the time of his visit in 1795 (Ahler and Weston 1981). Additionally, the decrease in approximated average temperature could also be due to the adoption of newer Knife River wares (Lehmer et al. 1978). Before 1750, Le Beau S-rim ware was the dominant ceramic type occurring in high percentages at Mandan sites near the Heart River and used by the Awatixa near the Knife River (Ahler and Weston 1981). It is considered a higher quality ware, and some have speculated it required more time and skill to produce than Knife River ware (Ahler and Weston 1981). It is hard to assign sherds to specific wares on the northern Plains unless they come from rim sherds. Regardless, the earliest sherds, pre-dating the historically documented smallpox pandemic of 1781-1782 had the highest approximated average temperature across all sites in this analysis.

*Increase in temperature at Sakakawea (32ME11)*

Sakakawea’s occupation post-dates the 1781-1782 pandemic, but the data indicate an increase in overall firing temperature. However, Sakakawea has the largest temperature range when the outlier is included in analysis. When the outlier is removed, the range is significantly smaller than the later sites and the approximated average temperature is still greater than the Knife River phase (1750-1780) at Lower Hidatsa. There was about a decade gap in time where the Awatixa abandoned Lower Hidatsa for Rock Village before establishing the village at Sakakawea (Ahler et al. 1980). Though this interim period had increased conflict with the Sioux, this length of time could have been long enough for the Awatixa population to somewhat recover (Hollenback 2012). By recover, I mean the community’s focus no longer solely being one of survival, but instead, a focus on resuming a relatively normal way of life. Even if this was not the case, all three Hidatsa groups were living in close proximity to one another and strengthened their relations after 1781-1782 epidemic with the formation of a tribal council between 1797 and 1798 (Bowers 1992). The Hidatsa groups also aligned themselves with the Mandan, and some, like the Awaxawi, co-resided with them (Ahler et al. 1980). Populations were coalescing during this time, so it is likely the Awatixa Hidatsa had moved from a time where they struggled to survive to a period where they did their best to cope and revitalize pre-pandemic traditional practices (Hollenback 2012). With the movement and intermingling of groups, it is also possible they absorbed skilled potters from other communities.

The approximated average increase in temperature at Sakakawea could also be due to a relatively stable period of economic prosperity between the 1820s and 1830s. The Hidatsa were participants in the fur trade from its earliest beginnings, but their involvement undoubtedly benefitted from the construction of a fur trading post around 1824 by the American Fur Company (Wood 1993). Later known as Fort Clark, the post sought to capitalize on Mandan and Hidatsa trade, as it was strategically located near the Mandan village of Mit-Tutta-Hangkush established in 1822 (Wood 1993). Sakakawea, like the other villages, served as a trade epicenter where nomadic groups stopped to camp and exchange goods (Hollenback 2012). Unfortunately, by the mid to late 1830s, environmental and societal stressors (e.g. raids by the Sioux) left the Hidatsa in a particularly vulnerable state when the epidemic of 1837-1838 hit the Plains (Hollenback 2012).

*Decrease in temperature after the 1837-1838 epidemic*

The estimated temperatures at Taylor Bluff were some of the lowest across all of the sites sampled. The range of temperatures was also one of the greatest. The fact that Taylor Bluff was created after the 1837-1838 epidemic, and during a period of increased aggression from other groups such as the Sioux, suggests that residents were stressed in terms of time, labor, and other demands. The 1837-1838 epidemic was said to have higher mortality rates than the 1781-1782 pandemic, and reports mentioned that the Awatixa that chose to stay in Sakakawea were mostly the elderly and those that wished to care for them (Hollenback 2012). Therefore, the dramatic decrease in temperatures at Taylor Bluff can possibly be explained by the epidemic’s disproportional effect on the older Awatixa population. Additionally, the combination of violence and disease was probably not the most conducive to pottery making or the teaching of other sacred crafts.

*The last traditional earthlodge village*

Results from Like-A-Fishhook are similar to those from Taylor Bluff. The approximated average temperature is low, and changes between the two sites are minimal. The range in temperatures is also large for Like-A-Fishhook. What is most important to note about this site is that pottery production was never eliminated. It continued into the reservation period and the 20th century (Wilson et al. 1977). Hollenback 2012 notes that among the Hidatsa groups and the Mandan at Like-A-Fishhook, the Awatixa continued to produce crafts in their traditional ways more often than the other groups (Hollenback 2012). The difference between the pots produced at previous sites and the ones made at Like-A-Fishhook, however, is that traditional pottery in the second half of the 19th century was used more often in ceremonial rather than utilitarian contexts (Hollenback 2012). Though not all cooking was done in metal vessels, traditional Hidatsa pots were more likely to be used in important ritual feasts than in everyday meals (Hollenback 2012). It could be that the demand for well-made, long-lasting, durable pots for daily use was far lower at Like-A-Fishhook than at previous sites. If this were the case, ritual pots certainly had to be made according to the sacred processes by the correct people, but higher temperatures may not have been necessary if the pot was only going to be used occasionally.

**Conclusion**

This study indicates that the methods of step-wise clay oxidation analysis combined with magnetic susceptibility are not nearly as simple when used to estimate the maximum firing temperature of low-fired clays (which were not fully oxidized), clays fired in reducing atmospheres, and clays that were smudged. The firing environment, especially the three factors I have just listed, must be thoughtfully considered when examining the Munsell changes and the first derivative squared of the low and high frequency magnetic susceptibility data.

Furthermore, this study has shown that the relationship between Hidatsa sacred craft knowledge and epidemic disasters was not one of steady knowledge loss. There is no doubt that the Awatixa Hidatsa suffered immensely due to smallpox, but despite everything, survivors and subsequent generations did their best with the available materials to continue the traditional practice of sacred crafts such as pottery. This study demonstrates that there were indeed substantial decreases in firing temperature, particularly after the 1837-1838 epidemic, but there was also an increase after the 1781-1782 epidemic at the site of Sakakawea. Additionally, this study supports Ahler and Weston’s hypothesis that there may have been a severe epidemic around 1750, at least based on the firing temperature data, that aligns with oral tradition despite not being recorded historically (Ahler and Weston 1981). The dips in firing temperatures could have been due to a number of reasons, including the proposed changes in (1) skill level of potters, (2) labor requirements, and (3) fuel demand. The prioritization of basic survival and a shift away from daily use of pottery to ceremonial use should also be considered, especially for sites like Taylor Bluff (32ME366) and Like-A-Fishhook (32ML2). Ethnographic accounts also support the idea that, during the 19th century, higher quality material sources were much harder to obtain. The knowledge of where to find the correct materials somewhat remained, but lower-quality substitutes were used in their stead due to the effort required.

In conclusion, the longevity of pottery production among Awatixa Hidatsa women is a testament to their resilience and steadfast reliance on tradition despite the disastrous epidemics faced in the late 18th and early 19th centuries.

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