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REPORT

Finding the protohistoric: bone modification analysis as a means of identifying post-contact levels at the vore site

Greg Pierce, Damian Kirkwood and Charles Reher

This paper discusses the utility of using bone modification analysis as a means of differentiating between pre- and post-contact sites, or strata within a site, and how these data can be used to track and understand the implications of the introduction of new technologies on indigenous systems. The authors examined a sample of bison elements from the Vore site, 48CK302, in Wyoming for the purpose of identifying different modifications on each bone, specifically stone and metal tool marks. The results of this analysis could be used to differentiate between pre- and post-contact strata at the Vore site which allowed the authors to enter into a discussion on the relative frequency of metal tool use on the site and how this may relate to regional trends.

KEYWORDS Cut mark analysis, alternative dating methods, protohistoric, high plains archaeology

The Vore Buffalo Jump, 48CK302, is located in the Red Valley of the Black Hills in northeastern Wyoming (Figure 1). The site comprised a large karst-like sinkhole measuring 30 m across and 15 m deep (Reher and Frison 1980:8). The sinkhole was used by Native Americans as a bison jump and contains at least 22 cultural levels, or discrete kill events (Crago 2003:16; Reher and Frison 1980:1). The results of this hunting activity were complex stratigraphic layers "with stacked bone middens lensing in and out, forming discrete levels in some areas and thick conglomerates in others" (Reher and Frison 1980:138).

Analyses of varve-like sediments, dendrochronology, radiocarbon dates, and the High Plains projectile point typology (Frison 1991) date the utilization of the

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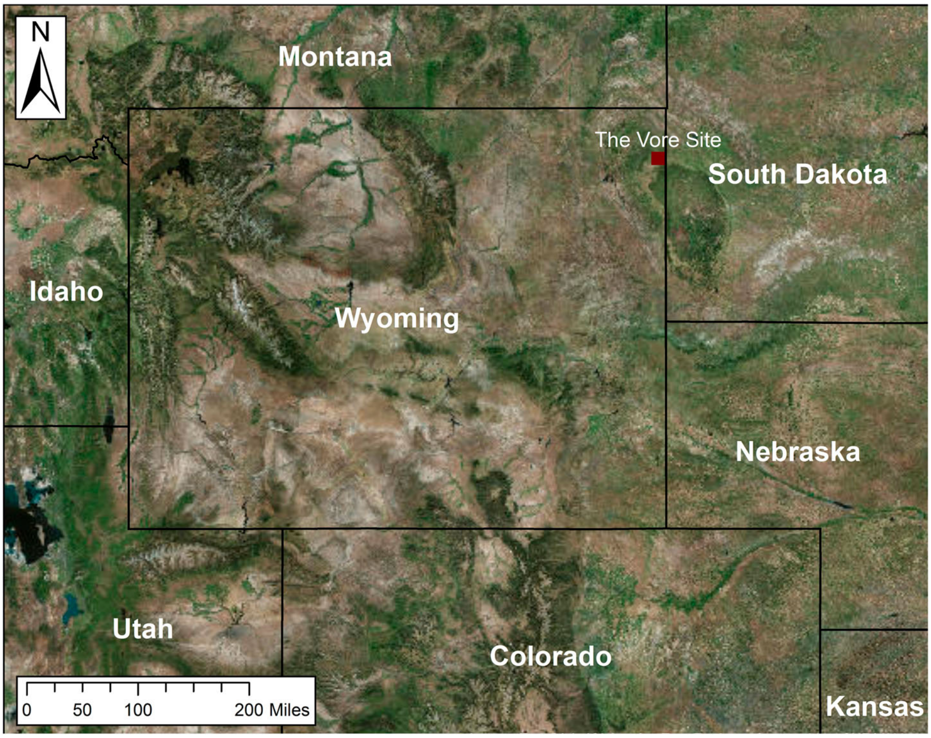

FIGURE 1 Location of the Vore site, 48CK302 (Esri et al. 2016).

jump between AD 1500 and 1800 (Crago 2003; Reher and Frison 1980). This places the use of the site temporally in the Late Prehistoric/Protohistoric/Early Historic transition in the region. The approximate 300-year span of time from the Late Prehistoric to the Early Historic period marks an especially dynamic era on the High Plains of North America. Native populations in the region saw environmental, demographic, and technological changes. The end of the Late Prehistoric period was the onset of the Little Ice Age, an environmental episode resulting in cooler and wetter conditions in parts of North America (Reher and Frison 1980:40). These environmental conditions arguably led to shifts in the settlement and subsistence practices of indigenous populations across North America and contributed to the migration of tribal populations into the High Plains region. By the late seventeenth and early eighteenth centuries, Euroamerican items were filtering into the region via existing native trade networks. Small numbers of Euroamerican trappers had moved into the High Plains and Rocky Mountains by the mid- to late-eighteenth century. These trappers were trading with and living among the indigenous populations. The Euroamerican presence in the area increased through the early part of the nineteenth century, marked by intense beaver hunting during the first few decades and emigration and the development of the buffalo robe trade by the 1840s. By the 1850s, the United States Military had established a permanent presence in the area, and the 1860s and 1870s saw war between the United States and many of the native tribes. Finally, the end of the century saw the relocation of these tribal groups to reservations.

Central to native subsistence during this period was the bison. Beginning in the Little Ice age, environmental conditions improved foraging capacity for bison resulting in larger, more densely distributed herds (Bamforth 1988:74). Changes to bison ecology ultimately led to improved bison foraging for native groups across the plains resulting in an increase in bison hunting activities by mobile and semi-sedentary populations alike (Sutton 2004:3). It is believed that increases in bison hunting resulted from the development of broad-based subsistence practices and in response to the need to feed larger populations (Bozell 1995:156–157). As their populations increased, bison hunting was further intensified as large communal hunts allowed for massive amounts of meat to be obtained at one time.

While communal hunting could be practiced year-round, it was the fall hunts that were especially important. Tribal groups required large quantities of preserved meat to survive the winter (Ferris et al. 2000:19; Reher and Frison 1980:236). To acquire this meat, smaller family units and bands aggregated into larger groups to participate in fall hunts (Bozell 1995:157). These hunts were governed by supernatural and ritual beliefs and practices that helped to organize the hunt, compelled people to adhere to the rules of the engagement, and to ensure the success of the endeavor (Forbis 1978:3; Frison 1991:219). After the introduction of the horse, the use of bison jumps and pounds fell off in favor of the chase method whereby mounted hunters would surround or chase a herd killing them with bows from horseback (Brink 2008:246–250; Forbis 1978:7; Frison 2004:120).

The use of the Vore site as a large communal bison jump during the Late Prehistoric/Protohistoric/Early Historic transitions presents researchers the opportunity to investigate the manner in which native populations responded to a range of external pressures: environmental, technological, and demographic. The use of this site also predates the wholesale movement of Euroamericans into the region, allowing for the investigation of the interplay between Euroamerican goods and technologies and indigenous subsistence practices prior to the increased influence of Euroamericans. Additionally, the prolonged use of the site allows for a comparative assessment of bison procurement and butchering strategies from one location over an extended period of time.

However, prior to engaging in this type of analysis, one must accurately differentiate between pre- and post-contact levels. Based on the temporal range of the site's use, one would expect Euroamerican goods, such as metal knives and projectile points, which would have been associated with hunting and butchering activities, to be present in the archaeological deposits.

Despite this, no Euroamerican goods have been recovered from Vore. The absence of Euroamerican goods makes it difficult to properly and confidently differentiate between pre- and post-contact levels, preventing researchers from developing an accurate timeline of the site's use. One possible means of addressing this issue is through bone modification analysis. Bone modification analysis can allow one to look for evidence of the presence of Euroamerican goods when the artifacts themselves are absent. While some preliminary, and unpublished, work has been conducted identifying human-made modifications on the Vore bones, this analysis did not differentiate between modifications generated by metal or stone tools. The stratified deposits and the temporal span of the Vore site make it an ideal dataset from which to examine the transition from stone tools to metal implements and test whether bone modification analysis can serve as an alternative dating method.

Bone modification analysis

A brief history of bone modification analysis

Bone modification studies have been ongoing since at least the 1970s. Much of this previous research has focused on recording the morphology and identifying characteristics of various modification types (Bello et al. 2009; Capaldo and Blumenschine 1994; Greenfield 2006; Potts and Shipman 1981; Walker and Long 1977) and developing methodologies aimed at differentiating between various modification types (Fisher 1995; Milner et al. 2000; Olsen and Shipman 1988; Shipman 1981; Shipman and Rose 1983a, 1983b).

This research has developed a robust methodology for identifying various human-made modifications on bone and for differentiating between those modifications and marks made by other natural processes. It is widely held that a V-shaped groove (Figure 2), fine parallel striations within the groove (Figure 3), and barbs at the end of the groove are traits commonly associated with cut marks made during the butchering process (Shipman 1981; Shipman and Rose 1983a; Walker and Long 1977). In comparison to cut marks, chop marks tend to be broad, relatively short, linear depressions with an elongated oval outline, a V-shaped cross-section, and crushed or fragmented bone in the nadir of the mark (Fisher 1995:19; Shipman 1981:366).

Fisher (1995:12–16) recommends using these diagnostic traits in concert with what he refers to as the configurational approach. A configurational approach examines contextual information such as the anatomical placement of the mark, the number of marks present on a given bone, the orientation of the mark, and the association of a mark with other bone surface modifications as a means of assessing the likelihood of human agency (Behrensmeyer et al. 1986; Oliver 1989, 1994; Olsen and Shipman 1988; Shipman 1988). The configurational approach provides further insight into surface modifications through the use of contextual information

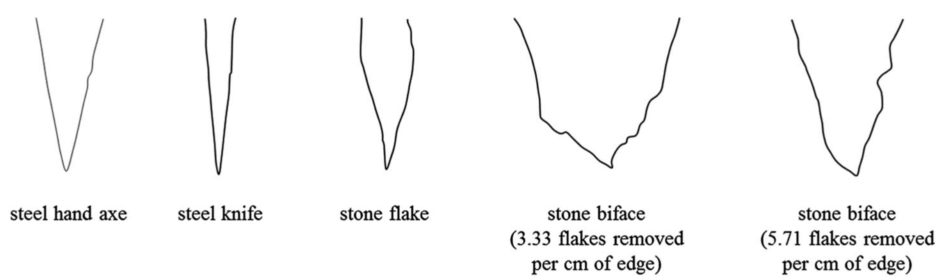

FIGURE 2 Basic cross-sectional morphologies of metal and stone modifications (Adapted from Walker and Long 1977:607).

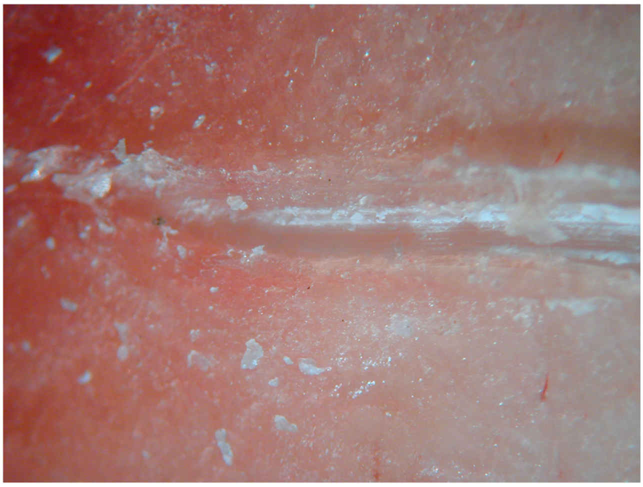

FIGURE 3 Low-power microscope image of a stone cut mark with internal striations.

based on our understanding of human butchering practices. Combining these methods of analyses allows researchers to operate with high levels of confidence.

Bone modification studies have also been used to examine a range of questions relating to human behavior. This form of analysis has been used as a means of investigating early hominin evolution (Pickering and Hensley-Marschand, 2008), early hominin hunting and scavenging (Binford 1981, 1985, 1988; Bunn 1981; Bunn and Kroll 1986; Potts 1983, 1988; Potts and Shipman 1981; Shipman 1986, 1988; Shipman and Rose 1983b), differentiating between carnivore and hominin activity (Blumenschine and Selvaggio 1988; Cruz-Uribe 1991), examining butchery and transport strategies (Binford 1978, 1981, 1984; Bonnichsen 1973, 1979; Crader 1974; Frison 1991; Guilday et al. 1962; Jones 1980), and to track the spread of metallurgy in Europe (Greenfield 1999, 2005).

Relationship to this study

Of interest to this paper are studies which have used human-generated bone modifications as a means of looking for the presence of items or technologies that were used at a location but did not pass into the archaeological record. These types of investigations have a long history in archaeological inquiry. As early as 1956, the identification of metal tool cut marks, as opposed to stone, on animal bones recovered from a rockshelter in New Zealand was used as a means of assigning a post-European contact date to the cultural occupation (Duff 1956). Decades later Walker and Long (1977:606) determined that human modifications to bones such as butchery marks can be used to infer the usage of tools at an archaeological site, even in the absence of the tools themselves.

More recently, and perhaps most relevant to this paper, Greenfield (1999, 2005) examined the frequency of metal versus stone butchering marks on animal assemblages dating to the Late Neolithic through the Bronze Age in the central Balkans and southeast Europe. He found that "quantifying the distribution of metal versus stone tool types over time and space provides insight into the processes underlying the introduction and diffusion of a functional metallurgical technology for subsistence activities" (Greenfield 1999:797). In this work, Greenfield used metal tool cut marks as a proxy measure to more accurately investigate the spread of metal items and associated technologies. Similarly, this paper uses the identification of metal tool marks at an archaeological site to identify post-contact strata within a larger site. This paper also discusses how differential cut mark frequencies between strata can be used to investigate issues relating to the spread of metal tools across the American West.

Methods

In an effort to identify post-contact levels at Vore, a sample of the site's faunal assemblage was analyzed. The Vore sample consisted of 82 elements including 8 femora, 15 humeri, 6 metacarpals, 20 scapulae, and 33 mandibles. These elements were chosen as they were likely to represent a range of butchering activities including skinning (metacarpals), defleshing (femora, humeri, and scapulae), and tongue removal (mandibles). The entire collection of excavated faunal remains from Vore easily numbers into the tens of thousands, making an analysis of every bone unrealistic. Researchers initially planned to take their sample from all 22 cultural levels. Unfortunately, this material was excavated in the 1970s and while still in excellent condition, these bones were unable to be used for this project as the small amount of deterioration due to exposure and handling had obscured the microscopic traits needed to engage in this form of analysis. Due to this, the elements were selected from the modern excavation units opened in the 1990s. Therefore, the sample used in this study comes from the top six cultural levels at Vore.

Each element was first examined under a 10× magnification lens by three researchers who recorded visible surface modifications. Marks with attributes common to human bone modifications were collectively recorded for each sample. These marks were then independently examined by two researchers under a stereoscopic microscope up to a magnification of 75×. While higher levels of magnification have been used in other studies employing scanning electron microscopes (SEM), magnification below 100× is often sufficient to accurately identify diagnostic traits. Low magnification analysis also offers some benefits over SEM analysis. SEM requires small samples which need to be treated before analysis. This treatment can be costly, and the small sample limits the portion of each cut mark which can be examined at one time. Low level magnification requires no pretreatment and can allow for diagnostic criteria to be more clearly identified as there is a greater field of vision (Greenfield 1999:799, 2006:151). The results of each researcher's analysis were compared, with concurring results being recorded as such. Modifications that were recorded differently by researchers were re-examined and recorded only when a consensus was reached. In the seven instances when no consensus could be reached, the mark was recorded as unidentified.

Researchers recorded the modification's length in millimeters, maximum and minimum width in microns, the association of the bone surface modification with other marks, the cross-section of the mark, the presence or absence of symmetrical sides, the presence or absence of a uniform rise to each side of the mark, the presence or absence of a uniform groove depth, trajectory as straight, arcuate, or serpentine; the orientation of the mark on long bones, the location of the cut mark on the bone, the presence or absence of barbs, the presence or absence of striations, and the presence or absence of uniformity in the striations. The relation of each of these attributes to this analysis is presented in Table 1.

The study conducted for this paper was based on the previous work by Blumenschine et al. (1996). This study used low-power microscope analysis to differentiate between carnivore tooth, hammerstone percussion, and cutting and scraping marks on bones that had been placed there by researchers so as to be able to accurately assess the results of the analysis. An overall accuracy of 90 percent was reached by novices with no prior experience in cut mark or faunal analysis after spending only three hours studying bone modification diagnostics and images. After a total of six hours studying the same materials, these individuals increased their accuracy to 95 percent. Experienced analysts reached over 97 percent accuracy in correctly differentiating between several types of bone surface modifications.

In an effort to duplicate this type of accuracy, researchers for this project spent over 10 hours examining bone modification diagnostics and an additional 10 hours analyzing a controlled sample under low magnification. The control sample consisted of 12 cow femora and humeri. The elements were obtained from a local butcher and boiled to remove the flesh and periosteum. Marks made by the initial butchering process were recorded, and then each element was marked with a variety of unifacial metal, bifacial metal, bifacial stone, and stone flake marks.

TABLE 1

RECORDED ATTRIBUTES AND THEIR MEANING.

RECORDED ATTRIBUTE	IMPORTANCE
WIDTH	Metal tool cut marks tend to be thinner than stone cut marks and chop marks. Metal tool cut marks often have a more consistent width across the length of the cut
SYMMETRICAL SIDES	Vascular grooves and root etching often have symmetrical sides while chop marks, trampling marks, and stone tool cut marks generally do not. Metal tool cut marks often have symmetrical sides on bifacial blades, although unifacial blades and different cut angles can present unsymmetrical sides
UNIFORM SIDES	Metal tool cut marks generally have uniform slopes to the sides of the groove. Stone tool cut marks do not
LOCATION	Some modifications show locational preference. Trampling marks are most often found on the shaft. Cut marks generally result from three activities: skinning, disarticulation, and filleting. Skinning marks can be found on the long shaft of the lower leg and phalanges and the lower portion of the mandible. Disarticulation marks can be found on vertebrae or pelvic bones as well as the articular surface of long bones. Filleting can result in cut marks that run parallel to the long axis of a bone (Binford 1981)
STRIATIONS	Stone tool cut marks often have internal striations that run parallel to the length of the cut. Vascular grooves, root etching, trampling marks, sediment abrasion, chop marks, excavator damage, and carnivore activity do not present internal striations. Metal tool cut marks generally do not leave internal striations. When they do they are of more uniform depth and spacing than those made by stone
UNIFORM STRIATIONS	Striations found in stone tool cut marks have less even length, thickness, and spacing than those found in metal tool cut marks

Each mark's location and source was recorded. Blind tests were conducted whereby researchers examined a selected number of modifications on each bone. The efficiency in analysis of this controlled sample increased from less than 80 percent on the first elements to over 98 percent after an additional 6 hours of microscopic analysis.

For each bone from the Vore sample, the number and location of each human modification was recorded. Cut marks were recorded as raw counts and as butchery instances. A butchery instance is defined as a discrete, non-adjacent (>1 cm apart), and non-overlapping mark or set of marks (Lyman 1992:250, 1994:304). Butchery instances were recorded because in many cases cut marks can be clustered and overlapping. When this occurs, earlier marks may be obscured or even destroyed, making the generation of an accurate tally of discrete marks impossible. There are also analytical implications to recording the modifications in this manner. When using the presence and frequency of cut marks as a metric for analyzing differences in the presence and/or intensity of usage of metal implements on a site, raw cut mark counts may not present an accurate representation of historic and prehistoric activities. This is due to the fact that butchering skill, tool shape and sharpness, seasonality, and tissue density can all influence the effectiveness of a single cut. Differences in these areas can result in differential cut mark counts from the same type of activity. Without the ability to control for these variables, it becomes difficult to determine if differences in cut mark counts are due to the number of metal items present, the intensity of metal use in a given level, or if the variability is in fact reflective of factors completely unrelated to metal tool use such as butchering skill, tool shape and sharpness, or tissue density. To compensate for this, cut mark instances are used as they likely represent a single butchery step and are more reflective of intensity of activity and use than raw cut mark counts.

Results

Of the 82 bones examined, 28 contained human-generated modifications. A total of 288 cut marks, 55 cutting instances, 4 chopping marks, and 1 chopping instance were recorded. Additionally, green bone breakage and interior bone flakes in the vicinity of green breakage were used to identify instances of marrow processing when no tool marks could be identified. Using these criteria, 16 instances of marrow processing were recorded. Overall, 34.1 percent of our sample bore visible human-made bone modifications. Lower percentages of bones with identifiable modification marks should not be considered unusual as other studies have identified human modifications on between 2.0 and 14.5 percent of the examined assemblage (Miller and Burgett 2000:30; Scheiber 2007:304). At Vore, previous studies have shown between 6.0 and 33.0 percent of a given analyzed sample bear evidence of butchery, depending on the element examined (Burgett 1989).

Of the 288 cut marks identified, 174 were made by metal implements and 114 were generated by stone tools. The material of the implement that created the four chop marks could not be identified. Further analysis of these cut marks reveals that there are 55 total butchery instances from this sample, 16 of which are from stone tools and 39 of which are from metal implements.

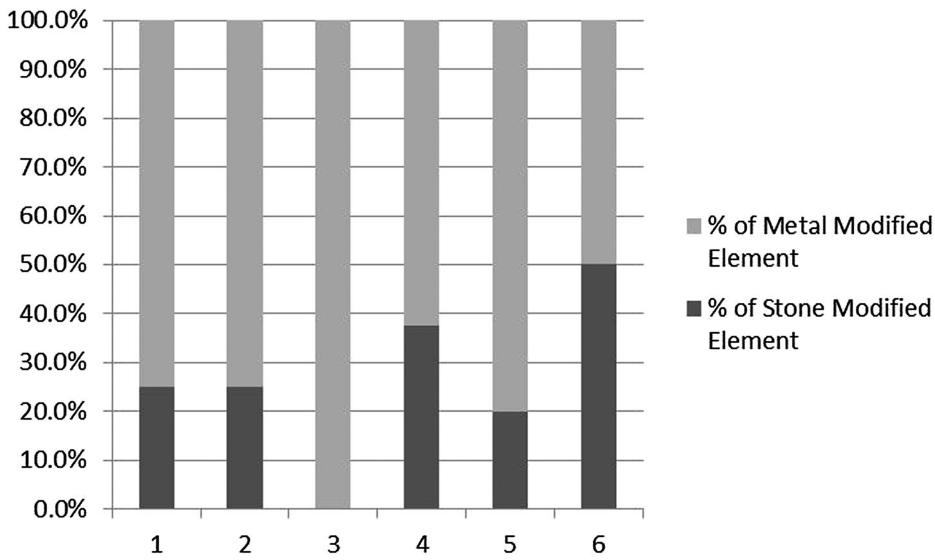

FIGURE 4 Percentage of stone- and metal-modified elements by cultural level.

The analysis reveals that every cultural level included in this study, cultural levels 1–6, contained bones with metal tool cut marks. This helps confirm the current understanding of the Vore chronology derived from radiocarbon dates and varve-like sediments that date the upper third of the site to AD 1700–1800 (Reher and Frison 1980:29). Stone tool cut marks can be found in every level with the exception of cultural level 3. Although the sample of bones with cut marks is small, between 3 and 8 per level (between 25.0 and 60.0 percent of the analyzed sample per level), there appears to be general similarities between cut mark instances and the percentage of elements modified by stone versus metal in cultural levels 1–5, with cultural level 6 standing in contrast. Cultural levels 1–5 have higher overall frequencies of elements modified by metal as opposed to stone, with a high of 100 percent metal to 0 percent stone in cultural level 3 and a low of 62.5 percent metal and 37.5 percent stone in cultural level 4. In cultural level 6, the ratio is 50 to 50 percent (Figure 4). This relationship is even more pronounced when butchery instances are analyzed. Cultural levels 1–5 have higher overall frequencies of metal versus stone butchery instances, with a high of 100 percent metal to 0 percent stone in cultural level 3 and a low of 66.7 percent metal and 33.3 percent stone in cultural level 4. In cultural level 6, the ratio is 66.7 percent stone to 33.3 percent metal (Figure 5). Tables 2 and 3 present the relationship between bone modifications and the Vore cultural levels.

Discussion and conclusion

An analysis of the Vore data show metal tool cut marks present in every level, indicating that the top six cultural levels at Vore date to the post-contact period. Unfortunately, due to limitations in the sample used for analysis, no pre-contact strata

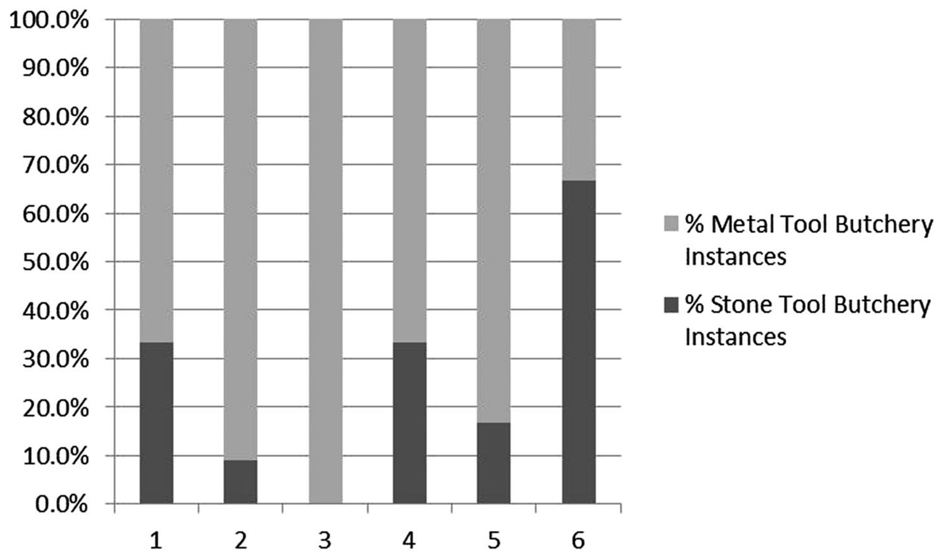

FIGURE 5 Percentage of stone and metal butchery instances by cultural level.

were identified. However, an analysis of the cut mark frequency data can provide insight into the relationship of the upper six cultural levels at Vore and the historical processes at work during the Late Prehistoric, Protohistoric, and Early Historic transition in the region.

The Vore data reveal continuity in the percentages of stone to metal tool cut mark distributions, and on the percentage of stone to metal butchery instances in cultural levels 1–5. In these levels, the majority of the bones were modified by metal implements and metal tool cut mark frequencies outnumbered stone. These data show a clear preference for metal tools for the first five cultural levels of the Vore site. Cultural level 6 deviates from the patterns seen in the upper levels. In this

TABLE 2

ELEMENT AND CUTMARK DATA BY LEVEL.

		Elements with cut marks		Elements with stone tool cut marks		Elements with metal tool cut marks		Percent of stone-or metal-modified elements	
Cultural level	Element count per level	# with	% of	# with	% of	# with	% of	Stone	Metal
1	16	4	25.0	1	6.3	3	18.8	25.0	75.0
2	13	4	30.8	1	7.7	3	23.1	25.0	75.0
3	5	3	60.0	0	0.0	3	60.0	0.0	100.0
4	26	8	32.0	3	12.0	5	20.0	37.5	62.5
5	11	5	45.5	1	9.1	4	36.4	20.0	80.0
6	11	4	36.4	2	18.2	2	18.2	50.0	50.0

TABLE 3

CUT MARK FREQUENCIES, INSTANCES, AND MARROW PROCESSING.

Cultural level	Count per level	Total cut marks	Total butchery instances	Stone tool cut marks	Stone tool butchery instances	Metal tool cut marks	Metal tool butchery instances	Percent of stone tool butchery instances	Percent of metal tool butchery instances	Marrow processing	Percent with marrow processing
1	16	59	6	46	2	13	4	33.3	66.7	5	31.3
2	13	76	11	1	1	75	10	9.1	90.9	0	0.0
3	5	11	5	0	0	11	5	0.0	100.0	0	0.0
4	26	50	18	14	6	36	12	33.3	66.7	9	36.0
5	11	12	6	1	1	11	5	16.7	83.3	2	18.2
6	11	80	9	52	6	28	3	66.7	33.3	0	0.0

level, 50 percent of the cut mark-bearing elements were modified by stone and the majority of cut marks were generated by stone tools. The cultural level 6 data suggest an increase in the use of metal implements at Vore in the upper five cultural levels.

Unfortunately, without data from the levels immediately below cultural level 6, it is difficult to determine if trends suggesting the reduction and eventual disappearance of metal tool cut marks continue into the lower levels. The presence of fewer metal tool cut mark counts in cultural level 6 could be a result of sampling issues from that level, tribal preference for traditional stone technologies, or short-term fluctuations in the availability of metal tools during the Protohistoric period.

Fortunately, differences in the presence, or at least the use, of metal implements across cultural levels as suggested by the analysis of cut mark frequencies can be supported by an analysis of the lithic assemblage from the site. Three general lithic types were recorded at the Vore site: retouching flakes, butchery tools, and projectile points. All three lithic categories are found in each of the site's 22 cultural levels. In examining the lithic assemblage from Vore, comparing raw numbers per level is likely not a productive means of investigating changes or similarities through time. This is primarily because of the variability of each kill event and in the excavated sample from each level. Each event was participated in by a different number of people, various tribes, and resulted in the collection of a different number of bison. Excavation levels 1–8 returned a Minimum Number of Individuals (MNI) of between 15 and 130 bison. This number, of course, does not reflect the actual number of bison contained within each excavation level as the sample ranges between an estimated 10–15 percent in the upper 12 cultural levels to only 1 to 3 percent from the lower levels (Pierce 2015:113; Reher and Frison 1980:13). However, as the lithic assemblage has the same sample rate as the bison bones themselves from each excavation level, these two sets of data provide a useful comparative sample on which to base our analysis.

In an effort to allow for a cross-level comparison, flake, tool, and point counts were generated in relation to the MNI for each level. This resulted in the creation of flakes per bison, tools per bison, and points per bison count ratios that provide a means of assessing the number of lithics deposited at the site in relation to the intensity and size of the actual kill event (Table 4).

Using this metric, an analysis of debitage, tools, and projectile points from the original and recent excavations was conducted with the understanding that as metal tools became more accessible and came to be possessed in greater numbers, the use of stone tools would have decreased. Archaeologically, this would have manifested itself in the presence of more metal tool cut marks and less made by stone tools onsite as indigenous populations gained greater access to metal implements. This would have coincided with a general reduction in the presence of stone tools and debitage in archaeological assemblages as these items were replaced by new metal technologies. An analysis of the Vore lithic data by level reveals that stone tools were present in higher numbers in the lower cultural levels. Lithic counts decrease in the upper cultural levels (Pierce 2015:135–140). The lithic data corroborate the cut mark analysis, showing a clear difference in the use of metal tools in the upper cultural levels at Vore, suggesting that metal tools were present in larger

TABLE 4

VORE LITHIC DATA.

Excavation level	Associated cultural levels	Level MNI	Number of flakes	Flakes per bison	Number of tools	Tools per bison	Number of points	Points per bison	Total number of lithics	Total lithics per bison
1	1, 2, 3	42	118	2.8	79	1.9	15	0.4	212	5
2	3, 4, 5	86	332	3.9	212	2.5	32	0.4	576	6.7
3	5, 6, 7	116	461	4.0	267	2.3	29	0.3	757	6.5
4	7, 8, 9	67	306	4.6	199	3.0	35	0.5	540	8.1
5	9, 10, 11	130	536	4.1	311	2.4	23	0.2	870	6.7
6	11, 12	22	34	1.5	32	1.5	15	0.7	81	3.7
7	12, 13, 14	18	56	3.1	57	3.2	26	1.4	139	7.7
8	14, 15, 16	15	62	4.1	55	3.7	23	1.5	140	9.3

numbers in the upper cultural levels and/or were used preferentially during these kill events.

These results have implications for our understanding of how items and technologies spread and are incorporated by new populations. Variability in the presence and/or use of metal tools within or between sites can allow researchers to better understand the movement of metal tools across the landscape, to investigate differential access to this resource by geography or cultural group, and to examine the interplay between existing indigenous technologies and new technologically superior foreign introductions.

At the Vore site, the lithic and cut mark datasets indicate that cultural levels 1–5 likely represent a portion of time on the High Plains and in the Rocky Mountains when indigenous populations had at least semi-regular access to Euroamerican manufactured trade items which were obtained through native trade networks as well as direct exchanges with Euroamerican trappers, traders, and trading posts. Variations in the percentages seen across these levels could be a result of changes in trade good availability from year to year, tribal preference, or sample size. These levels likely date to the Protohistoric and Early Historic periods. Cultural level 6 dates to the incipient Protohistoric period in the region, a time when Euroamerican trade goods were difficult to come by. Goods were likely obtained via down the line trade or from sporadic encounters with traders and trappers visiting the region. Metal tool marks would have been limited in relation to stone marks in the cultural levels immediately below cultural level 6 only to disappear in subsequent cultural levels dating to the Late Prehistoric period in the region.

The results of this study illustrate how bone modification analysis can be used not only to identify post-contact levels in Native American sites, but also to enter into larger discussions about how and where technologies spread and how new technologies and items are incorporated into existing indigenous cultural systems. The presence of metal tool cut marks on bones from the Vore assemblage confirmed what radiocarbon dating and varved sediment analysis suggested – that portions of the site's use dated to the Protohistoric period. More importantly, the study shows that analyses of bone surface modifications have the ability to serve as a means of investigating technological change and cultural adaptation. The Vore dataset allows researchers to track the influx of metal tools and assess the frequency of metal tool use onsite. This information presents researchers with an important jumping off point from which to address larger questions about the retention of traditional technologies in post-contact settings and the manner in which existing indigenous subsistence practices were impacted by the introduction of Euroamerican items.

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Disclosure statement

No potential conflict of interest was reported by the authors.

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