FOSSIL BISON AND ARTIFACTS FROM AN EARLY ALTITHERMAL PERIOD ARROYO TRAP IN WYOMING

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*The Hawken site is a steep-sided arroyo into which small groups of bison were driven and slaughtered. The bison, which date about 4500 B.C. during the Altithermal period, are an extinct variant (*B. bison occidentalis*) and are morphologically intermediate between* B. bison antiquus *and* B. bison bison. *The projectile points are in the Altithermal period Side-Notched tradition and the butchering tools are similar to those found in many bison kill sites from the Paleoindian to the end of the Late Prehistoric period. Continuity of bison procurement methods from Paleoindian through Altithermal and into post-Altithermal times is suggested.*

TRAPPING BISON AT THE SITE

THE HAWKEN SITE is located in the Wyoming part of the Black Hills about seven miles south of Sundance (Fig. 1). The site, located close to a large gathering area for bison, is well-watered with good grass, and there is a favorable approach for animals to the actual location of the kill.

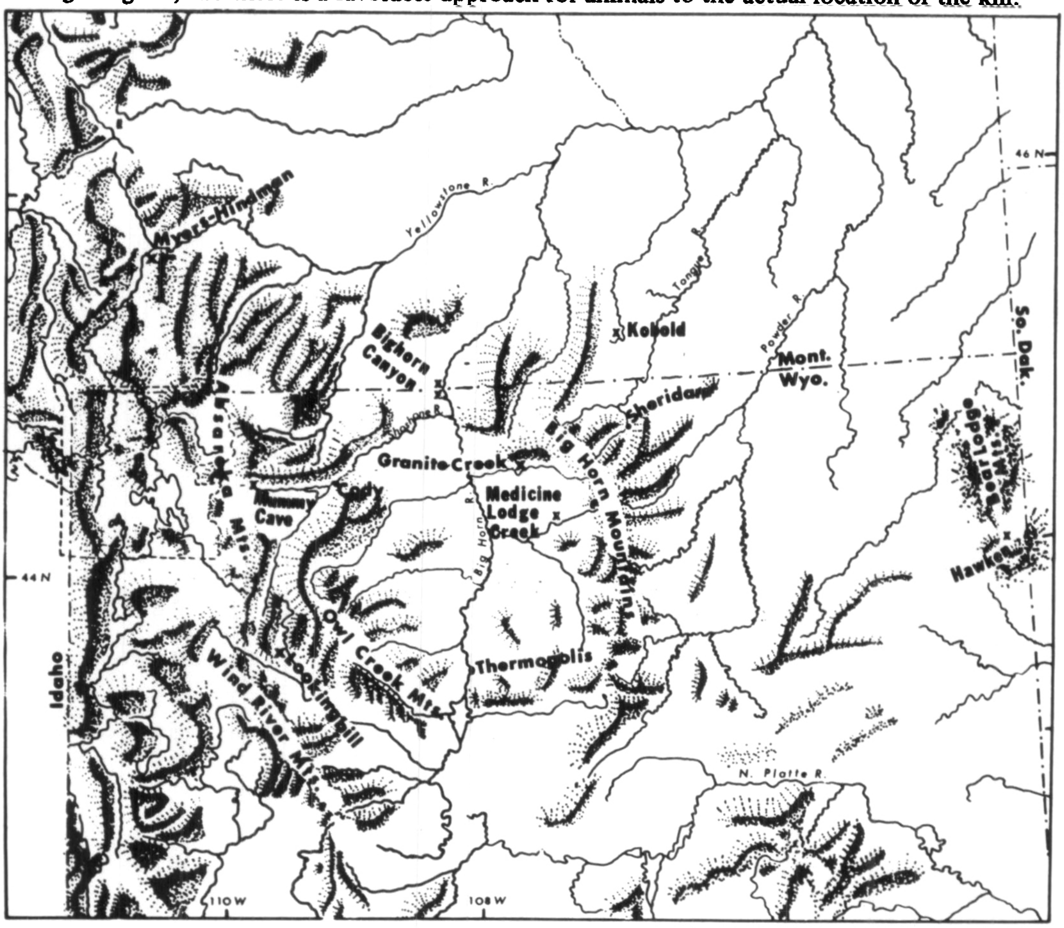

Fig. 1. Northern Wyoming and southern Montana with important geographical features and archaeological sites of the Altithermal period.

In prehistoric times the Black Hills area was apparently optimum for bison as evidenced by the number of bison procurement sites including jumps and natural traps which are known around its southern periphery where the proper geomorphic features are found. In the area of the Hawken site a Triassic red sandstone formation forms a scarp to the south of an area of low, rolling hills and shallow meandering arroyos. Slopes increase toward the base of the scarp for several hundred yards and the soils, derived from the erosion of the sandstone, are deep. Arroyos dissecting this area are deep and narrow with steep banks. They extend into the areas of lesser relief and, as their gradients decrease, become wider with flat bottoms and lower banks. They provided ideal avenues up which bison could be driven until knickpoints (Schumm and Hadley 1957) formed natural traps.

The Hawken site was a bison trap of this nature (Figs. 2, 3, 4). Downstream from the scarp the sides of the arroyo were up to 35 feet high and too steep for the animals to negotiate (Fig. 5).

Fig. 2. Bison bone in part of the middle level at the Hawken site.

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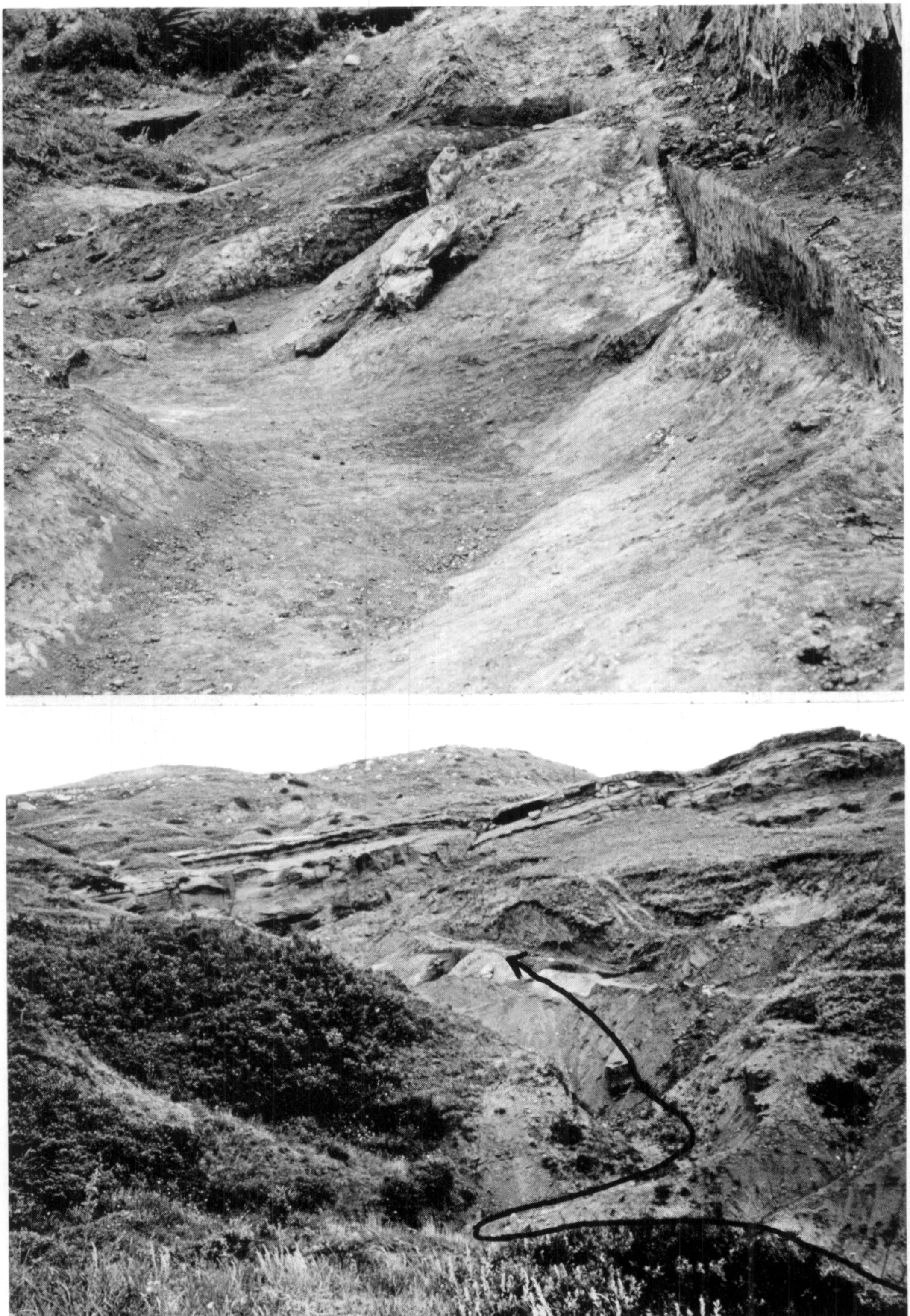

Fig. 3. The old arroyo with bone removed (top), and the route up the arroyo that bison were driven to the kill site (bottom).

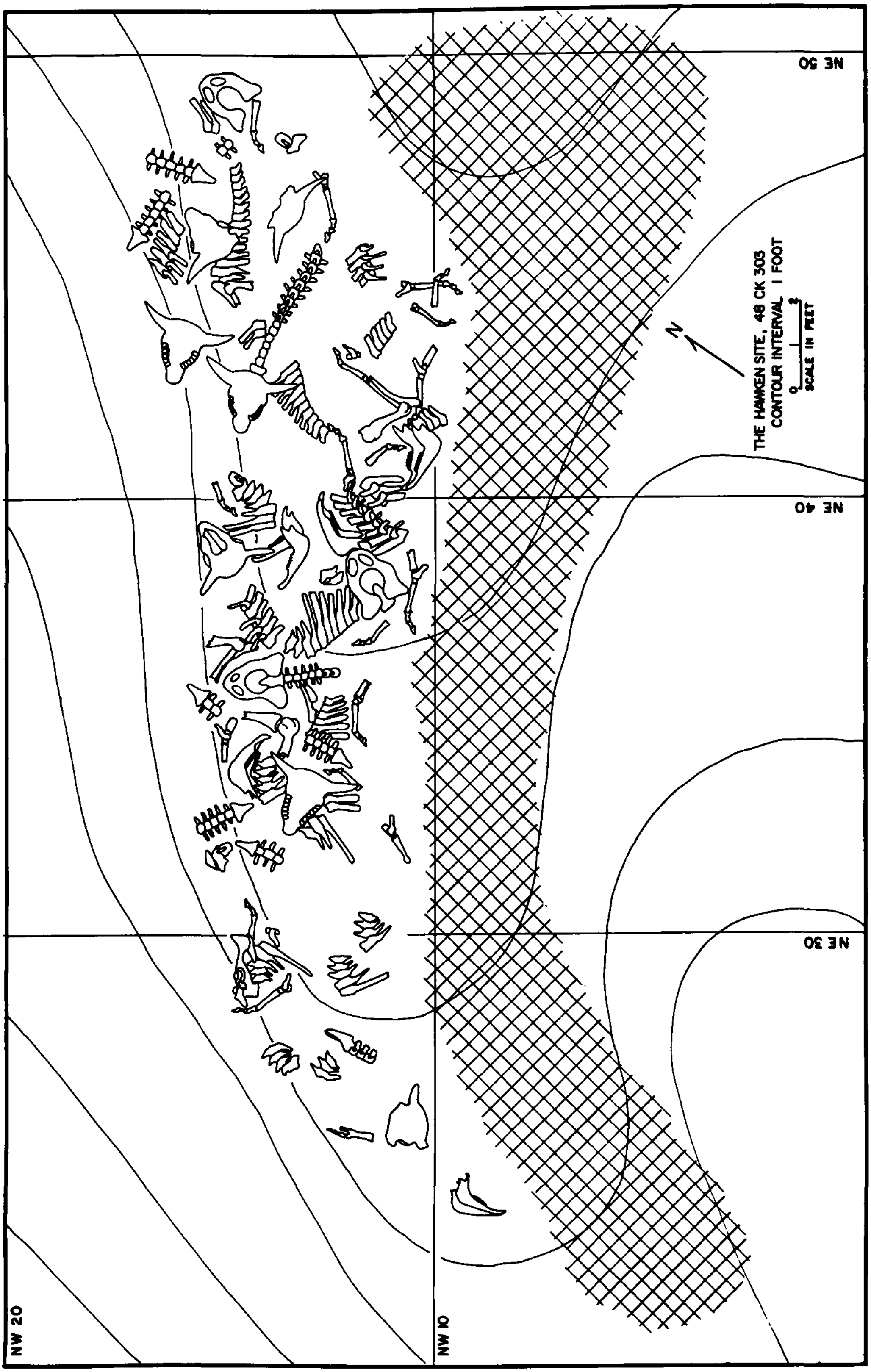

Fig. 4. Articulated bison bone units and skulls in the middle level at the Hawken site. Disarticulated bones left out for clarity. Checkered area indicates disturbance of the bone bed by collectors.

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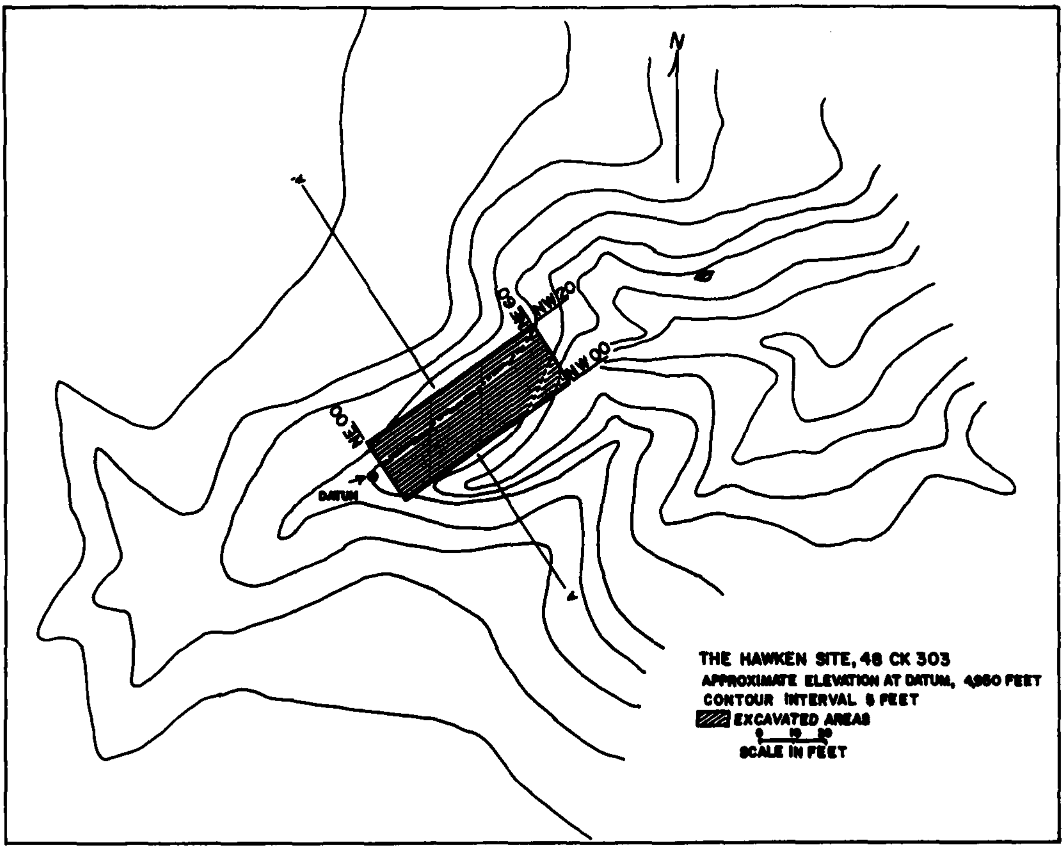

Fig. 5. Topographic map of the arroyo at the Hawken site.

Bison were herded into the arroyo and driven rapidly up the bottom for several hundred yards. Persons were stationed at strategic locations to keep the animals in the bottom and to make sure the herd did not make a wrong turn or try to reverse directions. Assuming that past conditions were similar to the present, animals could not have gotten out of the arroyo for the last 250 feet before the knickpoint (Fig. 3, bottom).

Once the lead animal reached the knickpoint there would have been confusion as the bison in the rear collided with it. At this point hunters would have thrown darts or spears into the animals, and a simple blind of hides could have been stretched across the arroyo behind the animals to deter escape. The bones which were left in the arroyo after butchering (Figs. 2, 4) trapped sediment and ultimately forced the course of the arroyo to move laterally several feet. Subsequent down-cutting left part of the old arroyo fill intact (Fig. 6).

This bison procurement pattern, with many variations, existed for several thousand years on the Plains (e.g., Frison 1968, Bentzen 1961). Sand dunes were also used as natural traps (see Frison 1974) and corrals were added in a later period to enhance a natural feature (Frison 1970, 1973). Buffalo jumps were fundamentally different from traps of this nature and are not considered here.

Most known bison kills contain nursery herd animals. This is reasonable because mature males usually leave the nursery herds except during the rutting period. Mature males are disruptive to systematic bison driving so their absence is welcome. It is hard to drive herds with newborn and very young calves so the calving and rutting periods are not good times for driving bison. Nursery herds may have been more desirable in terms of quality of meat but herds of mature males were also driven as is clearly demonstrated here.

An analysis of the Hawken site bison mandibles shows that nearly 100 animals were trapped during one or more communal winter drives. However, the sample of crania falls far short of this number. It is of interest that the sample of measurable skulls contains only males; a sharp contrast to the 10,000 year-old Casper site sample which included skulls of three males and 20 measurable females in addition to juveniles (Wilson 1974b). The size distribution of metacarpals from the Hawken site is similarly weighted toward the males (Bedord 1974:227), indicating that herd composition did differ from that at Casper. The most plausible explanation for the number of males is that one drive was of a bull group (McHugh 1958:14).

We see many variations in the population structures of the bison in arroyo kill sites. Such traps allowed for the procurement of groups from possibly a half dozen up to two or three dozen and the composition could have varied widely in number, sex, and age. The maximim number of animals that could be taken in an arroyo trap such as the Hawken site is conjecture, but 15 to 30 animals would seem ideal for 10 to 15 hunters. Larger herds would tend to split up, especially when first herded into the arroyo bottom, and the loss of a small part of the herd at this time could have been critical since the others might have tried to follow. Successful operation of these traps probably required relatively small numbers of animals and repeated attempts.

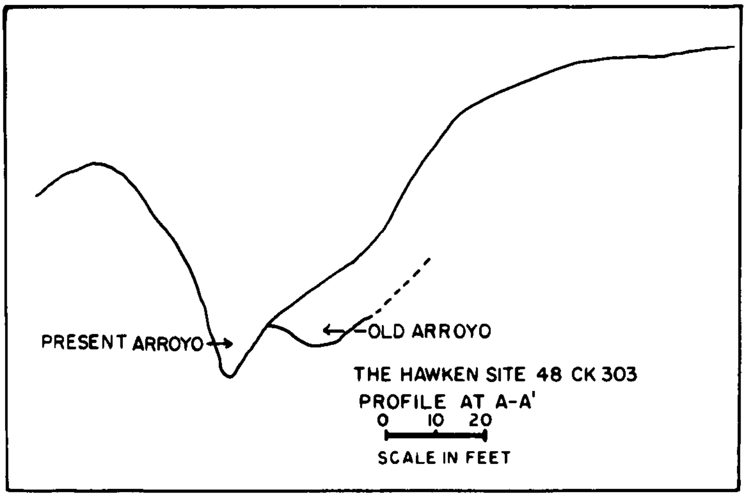

Fig. 6. Profile of the Hawken site to demonstrate the position of the old arroyo in relation to the new one.

THE ALTITHERMAL PERIOD

According to Antevs (1948, 1955) the Altithermal was a period of aridity from about 4500 to 2000 B.C., but the effects of the aridity on prehistoric Plains cultures are still uncertain because we have few reliable data. The Altithermal period itself, its causes, areal distribution, intensity, duration, manifestations from one place to another, and many other aspects are not at all clear. Recently Bryson and others (1970) have included the Altithermal in the Atlantic climatic episode, about 6500 to 2700 B.C.

Nearly two decades ago archaeologists noticed a paucity of cultural evidence from this period on the northwestern Plains (Mulloy 1958) and the concept of a cultural hiatus came into being. This was unfortunate as the term "hiatus" strongly suggests an absence of cultures and allows no alternatives such as a shift in settlement patterns or a change in economic orientation to broad-spectrum hunting and gathering from specialized hunting of large herbivores. Consequently, it became fashionable to either support or attack the concept of a cultural hiatus during the Altithermal rather than to work toward establishing the true nature of prehistoric occupations during the Altithermal period.

A breakthrough in interpretation came from the results of the excavations in Mummy Cave on the North Fork of the Shoshone River near the east entrance to Yellowstone National Park (Wedel and others 1968). This site yielded a series of radiocarbon-dated occupations through the

Altithermal period. The Mummy Cave sequence also demonstrated an abrupt change from the lanceolate projectile point styles of the Paleoindian to the side-notched styles of the Altithermal.

Reeves' (1973) summary paper on human activity during the Altithermal period (or the Atlantic climatic episode) can be supplemented by data from three new sites. One is the Hawken site; the other two are connected with the Medicine Lodge Creek project (Frison n.d.a) in the Bighorn Basin in north-central Wyoming close to Mummy Cave. As yet undated Altithermal period levels appeared at the Medicine Lodge Creek site and a date of 5390±120 years: 3440 B.C. (RL-390) was obtained from a cultural level in Granite Creek Rockshelter in Shell Canyon on the western slopes of the Big Horn Mountains a few miles east of Shell, Wyoming (see Fig. 1). Just east of the Medicine Lodge Creek site, a date of 6830±260 years: 4880 B.C. (RL-445) was obtained from a cultural level in an open site while a nearby rockshelter yielded a date of 4730±140 years: 2780 B.C. (RL-483). All three dates were from charcoal in association with projectile points of the Altithermal period Side-Notched tradition.

A stratified site in the Absaroka Mountains (Lookingbill site, Fig. 1) has a cultural level that yielded projectile points of the same tradition directly above a Paleoindian level (Frison n.d.b). The site has extensive workshop areas with good evidence of the technological production sequence of the projectile points. Flakes were reduced by percussion flaking to preform stages and finally pressure flaked to side-notched forms reminiscent in outline, but larger than some Late Prehistoric period side-notched projectile points. The latter, however, are smaller and were usually produced by pressure flaking on relatively small percussion flakes, usually without the preform stage.

These sites provide a growing body of reliable evidence of Altithermal period cultural occupations but none is actually from the Plains. The sites are in a variety of locations including high elevations in the mountains; along streams that extend far back into the mountains; and in areas within or peripheral to mountain ranges or uplifts. The Hawken site falls into the latter category; it is within the Black Hills in an area of higher rainfall and consequently more grass than surrounding areas. During periods of aridity the Black Hills may have been more attractive than the surrounding plains.

Unless the Hawken site was unique during this time (4400-4500 B.C.) the Black Hills and its immediate environs must have supported a sizable herd of now-extinct bison. There are gaps to fill before the cultural record of man and the biological record of the bison are resolved for the Altithermal period but the Hawken site does provide a basis for some hypotheses along both lines.

THE BISON

The Hawken site sample includes 8 measurable male skulls, along with cranial fragments, mandibles, and postcranial remains of nearly 100 individuals, most of them mature (see Fig. 7). Mensural data relating to the crania are summarized in Table 1, and more complete data will be presented elsewhere. Certain cranial measurements and indices extend beyond the known limits of the subspecies *B. bison occidentalis* (Skinner and Kaisen 1947:170). In several cases the Hawken sample falls consistently above the average, with the largest specimens extralimital. This is more significant than the mere occurrence of one or two extralimital measurements.

Horn cores are typically more massive with respect to their length than in previously known *occidentalis*. This massiveness of cores is strikingly similar in many "classic" *B. bison antiquus*, a similarity noted in some other measurements and indices as well.

Cranial measurements tend to conform with the narrow frontals of *occidentalis* rather than the broad frontals of *antiquus*. Orbital protrusion is variable and ranges between previously published values for *occidentalis* (85, computed from average values in Skinner and Kaisen, 1947:170) and *antiquus* (90, Guthrie 1966, computed after Skinner and Kaisen 1947:178). Hawken site values cluster at 85 with a range from 79.5 to 89. This may well be a normal amount of variation, but comparative data are very few at present.

In measurement #11 (occipital crest to lower border of foramen magnum) all measurements for the Hawken site sample fall below the average for *occidentalis*. Part of this can be explained through compression of the skulls after burial; however, this probably does not account for all of the trend.

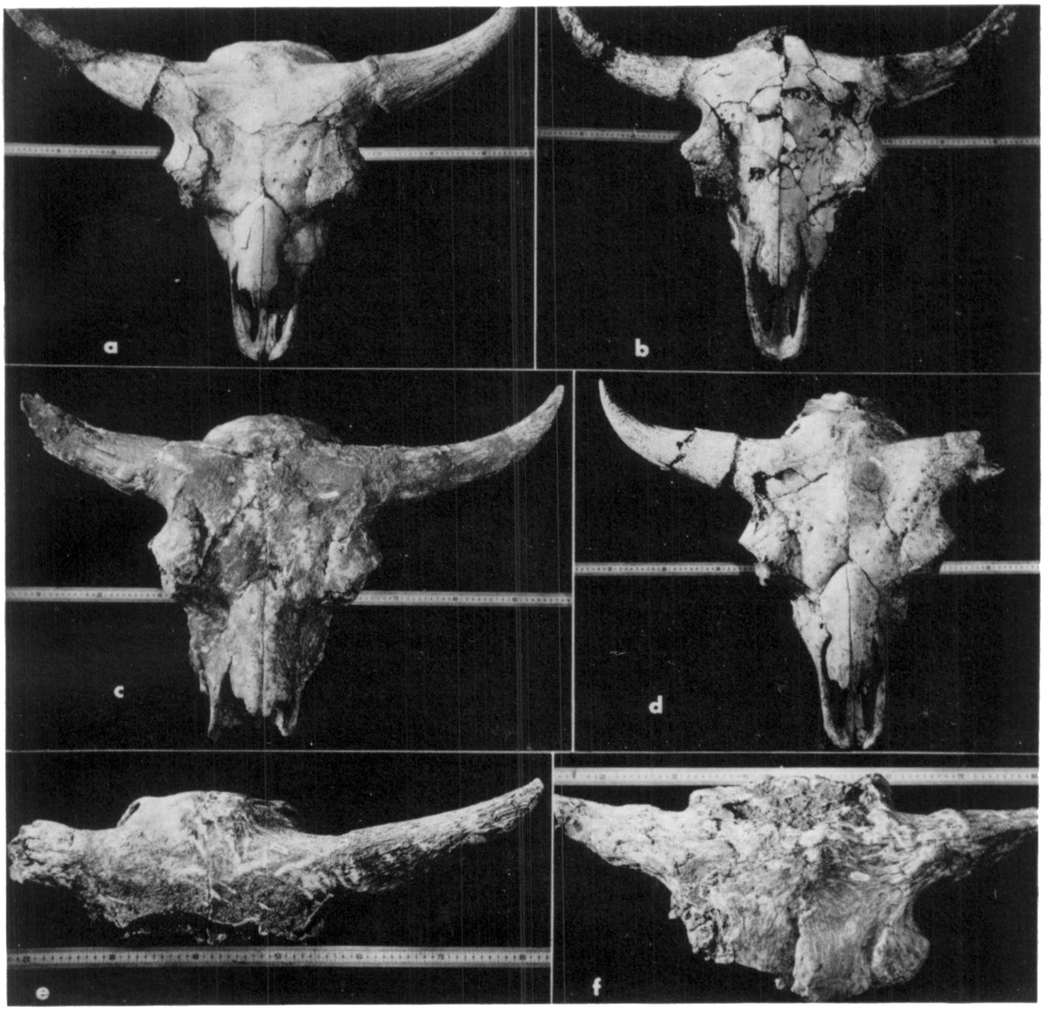

Fig. 7. Male bison skulls from the Hawken site. Note that all are at different scales.

Rostral measurements such as #17 (width at masseteric processes above M^1) tend to be wider than average for *occidentalis*, but very typical for *antiquus*. Two skulls display tooth rows longer than the maxima reported by Skinner and Kaisen (1947) for *occidentalis*. This is not accompanied by a lengthening of the rostrum: M-P (length beyond P^2 to tip of premaxilla) is well below average, and the overall lengths of the skulls (O-P) remain average.

On the whole, referral of the sample to *B. bison occidentalis* seems warranted. We must, however, note certain similarities to "classic" *B. bison antiquus*, particularly in the massive horn cores. As was the case with the Casper site sample, these bison thus display phenotypic characters intermediate between the two clinal extremes, *occidentalis* and *antiquus*. Given the geographic setting, this is not at all surprising.

While the Casper site bison exhibited a predominantly southern phenotype, the later Hawken site bison exhibit a more northern phenotype. This suggests a southward depression of the *occidentalis/antiquus* cline during the early Holocene (Wilson 1975). The fact that horn cores are more massive at Hawken than at Casper may indicate that a chronocline existed in this character, independent of clinal shifts in cranial breadth.

Table 1. Measurements of Bison Skulls from the Hawken Site, Wyoming (Summary).

	Standard Measurement	N	Range (mm)
1.	Spread of horn cores, tip to tip	5	740-910
2.	Greatest spread of cores on outside curve	5	760-920
3.	Length of horn core on upper curve, tip to burr	6	200-320
4.	Length on lower curve, tip to burr	7	230-340
5.	Length, tip of core to upper base at burr	6	190-300
6.	Vertical diameter of horn core	9	91-112
7.	Circumference of horn core	9	275-345
8.	Greatest width at auditory openings	7	258-295
9.	Width of condyles	7	122-144.5
10.	Length, occipital crest to top of foramen magnum	5	98-112
11.	Length, occipital crest to bottom of foramen magnum	5	132-151
12.	Transverse diameter of horn core	9	80-109
13.	Width between bases of horn cores	6	235-265
14.	Width of cranium between horn cores and orbits	6	285-315
15.	Greatest postorbital width	5	340-365
16.	Anterior orbital width at notch	5	245-290
17.	Width of rostrum at masseteric processes above M^1	5	193-210
18.	Rostral width at maxillary/premaxillary suture	5	121-165
19.	Alveolar length P^2–M^3	5	142-165
20.	Alveolar length M^1–M^3	10	84-108
21.	Angle of posterior horn core divergence	6	68°-78°
22.	Angle of proximal horn core depression	8	3°-17°
O-P	Overall length, occipital crest to tip of premaxilla	3	568-578
F-P	Basilar length, foramen magnum to tip of premaxilla	3	508-517
O-T	Length, occipital crest to tip of nasals	4	453-476
O-N	Length, occipital crest to nasal/frontal suture	4	245-260
M-P	Length beyond P^2 to tip of premaxilla	3	135-143
N-T	Length of nasals	5	191-212
Index of horn core curvature		6	113-131
Index of horn core compression		9	98-114
Index of horn core proportion		6	73- 99
Index of horn core length		4	86-102
Index of orbital protrusion		5	79.5- 89

Accurate interpretation is hampered by our lack of adequate, temporally controlled bison populations. Skinner and Kaisen (1947) had almost no absolute temporal control on their sample, and may have grouped together specimens of widely differing ages. For instance, they characterized "*B. antiquus antiquus*" as having massive horn cores; but several archaeological occurrences from the same area (southern U.S.A.), referred by them to "*B. antiquus taylori*" or "*B. antiquus figginsi*" include males with relatively slender horn cores. The temporal relationships of these minor variants of *antiquus* are very unclear.

However, it is also possible that the two forms were contemporary, and that the horn core differences are a function of individual age. Deposits derived from catastrophic kills display age distributions that differ from those characteristic of kill sites (Voorhies 1969:47; Reher 1974:118). This must be kept in mind if archaeological kill site populations are compared with natural accumulations from such deposits as gravel pits.

In summary, the Hawken site bison population has provided us with our first good look at early Altithermal *Bison bison occidentalis* from the Great Plains. They are very large, with particularly massive horn cores in some individuals. The sample of *occidentalis* used by Skinner and Kaisen (1947) was small and was a geographic and temporal grab-bag. It is not surprising that the Hawken site bison extend some mensural limits, but it is rather unexpected that the overall population shows tendencies away from the Skinner and Kaisen distributions.

We at last have a base line for the reanalysis and reinterpretation of Altithermal and post-Altithermal finds of large bison from the northern Plains, a subject to be considered in subsequent papers. As in the Casper site bison (Wilson 1974b), some of the morphologic features of the Hawken site bison are interpreted as "intermediate" in a clinal sense between *B. bison occidentalis* and *B. bison antiquus*. In addition, they are certainly intermediate between Casper *antiquus* and the modern Plains bison. The case for intergradation, and hence for the subspecific nature of these forms, is therefore strengthened.

Animal Population Studies

Although the Hawken site produced the remains of nearly 100 bison, arroyo cutting left only part of the site intact, local collectors had damaged part of what remained (see Fig. 4), and the behavioral characteristics of the animals along with butchering and processing activities could have affected the content of the site in terms of age and sex of the animals. There were three separate levels in the site and all are regarded as bison kills by a single cultural group within a short time with no antecedent or subsequent use of the site. All skeletal elements remaining including those exacavated by the senior author and those discarded by collectors were saved. The total number of individual teeth along with partial and complete mandibles and maxillae was sufficient to form the basis for approximate time-of-year determination of the kill and the age groups of the bison population. The bulk of the bones were in the middle level and whether or not the three levels represent events during a single procurement season or over several seasons cannot be determined. Milling of animals in a site of this nature could have loosened enough soil from the steep banks within a few minutes to create the impression of a thick sterile level formed over a long period. Time of year, however, was the same for all three levels.

Certain assumptions can be made about a bison kill provided it was a single event, more than one event within a short period, or several events that occurred at the same time of the year but over several years. First, the animals will fall into age groups one year apart. Second, the variation in age of animals within an age group will amount to the duration of the calving season. The calving period begins with an early calf or so, builds up to a peak, and then tapers off, ending much like it began. The bulk of the calves are born during the peak period of a few weeks. Third, the age groups can be determined by tooth eruption up to about five years and from there on, tooth wear can be used as age group indicators. This has been proposed for fossil populations (Voorhies 1969), for several bison populations (Reher 1970, 1973, 1974) and for a pronghorn antelope population (Nimmo 1971). Fourth, the animals found in a kill situation, although they constitute a large number, may not necessarily be an unbiased indicator of the structure of the source population. The herds at a given time may lack certain elements such as mature bulls; and during the processing of the carcasses, individuals in certain age groups such as calves and yearlings may have been removed entirely and treated differently from older animals.

Fortunately, mandibles and skull parts were regularly left where the animals were killed even though the tongue and part of the skull were removed and on certain animals the ventral part of the mandible directly below the molar tooth row was chopped off. In several large communal bison kill sites, this has provided us with enough specimens of teeth to set up age groups and give time-of-year determinations. It was also common in many kills to split the skulls by chopping into the palate. Many isolated upper dentitions remained in the Hawken site although the exact nature of skull breakage could not be determined due to bone deterioration.

Aging of Animals by Dentition

Our source of comparative data on molar tooth eruption in *Bison* is a considerable collection of aged mandibles which were collected over eight years from present-day bison herds. Animals killed for commercial purposes are usually dispatched in late fall or early winter, for economic reasons: the bison robes are best then, and the meat is also good. Generally males are butchered as female breeding stock is too valuable to butcher for meat unless they are barren or old and no longer produce calves.

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Most of our known-age modern samples are in the between-year age ranges. Most calves are born between April 15 and May 15 so that long yearlings butchered on December 1 will range in age from about 18.5 to 19.5 months. Long two-year-olds will be 30.5 to 31.5 months old. These two age groups are the ones regularly butchered along with old cows. Calves are rarely butchered as they have neither a large hide that commands a high price nor enough weight to make it profitable to butcher them. However, animals in herds regularly die and a sufficient number of these known-age animals were collected so that ages of most immature animals can be determined quite closely through the stages of tooth eruption.

Description of tooth wear proved complicated if available cusp terminologies were used. A system was needed for the description of wear *facets*, often on the flanks of the cusps rather than atop the cusps themselves. Although Crompton and Hiiemäe (1969:28) illustrated a selenodont tooth with some of the wear facets numbered, their intention was to illustrate the evolutionary fate of the shearing planes of a primitive mammalian tooth as they were modified into a selenodont condition. They did not attempt exhaustive description of the selenodont tooth's wear surfaces, so that some of them went unnumbered. Our descriptive goals differ from those of Crompton and Hiiemäe, and we have decided against taking their cusp numbering system and supplementing it for our own use. In doing so, we could well come in conflict with any supplementary numbering that they might undertake.

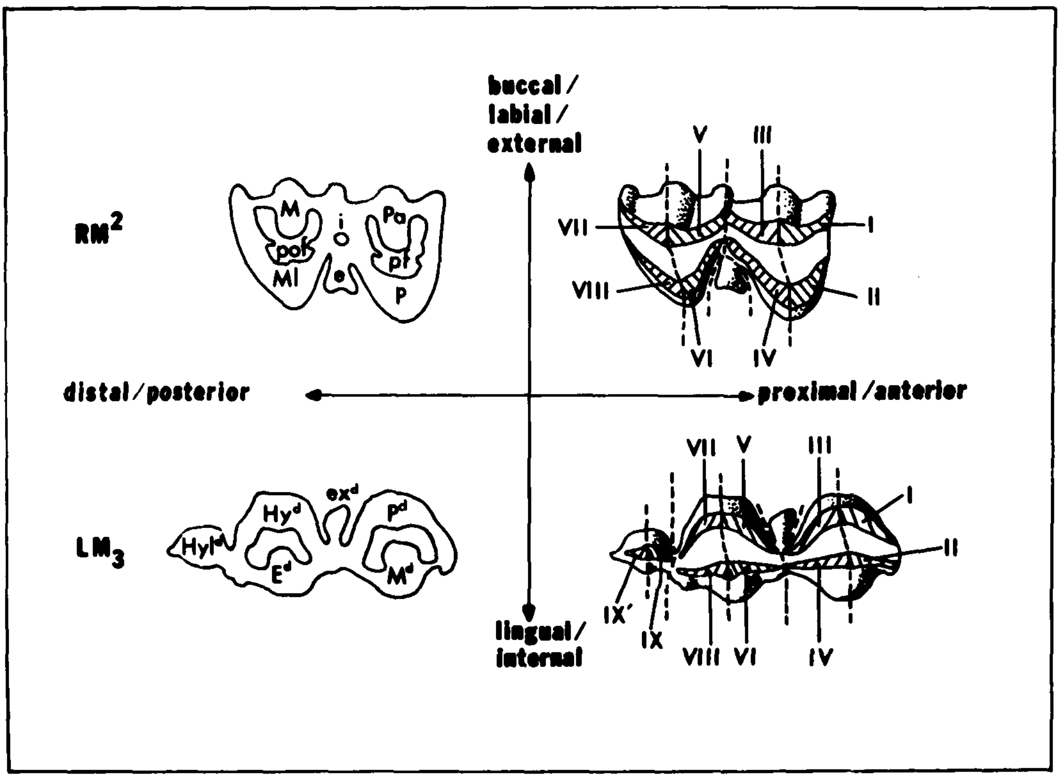

Fig. 8. Descriptive aids for the discussion of bison dental morphology and wear. Upper left: right M^2 (worn), showing cusps and fossettes. e, endostyle; i, interfossette; M, metacone; Ml, metaconule; P, protocone; Pa, paracone; pf, prefossette; pof, postfossette. Upper right: right M^2 (lightly worn) showing numbering of wear facets referred to in text. Numbers increase in posteriad direction. Lower left: left M_3 (worn), showing cusps. E^d, entoconid; ex^d, exostylid; Hy^d, hypoconid; Hyl^d, hypoconulid; M^d, metaconid; P^d, protoconid. Fossettes as in RM^2. Lower right: left M_3 (lightly worn) showing numbering of wear facets referred to in text. Numbers increase in posteriad direction. Directional terminology for teeth is shown at termini of the four cardinal axes: alternatives reflect the varying usage of different authors. Other terms are also available, and are used in specialized contexts.

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To avoid confusion, we have used Roman numerals for the wear surfaces in our descriptions (Fig. 8). Both upper and lower teeth are shown, although we describe only the lowers here. Wear surfaces are numbered in pairs from proximal to distal on lower and upper teeth. With the exception of the hypoconulid (IX-IX′) in M_3, even numbers denote lingual facets, and odd numbers denote buccal facets. Unworn hypoconulids are peaked, and thus two wear surfaces are labelled (IX-IX′); however, the peak disappears very early in the wear of this cusp, and the two wear surfaces merge into one planar facet.

We provide a cusp terminology (Fig. 8) in addition to our wear surface terminology. Cusps are named following Churcher (1972:63) and the advice of Dr. Paul O. McGrew (personal communication). We realize that a certain amount of disagreement exists concerning the nomenclature of the metaconule (hypocone?) and certain other cusp homologies, but the controversy need not concern us here.

Age Groups Based on Lower Molars

Lower dentitions from the Hawken site fall into 12 yearly age groups. From this it is concluded the bison lived to 12 years although occasional animals may have survived beyond this. The age categories were determined on the basis of tooth eruption and wear. The youngest group (age group 1) is believed to contain animals whose average age is about 0.7 years; age group 2 is 1.7 years, age group 3 is 2.7 years, and so on up to group 12.

Group 1: 0.7 Years (Fig. 9*a*). 3 animals. One specimen has all deciduous incisors in place. All deciduous premolars in wear. M_1 erupted with wear on facets I-VI (Fig. 8); wear on facets V and VI light. M_2 not yet erupted although visible in opening behind M_1. M_3 in bud, totally enclosed behind M_2.

Group 2: 1.7 Years (Fig. 9*b*). 12 animals. All deciduous premolars still in place. M_1 fully erupted and in wear. M_2 erupted; specimens vary as to wear. Some have very light wear on facets I and II. On others facets I and II show more wear with light wear on III and IV. M_3 not erupted but visible in opening behind M_2. On one specimen it can be determined that I_1 is not yet erupted.

Group 3: 2.7 Years (Fig. 9*c*). 9 animals. dP_2 and dP_3 lost; P_2 and P_3 in place but with little or no wear. dP_4 still in place but being pushed up by P_4 which is usually visible above the alveolus. M_1 and M_2 in full wear. Exostylid on M_1 just beginning to wear. M_3 erupted but with either no wear or light wear on facets I and II. Hypoconulid still below level of jaw but may be visible. On one specimen, I_1 is fully erupted and in wear but I_2 is not yet erupted.

Group 4: 3.7 Years (Fig. 9*d*). 10 animals. All premolars erupted and P_4 just coming into wear. M_1 and M_2 in full wear and facets I-VIII on M_3 usually in wear; wear may be very light or absent on VII and VIII. On two specimens wear is evident on facet VII with none on VIII. Hypoconulid erupted above alveolus but not yet in wear.

Group 5: 4.7 Years (Fig. 9*e*). 9 animals. All premolars and molars in place and in wear. Exostylid on M_2 usually in wear. Hypoconulid of M_3 in wear but often the cusp still appears isolated from remainder of tooth. These are essentially mature animals. Although there is some bimodality in crown height measurements, the first five age groups are discrete eruption groups, with no intermediate specimens. The remaining seven groups were determined on the basis of tooth wear alone.

Group 6: 5.7 Years (Fig. 9*f*). 11 animals. Enamel line at base of M_1 metaconid is close to level of alveolus.

Group 7: 6.7 Years. 13 animals. Enamel base of M_1 above level of alveolus but that of M_2 still below. Prefossette on M_1 may be becoming noticeably narrow and some breakdown of the tooth may be appearing. Exostylid on M_3 usually in wear.

Group 8: 7.7 Years. 9 animals. At this point deterioration of M_1 is quite evident. Prefossette may be gone or nearly so and deep cupping is evident. M_2 still in good condition and base of the enamel on metaconid is close to level of alveolus.

Group 9: 8.7 Years. 8 animals. M_1 now deeply cupped. In many cases enamel remains only as small projections; in others wear is below enamel level and both fossettes are gone. M_2 now deteriorating with evident cupping. Enamel base of M_2 is above level of alveolus. The group is identifiable mainly from the height of the metaconid on M_3.

Group 10: 9.7 Years. 6 animals. Continued wear further reduces level of M_2 and M_3. A good deal of variation is seen in condition of M_1 and M_2. Most reliable indicator of age is height of M_3. Enamel level on M_3 metaconid is at or close to level of alveolus.

Group 11: 10.7 Years. 4 animals. Enamel base of M_3 metaconid is now above alveolus and total height of M_3 is further reduced. Tooth row may still be intact but reduction in height of teeth and the appearance of all crown bases are quite obvious.

Group 12: 11.7 Years. 1 animal, based on a single M_3. This specimen is reduced in height more than any other M_3 and shows fossette deterioration. Metaconid height of M_3 only 11 mm.

These age groups represent a total of at least 95 animals killed at the site. Distribution is shown graphically in Fig. 10.

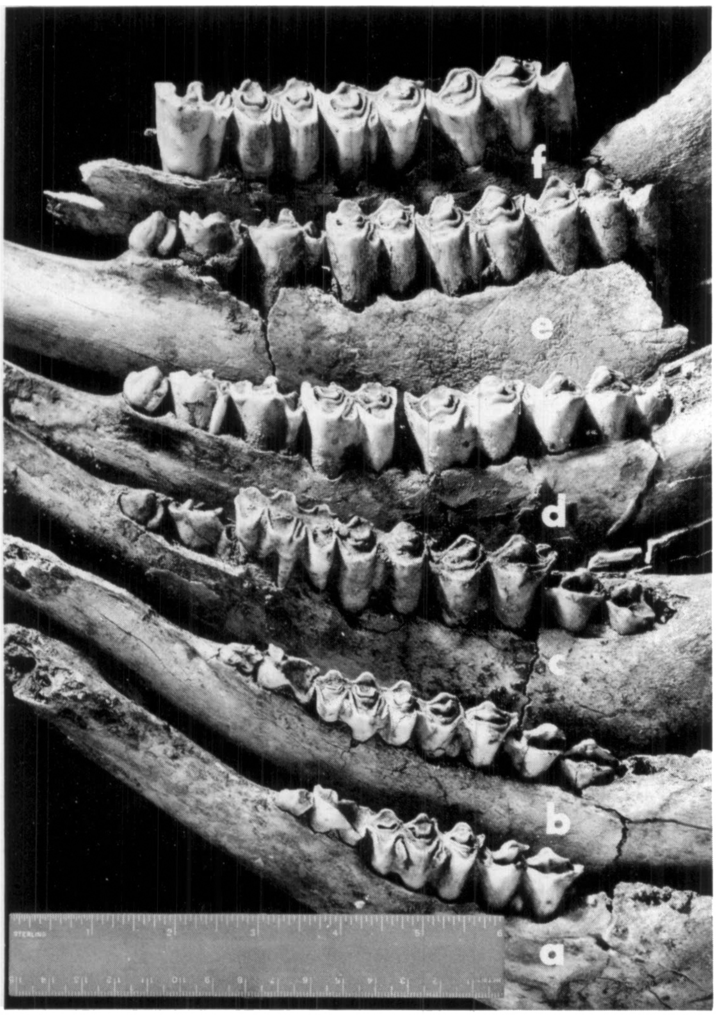

Fig. 9. Mandibles from age groups 1 through 6 (*a-f*) at the Hawken site.

Seasonality

The calves in age group 1 were close to 8.5 months of age. If the calving season peaked in late April, the Hawken bison were probably killed from the middle of December to the middle of January. At the outside, an event occurring between early December and late January is indicated,

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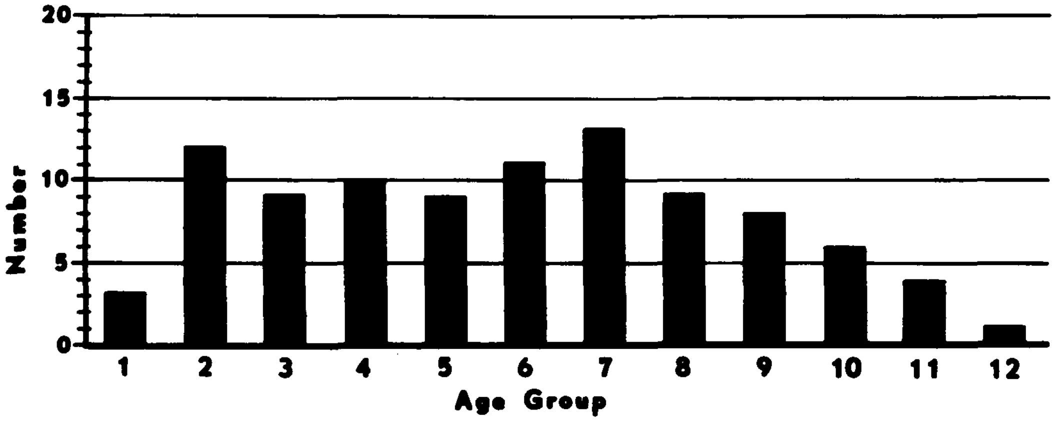

Fig. 10. Age groups of Hawken site bison based on lower teeth.

depending on the actual peak of the calving season and the possibility that our calculations of age are slightly off. A larger sample in age Group 1 would have made closer age determination possible.

The sensitivity of tooth eruption as a means of determining ages of animals clearly enough to determine sesonality has been questioned (e.g., Brumley 1974:18-19). There are limitations to the method but if immature animals, especially calves and yearlings, are present in a single-event kill in numbers that are sufficient to provide a valid sample of a year's calf crop, then eruption schedules can indeed be used to age the animals. Our examination of modern samples has shown us that eruption, particularly of the molars, is a very sensitive indicator of age. Once the individual ages are known, it is possible to apply an estimate of the time from calving to death of the animals. Within acceptable limits the seasonality of the procurement event can be calculated. Further refinements will undoubtedly increase reliability.

At ages beyond tooth-eruption, close determination of age of individual specimens is difficult and sometimes impossible with present methods unless it is known that the particular specimen is part of a catastrophic kill for which older age groups can be determined on the basis of the immature animals. The single-event, large kill is the ideal situation for population studies of this nature. Tooth eruption and wear of an occasional animal may fall outside normal limits but such specimens can be recognized and do not negate the validity of the method as long as proper samples are available for analysis.

It should be added also that cementum annuli determinations were not satisfactory for age grouping of the Hawken site bison. Incisor teeth, which may have given consistent results, were not preserved in sufficient numbers and the molar teeth did not provide consistent results. Physical and chemical alteration of the Hawken site bison teeth has occurred, making counts of annuli difficult and approximate. There is little doubt that the technique could be used in less altered samples.

THE ARTIFACT ASSEMBLAGE

The artifact assemblage at the Hawken site is assumed to be oriented toward the killing and basic butchering of numerous bison. The assemblage includes a large sample of projectile points used to kill the animals, some simple tools used in the basic butchering processes, and some of the debitage produced in tool manufacture and sharpening.

Projectile Points

Certain assumptions can reasonably be made about the Hawken site projectile point assemblage. The sample is large and represents a range of variation of projectiles used by one hunting group for one specific purpose. No evidence indicates any significant use for the points other than as projectiles, so each one must be regarded as functional for that specific purpose. Further, these points were used chiefly in killing a single species of animal.

Most projectile points broke during use and since many of these were reworked into functional projectile points, the total range of variation is quite large (see Table 2). However, it can be demonstrated that the original points clustered around a single style with minor variations: elongate with concave to slightly convex base. Most of the variation in the Hawken collection is in

Table 2. Projectile Point Measurements in Millimeters.

Cat. No.	L	BlW	BlWN	BaW	T	SW	BlL	Base	Fig. No.
60005	32.2	15.3	15.1	17.8	5.1	13.1	25.4	Cv	
60006	32.3	16.4	16.3	18.3	4.6	12.1	25.3	Cv	
60015	30.6	16.8	16.2	16.7	5.0	12.8	24.2	Cv	
60020	37.0	18.0	17.5	16.1	4.8	12.1	31.8	Cv	11*l*
60025	40.8	16.2	15.7	15.2	4.7	11.2	34.2	Cx	
60027	32.6	19.2	19.2	16.7	5.5	15.4	24.4	Cx	
60032	45.6	17.3	14.7	14.0	6.1	11.0	39.3	Cv	
60035	30.5	17.9	17.2	18.7	5.9	13.2	24.3	Cx	
60038	30.9	17.6	17.6	16.7	6.0	14.6	23.4	St	12*c*
60049	38.2	17.7	17.5	16.7	5.4	12.5	30.1	Cv	
60053	35.5	17.5	16.2	17.0	5.5	14.5	28.6	St	12*b*
60054	29.8	18.3	18.2	17.9	6.9	13.2	23.7	St	12*o*, 13*f*
60059	38.7	16.5	15.6	12.9	4.8	11.4	33.1	St	
60060	47.6	17.0	16.4	14.6	6.0	11.2	42.0	St	
60067	36.0	16.5	16.3	16.6	5.2	12.7	29.2	St	
60069	55.6	16.1	15.1	15.6	5.6	11.3	46.6	St	11*c*
60070	61.1	19.7	18.4	17.8	5.0	13.5	53.0	St	
60080	42.1	16.5	16.8	17.8	5.1	15.0	36.8	Cv	
60127	56.5	20.6	18.6	18.6	6.6	14.0	48.0	St	11*d*, 13*j*
60128	49.8	20.0	18.8	17.9	5.6	13.9	43.7	St	11*j*, 13*l*
60129	45.6	16.1	14.1	15.5	5.5	11.4	38.7	Cv	12*g*, 13*c*
60130	51.6	19.5	18.8	19.2	5.7	14.4	44.4	St	11*e*
60170	34.8	17.0	16.5	19.1	6.2	15.0	26.9	Cx	12*l*, 13*i*
60189	43.0	18.2	17.5	17.9	6.3	13.8	35.5	St	12*a*, 13*e*
60190	46.5	17.0	16.5	17.8	6.3	12.8	33.7	St	
60191	54.8	19.6	17.8	18.1	6.3	14.5	48.9	Cv	11*h*, 13*a*
60193	68.3	27.2	25.3	22.7	6.3	16.2	60.7	Cv	11*f*
60194	51.3	18.6	17.8	17.0	6.9	14.2	47.0	Cv	
60195	57.3	21.2	19.8	18.2	5.6	13.2	51.9	St	
60197	43.1	18.3	18.3	17.5	5.7	13.2	34.6	St	
60199	64.0	20.1	19.6	18.5	5.1	14.0	57.6	Cv	11*a*, 13*d*
60200	62.4	23.4	20.7	17.9	6.2	13.6	56.0	St	
60203	37.5	17.9	17.3	16.4	5.2	12.9	30.8	Cv	
60204	41.5	20.3	20.3	19.5	5.0	14.6	34.8	St	
60205	41.2	17.0	16.7	18.5	5.9	12.3	32.6	St	
60206	39.7	18.8	16.7	17.3	5.8	13.4	33.9	St	
60207	22.6	15.9	15.9	15.4	5.0	13.1	16.7	Cx	12*f*, 13*m*
60208	50.0	19.7	17.3	14.9	5.9	11.0	44.8	St	
60209	48.6	22.5	19.4	16.7	5.8	12.7	42.1	St	11*k*, 13*h*
60210	62.4	19.4	18.1	18.8	7.1	14.6	55.6	Cv	12*n*, 13*k*
60211	43.7	20.0	18.8	18.6	5.7	12.4	37.0	Cv	
60212	31.3	16.5	16.5	14.0	5.6	10.7	26.8	Cv	12*k*, 13*b*
60213	30.6	16.7	16.7	16.8	5.6	13.4	24.7	St	12*m*, 13*n*
60215	43.9	19.1	17.2	15.5	5.7	11.9	37.8	St	
60216	45.5	19.5	19.1	16.0	5.6	13.5	38.1	St	

L = Length, BlW = Maximum Blade Width, BlWN = Blade Width Immediately Above Notches, BaW = Base Width, T = Thickness, SW = Notch Width, BlL = Blade Length
Base: Cx = Convex, St = Straight, Cv = Concave

the blade edges. One variant demonstrates blade edges that are nearly parallel for a distance (Fig. 11*a, b, e*) although they may contract or be rounded below the notches. Blade edges may expand slightly from the base so that the widest part of the point is about halfway between base and tip (Fig. 11*d, j, k, l*) or they may maintain the expansion so that the widest part is farther forward (Fig. 11*h, i*). On yet another variant the blade edges contract sharply below the notches and the widest part of the point is just forward of the notches (Fig. 11*f, g*). On all specimens the extreme tip was elongated slightly to form a needle-sharp, penetrating point. Notches were placed on the sides a short distance from the base. On original specimens they were carefully placed and formed sharp corners with the blade edges. Bases either formed sharp corners with blade edges or else were rounded slightly. Grinding was common on bases and inside the notches.

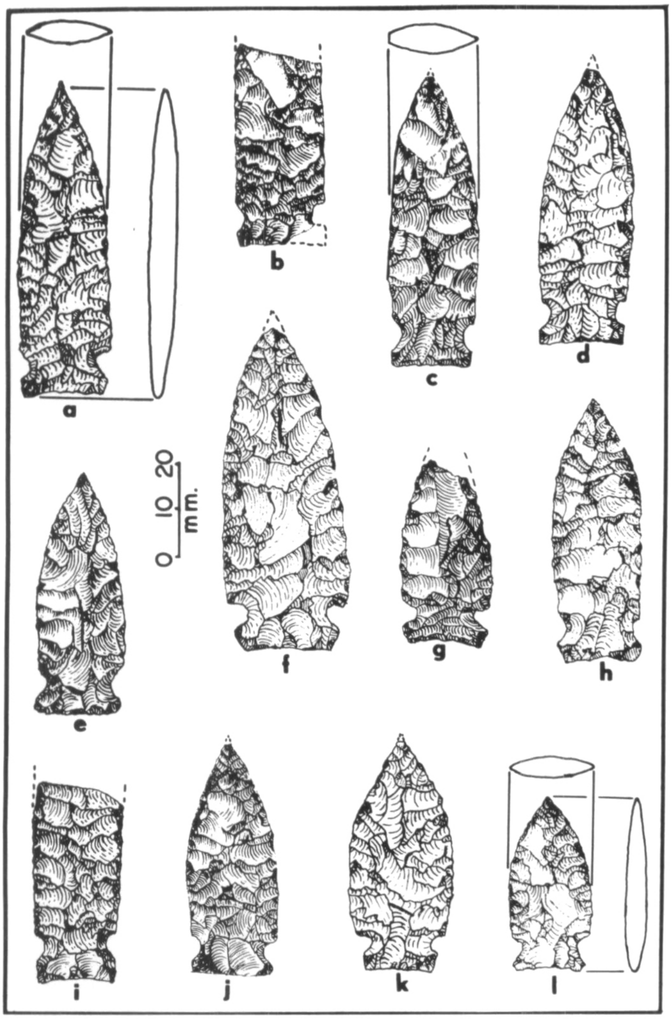

Fig. 11. Unmodified projectile points from the Hawken site.

Original specimens vary considerably in length, width, thickness, and weight, and there are diagnostic features that separate original specimens from reworked ones. The original specimens have lenticular cross sections in both axes and they expand gradually from a ground, blunted base to the thickest part usually near the center and then taper evenly to a sharp point (Fig. 11*a, l*). Interruptions in these cross sections usually indicate modification from the original form and result from subsequent flaking patterns superimposed over the original.

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The following kinds of breaks were observed.

(1) The delicate, needle-sharp point usually shattered on impact.

(2) Blade edges snapped transversely or at various angles at about any point, but were extremely vulnerable across the notches.

(3) Notches often suffered damage, presumably from impact. The sharp corners at the juncture of the notches and blade edges regularly broke off or shattered; opposite corners of both notches often broke as a result of direct impact, and alternating corners often broke or shattered, possibly the result of the projectile point's moving sideways in the neck upon impact.

(4) Breakage often occurred from one notch or from both notches to the base rather than across the notches and often a triangular-shaped corner at the juncture of the base and blade edge broke off.

(5) A rare but still surprisingly consistent breakage involved a long, thin sliver being driven off one blade edge behind the tip; in one case extending nearly to the notch.

(6) Impact flutes often extended down one face and rarely both faces of a point. Impact flakes often extended down the blade edges also.

Modification of projectile points after these kinds of breakage resulted in considerable variation in form. After the extreme tip was broken, the point could be made functional again by simply

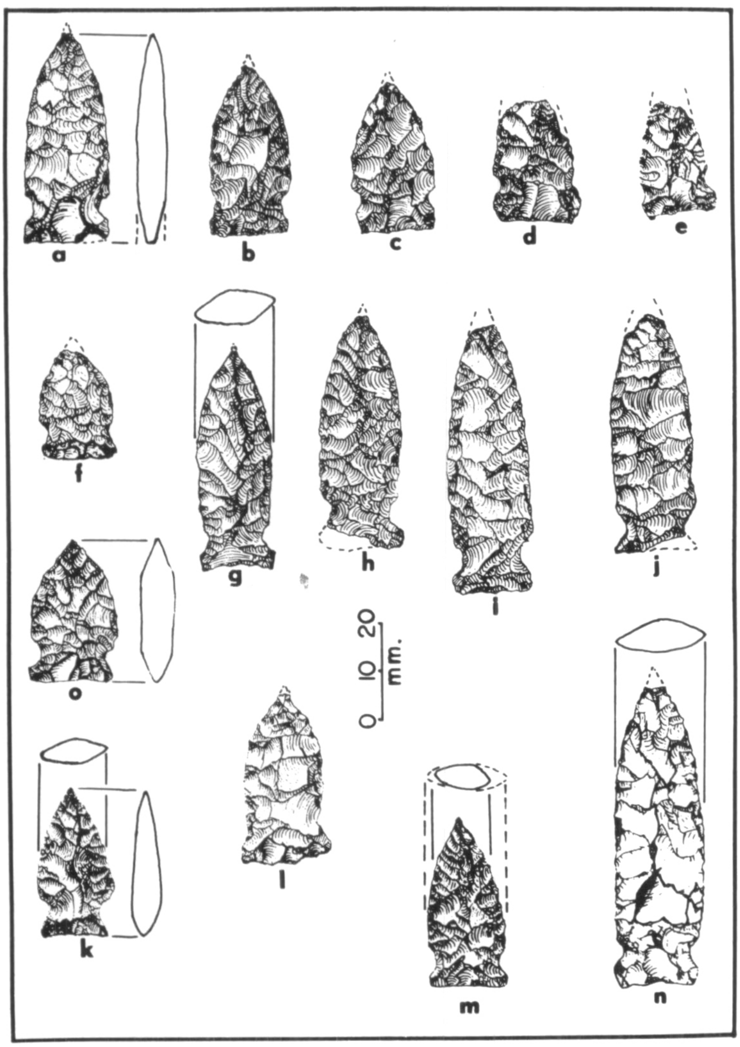

Fig. 12. Projectile points from the Hawken site modified after breakage.

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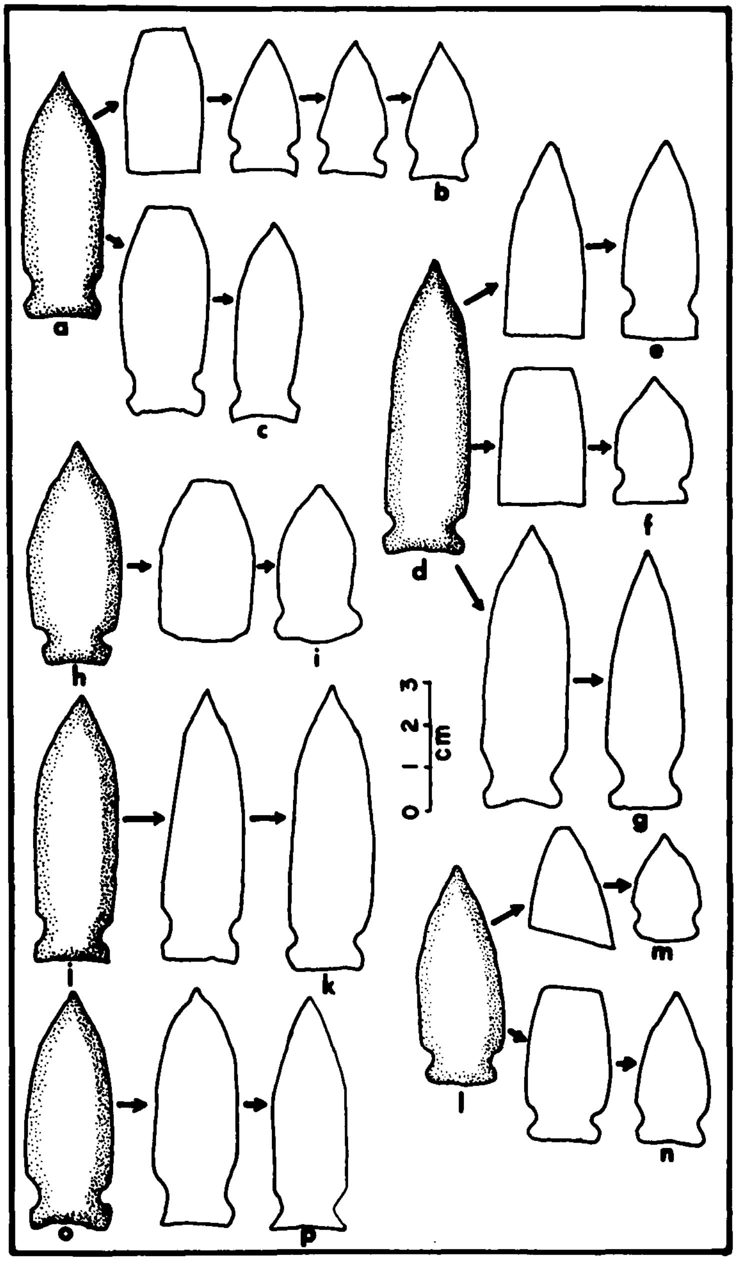

Fig. 13. Archetypal forms (shaded) and hypothetical breakage followed by reworking to regain functional utility of the broken specimens.

reworking the distal end slightly to form a new tip. Breakage at a distance behind the tip required varying degrees of modification. Often the entire point forward of the notches was reworked resulting in the base being wider than the blade. Reworking may sometimes have been done with the point on the shaft since an alternate flaking pattern is superimposed over the original pattern and the transverse cross section is no longer lenticular (Fig. 12*g*, *h*). A projectile point such as Fig. 11*h* could have been broken near the tip and then reworked into the general style of Fig. 12*g* or *h* (Fig. 13*a-c*). A variation of this is a flat-based specimen such as Fig. 11*j* broken and reworked to the shape of Fig 12*m* (Fig. 13*l-n*).

When the breakage was across the notches or distal to the notches so that enough blade still remained to form a complete point, side notches were merely added along with basal thinning (see

Fig. 13*d-e*). This is obvious in longitudinal cross section and the smooth taper from center to base is lost. These are quite common in the assemblage (Fig. 12*a-f*). Often the transverse break was at an angle and the new base was not straightened to restore symmetry (Fig. 12*d-e*), while in other cases symmetry was maintained (Fig. 12*a-c*).

In other cases, midsections were reworked on both ends and notches added. This is manifested by superimposed flaking patterns and interruption of the longitudinal cross sections on both ends (Fig. 12*o*; Fig. 13*d-f*). On one specimen, both ends demonstrate reworking and the notches have almost the appearance of an expanding stem (Fig. 12*k*). A possible sequence of events is postulated in Fig. 13*a-b*. One specimen was broken across the notches and close to the point and the center section was reworked into a unique shape (Fig. 12*l*). A possible sequence of breakage and reworking is illustrated in Fig. 13*h-i*.

Damage to the notches resulted in many changes to the configuration of the point because symmetry of the notches was important for binding the point to a shaft. Restoration of symmetry resulted in wider notches, the extra width added distally if damage was distal to the notches (Fig. 12*i*; Fig. 13*d-g*). The extra notch width may have been added both proximally and distally if the damage was such and this often resulted in an almost corner-notched appearance (Fig. 12*j*; Fig. 13*o-p*).

In the case where a sliver of a blade edge was driven off by impact (Fig. 11*c*), functional utility was restored by reworking one blade edge only (Fig. 13*j-k*). This is obvious from a superimposed flaking pattern applied over the original to alter the lenticular cross section between the notches and the tip although the extreme tip is not modified (Fig. 12*n*).

All of the breakage described here probably resulted from impact but impact fractures are regarded here as flakes actually driven off the distal end of a projectile point by impact. These are manifested on some projectile points by flake scars that extend proximally from the tip. The scars may be on the blade edges or they may resemble flutes on the face. Impact flakes were recovered throughout the bone levels and are quite distinguishable visually from tool sharpening flakes here as in other contexts, (Frison 1974:95-99). One example of a reworked projectile point with an obvious impact flake scar was recovered. This was the distal end of a point that was embedded in the atlas of a calf bison. The point bears a long scar from former impact that had been partly obscured by reworking. In this case about 1.5 mm of the reworked needle-like point shattered from impact into at least 13 microscopic fragments that were recovered from where they were lodged in the bone.

Reworking and reuse of projectile points is noted in other bison kills of both Paleoindian (Frison 1974:82-83; Bradley 1974) and late Middle Prehistoric or late Archaic ages (Frison 1971:80). The seemingly wide range of variation of the Hawken site projectile points resulted largely from modification of broken projectile points. One should be aware of this kind of variation and of the total range of variation of projectile point type before its usefulness as a cultural indicator can be fully exploited.

Chipped Stone Butchering Tools

Knives. Sixteen flake tools vary considerably in size and shape (Fig. 14*c-h*) but all are highly functional for bison butchering. Retouching of cutting edges was common along with dulling of sharp areas that came into contact with the hand. Sharpening flakes occurred throughout the bone deposits indicating tool use and sharpening, and some cortex and waste flakes suggest manufacture of simple flake tools in the kill area. Fragments of three additional bifaces suggest they were used as knives.

Choppers and Hammerstones. Eight choppers of varying size are of local quartzite and the only modification was to form a handhold and a sharp point. They are known to be highly functional for butchering in conjunction with flake knives (Fig. 14*i-l*). Two quartzite cobbles were not modified but had naturally good handholds and edges to serve as hammerstones to break and crush bone during butchering (Fig. 14*a-b*).

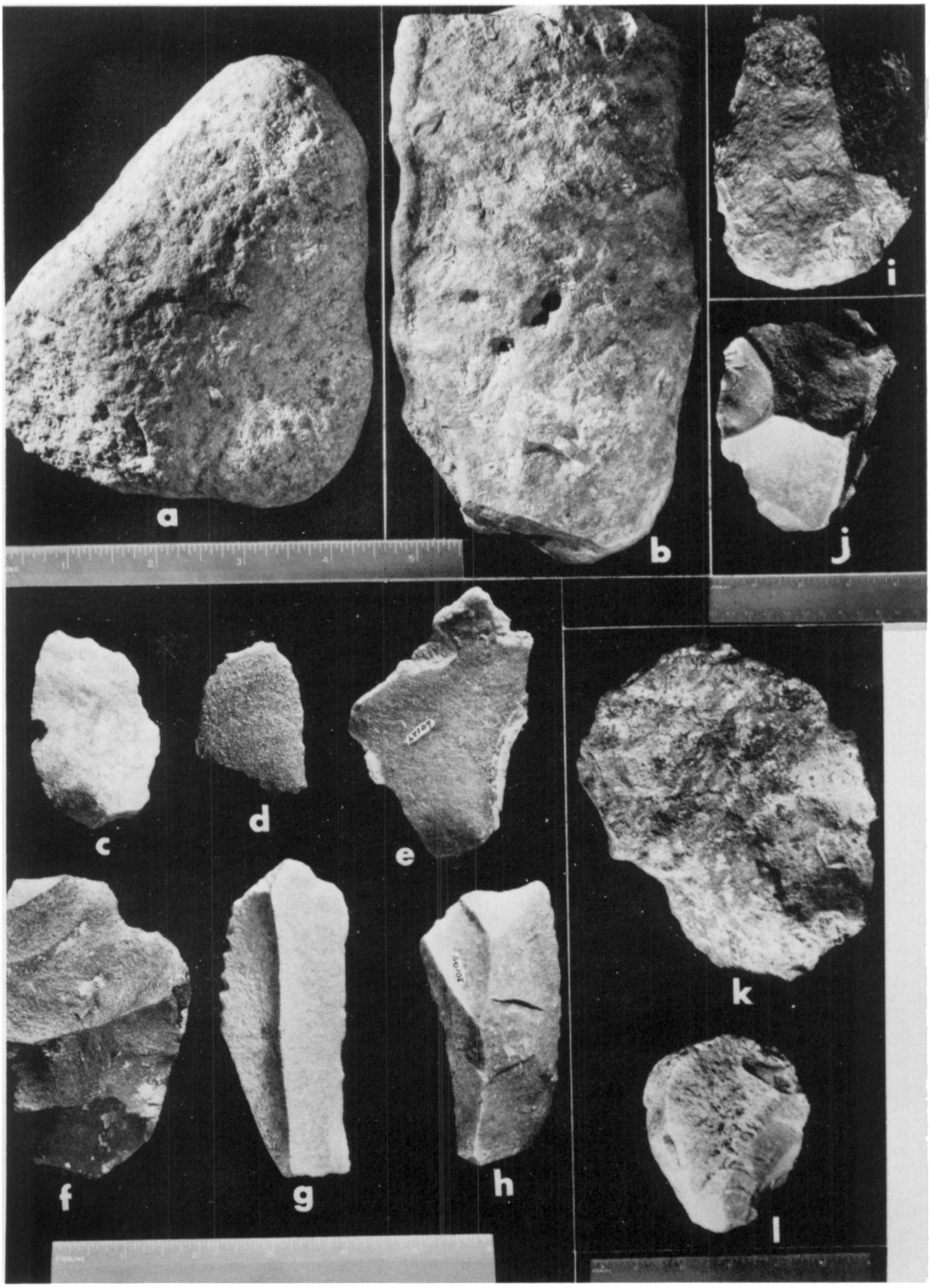

Fig. 14. Butchering tools from the Hawken site; *a-b* hammerstone; *c-h*, flake cutting tools; and *i-l*, choppers.

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Butchering Tools of Bone

The presence and use of butchering tools of bone has been established at communal bison kills on the Plains in both Paleoindian and Late Prehistoric contexts (Frison 1970:26-33, 1974:35-37; Wilson 1974a). Although bone preservation was not especially good at the Hawken site, some of the same types of bone tools were found. These include tibia choppers (Fig. 15*b*) and humerus tools (Fig. 15*d*). Several broken points from bone choppers appeared also (Fig 15*a*). More convincing evidence for the use of bone choppers is a rib chopped off near the head. A flake broken from a bone chopper still lies embedded in the rib.

The humerus tools are believed to have been used in skinning and fleshing. Most were made from left humeri, although a left-handed person would presumably have used a right humerus. The proximal articular end was removed and the circumference of the break was scalloped to leave a number of sharp points. Fig. 15*c* is one recovered from a Late Prehistoric period bison kill, but three broken specimens (Fig. 15*d*) were recovered from the Hawken site. These tools are particularly effective in skinning and fleshing but probably had other uses as well. Long-bone choppers and humerus tools have appeared in Paleoindian kills (Frison 1974:51-57) and Late Prehistoric period bison kills (Frison 1970) and were an integral and functional part of butchering tool assemblages.

Two pieces of split bison ribs were rounded on one end and appear to have been knapping tools. Another knapping tool was made from the distal part of an antelope metapodial. Tools were apparently sharpened at the site with pressure flakers and these would have served for that purpose.

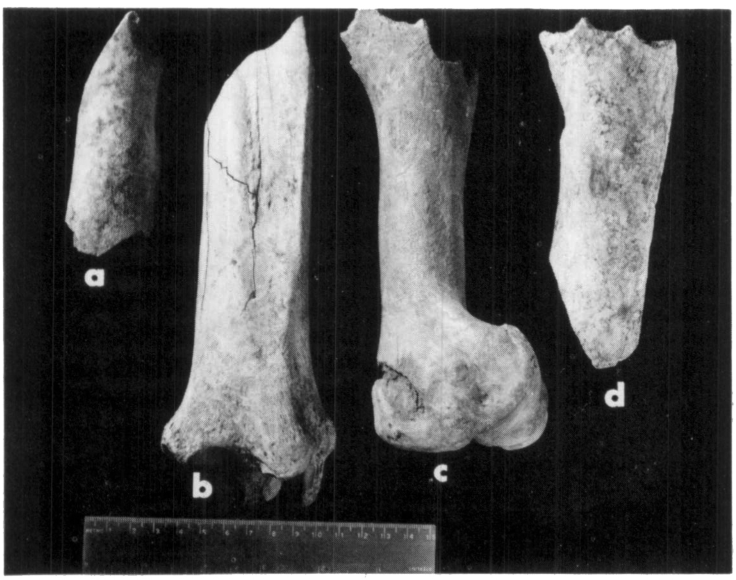

Fig. 15. ***b*, bison tibia chopper; and *a*, broken point from a similar tool from the Hawken site; *c*, humerus tool from a Late Prehistoric period bison kill; and *d*, a broken similar tool from the Hawken site.**

Technological Aspects and Sources of Raw Materials

Only finished projectile points are present at the Hawken site; evidence for their manufacture is lacking. Chipped stone tools are all large percussion flakes and some of these were probably made at the site judging from the presence of core preparation and waste flakes.

The raw materials were all local. Most common is a good grade of quartzite widespread in the Black Hills area. The chert is locally available and there was very limited use of a distinctive metamorphosed shale which was available a short distance west of the Black Hills. Silicified wood occurs in certain geological formations close to the site area and was utilized. No evidence of exotic raw materials such as Knife River flint from North Dakota appears at the Hawken site although it occurs in both earlier and later sites in the immediate area.

REMARKS ON BUTCHERING

Butchering animals the size of the Hawken site bison was not easy. One can confirm this by butchering a small modern bison with a tool assemblage similar to that from most typical Plains prehistoric bison butchering sites. Such an assemblage is very simple, very functional and not very aesthetic. A steel knife and a steel axe are greatly superior to a stone or stone-and-bone butchering assemblage. Butchering time and effort can be more than halved with metal tools compared to stone tools but even so, butchering bison with metal tools is hard work.

Although animals are usually butchered as soon after they are killed as possible, there are different kinds of butchering. An animal may have been completely butchered on the spot or it may have been halved, quartered or further reduced and the parts moved to another area for further processing. In hot weather there is an urgency, which is not as critical in cold weather, to open the carcass and remove the contents of the intestinal cavity as soon as possible, and this is particularly true of animals on green feed. All things considered the optimum time to butcher an animal is immediately after it dies; it is skinned more easily, its appendages can be manipulated more easily, and the final products are better in quality.

Butchering was a systematic process which required a choice of tools that enabled completion of the job with a minimum of effort.

Experimental butchering can be a valuable heuristic device provided the experimenter performs the entire operation enough times to acquire some proficiency. As proficiency is acquired in butchering, certain patterns of behavior appear. Even a person with experience in butchering with metal tools would probably not be able to take a typical stone-and-bone tool assemblage and completely butcher a mature buffalo. Long before being half done he would find that he was punishing a group of muscles to the extreme. Fatigue combined with ineptness in use of stone tools would cause him to terminate the operation probably about half-way. After he had butchered a half-dozen or so bison, however, he would have gained a certain measure of beginning competence. He would recognize the proper tool shape, the best methods of sharpening, and develop the proper motor habits along with the requisite muscles. Much later he would develop true competence in butchering bison with stone tools.

In acquiring competence with tools, (metal, stone, bone, or otherwise) one quickly learns that preparation and maintenance of tools is the most important aspect of their successful use. It is impossible to conceive of any prehistoric butcher handicapping himself with improperly prepared or maintained tools. Stone tools are used up rapidly during intensive butchering and thick hides dull the sharp edge of a tool quickly. The only recourse is to sharpen the edge and there are abundant stone resharpening flakes in most kill sites.

At the Hawken site, the projectile points were not used as butchering tools, nor were they functionally designed for butchering. The projectile points were relatively small, delicate, and carefully designed to penetrate a buffalo hide and continue on into a vital spot. Even mounted on foreshafts they would not be good butchering tools because the binding would have been designed to withstand entirely different pressures than those encountered in butchering. In addition, there is no evidence of use or sharpening on a single specimen.

The Indians did, however, modify large percussion flakes for use as butchering tools. After extensive experimentation and the acquisition of some measure of competence in butchering we believe that they are the optimum tool for the job. These combined with bone choppers, stone choppers, and bone fleshers, constituted the tool assemblage that was used at the Hawken site and at a number of other bison butchering sites.

An attempt has been made to reconstruct butchering processes at two Late Prehistoric period sites based on tool marks on bone and tool assemblages used in experimental contexts (Frison 1973:85-88). Tool marks, breaks on bones, and butchering units that constantly reappear suggest patterned behavior in prehistoric butchering. Differences in this evidence may reflect individual variations, alternative processes, and probably also differences between cultural groups. Eventually butchering analysis may become as much a cultural indicator as the projectile point assemblages.

BUTCHERING OF THE HAWKEN SITE BISON

Some observations can be made on the butchering process although much of the bone was removed from the site and preservation of the remainder was not always good. There are general patterns of butchering that occurred widely (e.g., Frison 1970, 1973, 1974; Wheat 1972) in prehistoric situations. The parameters that affected butchering were so numerous, however, that many variations observed in the process may reflect nothing more than conditions of the moment. Things to consider in analyzing a butchering process at any given site might include the following: time of year, time of day, weather conditions, number of animals killed, condition of animals killed, age and sex of animals killed, accessibility of the kill site, relationships between camp, processing, and kill areas, nature of trap (natural arroyo trap; modified arroyo trap; corral trap; sand dune trap), and soil conditions in the trap (clayey, sandy, dusty, muddy, frozen). An exhaustive list would include much more.

The Hawken bison were utilized to a high degree. No butchering units remained in the site that could have retained any significant amount of meat—even those from extremely old males. Complete skinning is also indicated because many operations could not have been done with the hide on the animal. Most marrow-producing long bones were removed entirely and with few exceptions those remaining were broken open. This may suggest eating of some marrow during butchering, and several fires in the site suggest cooking or searing of choice parts such as possibly the liver during butchering.

It cannot be determined whether the hide was cut down the back or belly. No marks appear on metacarpals or metatarsals such as those of Late Prehistoric times that are believed to be evidence for cutting initial holes in the hide. There are, however, cut marks on the ventral side of the mandibles directly below the first and second premolar that are believed to represent the cutting of holes in the hide for skinning (see e.g., Frison 1970:11).

Some butchering marks on long bones remaining at the site are diagnostic. One of these was from chopping into the femoral trochlea to gain access to the patella in order to strip rear leg muscles. Chopper tool marks are evident and are very likely from a sharp-pointed bone chopper (Fig. 16*e*). The trochanter major was chopped off in similar manner to continue the muscle stripping process on up the rear leg. In most cases, the entire pelvis was removed but on the few remaining at the site the ischium, ilium, and pubis were broken at their narrowest points adjacent to the acetabulum. The remainder of the pelvis was apparently removed from the kill area, probably with muscles that were still attached. Neural spines were chopped off close to the vertebrae; the ventral branches of the transverse processes were usually broken off the cervical vertebrae; and ribs were chopped off both proximally and distally suggesting that rib cuts and the brisket were highly regarded. Lateral and medial tuberosities on the proximal ends of humeri were chopped loose while the scapulae were usually broken transversely just above the glenoid fossa.

Knife-cut marks occur regularly on the lingual side of mandibles, and along the ventral border (Fig. 16*c*), presumably from the cutting of muscles holding the tongue. These are entirely different marks from those already mentioned on the ventral borders that are believed to have resulted from cutting a hole in the hide for skinning purposes. Mandibles were removed from skulls and in addition many skulls were removed from the site while mandibles were left behind. Mandibles of older animals especially had the ventral borders chopped and broken off. This was presumably to gain access to the pulp cavity at the base of the molar teeth. As the animals approach old age, the teeth migrate to the dorsal part of the mandible leaving a larger pulp cavity than in younger animals.

Knife cuts appear also along the thoracic vertebrae at the base of the neural spine presumably from removal of the muscles along the back. Skulls were usually removed from the vertebral column with one exception where the skull, cervicals, and several thoracics were still articulated (Fig. 16*d*). Cervical and lumbar vertebral units were common. Separation points on the vertebral column demonstrate chopping and breaking. Common separation points were between cervical and thoracic series and at the last three to four thoracics. Especially noticeable is the breakage on the wings of the atlases and depressed fractures both ventrally and dorsally where thoracic vertebrae

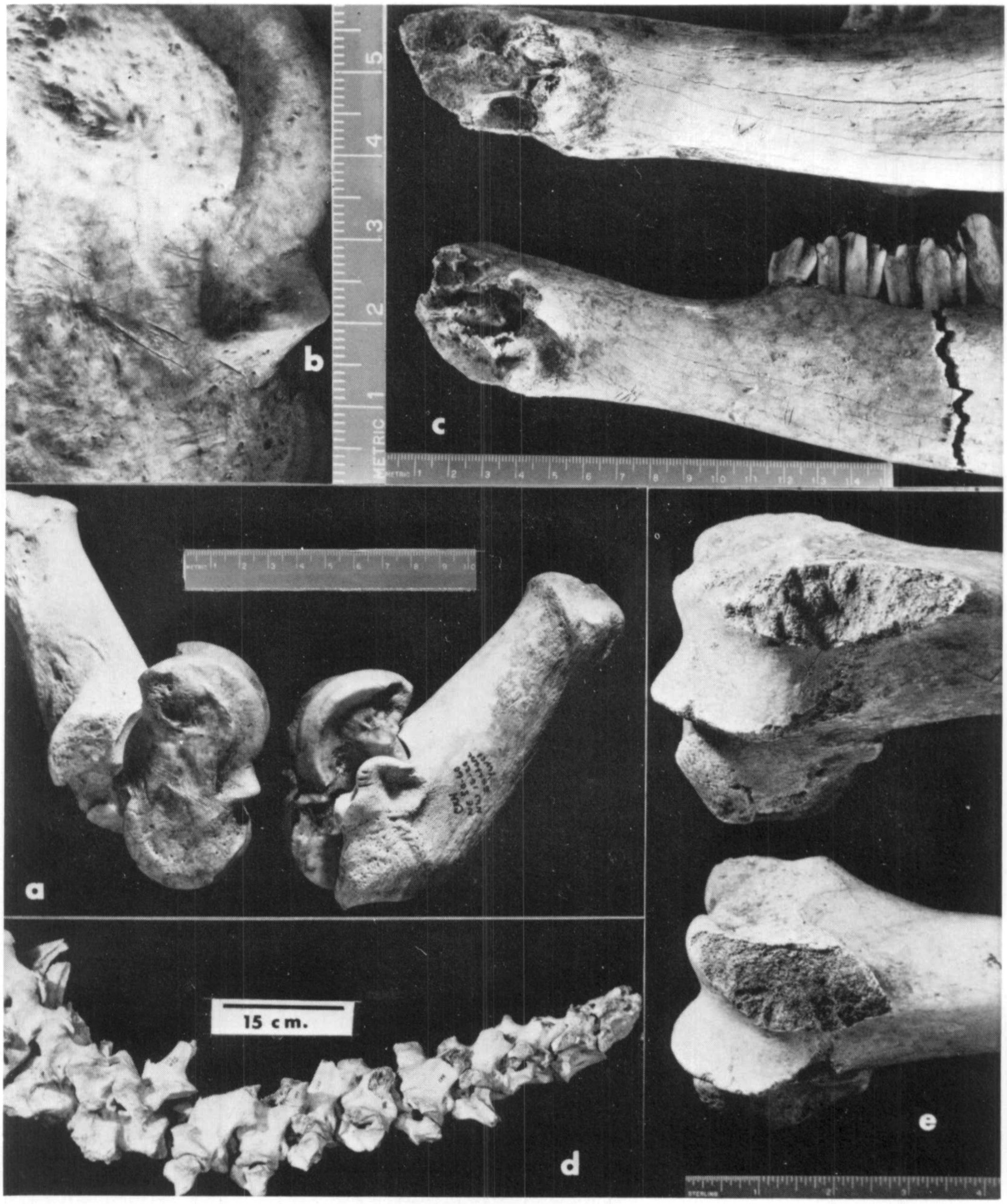

Fig. 16. Butchering marks on bone from the Hawken site.

were chopped into to make separations. The sacrum was usually crushed and broken in the vicinity of the caudals, probably from removal of the tail which probably stayed with the hide.

It was common at the Hawken site to break off the radius-ulnae close to the distal end. There is also evidence, in the form of cutting marks on some distal ends of radius-ulnae, of cutting off the feet between radius-ulna and metacarpal. Several ulnae demonstrate crushing and breaking of the olecranon. Rarely was the metacarpal broken but some specimens were cracked open possibly for marrow. No evidence suggests utilization of either front or rear phalanges.

On several specimens, cut marks appear at the base of the lateral malleolar facet of the

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calcaneus and also on the astragalus suggesting that the tendons were cut to remove the hind foot (Fig. 16*a*, *b*). On other specimens, the distal ends of tibiae were chopped off. Commonly, the calcaneus was given a sharp blow laterally to break it just ventral to the sustentaculum. Cutting of tendons may also have been done in conjunction with the latter process. This method of removing the hind foot strongly suggests that the animal was on its side and that the butcher held the leg fully extended. It is highly probable also that one side of the animal was butchered completely before the animal was turned over on the hide for butchering of the opposite side. By this means it is simple to field dress a bison or any large animal and keep the meat clean. A somewhat schematic representation of observable butchering evidence on the Hawken site bones is presented in Fig. 17.

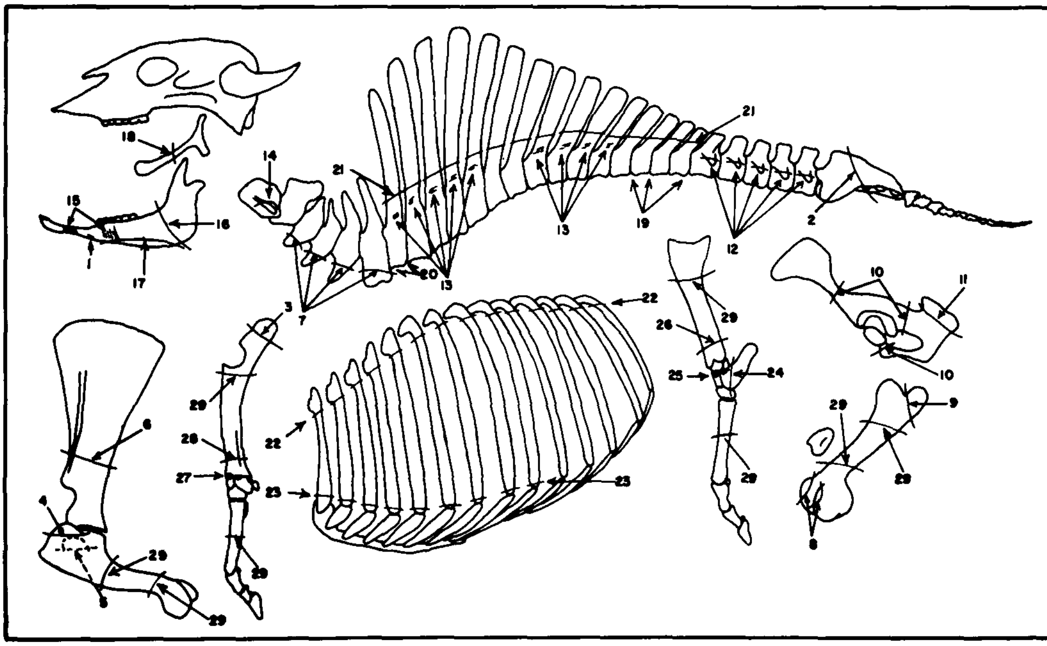

Fig. 17. Patterned butchering marks on Hawken site bones: (1) sawing marks on ventral border of mandible; (2) crushing and breaking of sacrum; (3) crushing and breaking of olecranon; (4-5) chopping off lateral and medial tuberosities of humerus; (6) breaking of scapula; (7) breaking of ventral branches of cervicals; (8-9) chopping into trochlea and breaking off major troxhanter of femur; (10) breaking of the pelvis; (11) chopping off tuber coxae; (12) breaking of transverse processes of lumbars; (13) knife marks from cutting back muscles; (14) breaking wings of the atlas; (15) knife marks from cutting loose tongue; (16-17) crushing and breaking mandible; (18) breaking hyoid bone; (19-20) chopping and crushing to separate vertebral column; (21) breaking and chopping loose dorsal spines; (22-23) chopping and breaking of ribs; (24) breaking calcaneus; (25) knife marks on calcaneus and astragalus; (26) breaking distal end of tibia; (27) knife marks on distal radius-ulna; (28) breaking off distal radius-ulna; (29) long bone breakage for marrow.

PATHOLOGIES OF THE HAWKEN SITE BISON

Pathological bones found in an archaeological site usually constitute a small portion of the total remains recovered. These can, however, be of considerable value in the evaluation of conditions among the animals at the time of the archaeological event.

Dental Anomalies

Bison from the Casper local fauna were high in the frequency of incidence of various dental anomalies. Some of them seem to have been genetic, and probably of negative selective value. As a result, it was suggested that the herd may reflect some degree of inbreeding, coupled with a founder's effect from predatory pressures (Wilson 1974b:165-170). In marked contrast, the

Hawken site bison exhibit few dental pathologies, and most are minor. Few appear to be of genetic origin, and their selective importance is open to some discussion.

Dental anomalies at the Hawken site include one missing P_2, and numerous cases of crowded teeth. In some mandibles M_1 is extremely procumbent, such that P_4, in erupting, cut well into the front of the molar. While this reduced the wear surface of M_1, it ensured the continuity of wear surface from tooth to tooth, and therefore the absence of gaps that would have trapped food. As such, it does not seem to have been particularly disadvantageous, although any greater procumbence of M_1 might have been.

One mandible exhibited a duplicated P_3, and a few malformed teeth were noted. One malformed M_3 seems to represent an individual in which enamel formation was incomplete. Very likely this was an animal of poor condition resulting from some other stress to the body—perhaps a long-standing infection of some sort.

Post-cranial Pathologies

An associated atlas and axis display a probable traumatic lesion (Fig. 18*d*), mainly in the left alar process of the atlas. Reactive bone was deposited in response to a resulting infection, limited to this area of the two vertebrae.

Another pathology involving two adjacent bones involved a thoracic vertebra and rib (Fig. 18*e*). Extensive overgrowth of bone around the margin of the articulations on both rib and vertebra resembles that resulting from infective arthritis.

Another rib (Fig. 18*c*) exhibits two traumatic lesions, probably from a single injury. New bony tissue extends from the head through the neck area and onto the shaft of the rib. A few inches down the shaft from the head there is a second thickening resulting from the healing of an over-ride fracture.

A right humerus has a roughened growth of bone on the lateral face of the lateral epicondyle. This looks much like senile osteoarthritis around a muscle origin, a fairly normal condition in old animals.

A left ulna (Fig 18*a*) shows extensive reduction and remodeling of the olecranon process, from a prolonged or chronic infection.

Two metatarsals (Fig. 18*b*) from separate animals, exhibit what appear to be localized osteitis..

The Hawken site lesions appear to have been quite minor, and with the possible exception of the deformed ulna, none of them are likely to have produced serious motor disability to the affected animals. The proportionately high number of old males in the sample may have affected the frequency of traumatic lesions. Several of the lesions may have resulted from male-male dominance displays.

OTHER FAUNAL REMAINS

Non-bison faunal material included three species. Mandibles and part of the postcranial skeleton represent a wolf (*Canis lupus*) of quite old age. Bone breakage suggests the animal may have been deliberately butchered. Both mandibles and two cervical vertebrae of a mule deer (*Odocoileus hemionus*) were found. The distal end of an antelope metatarsal (*Antilocapra americana*) was modified into a knapping tool.

SUMMARY AND SPECULATIONS

The Hawken site represents a period poorly known on the northwestern Plains. Two radiocarbon dates derived from charcoal from the site (6470±140 years: 4520 B.C.; RL-185 and 6270±170 years: 4320 B.C.; RL-437) indicate an early Altithermal period age. It postdates by about 1,000 years the terminal Paleoindian period as it has been described at the Hell Gap site (Irwin-Williams and others 1973), yet the Hawken site is in many ways reminiscent of Paleoindian bison kills. It demonstrates that the larger, now extinct bison lingered on and were hunted on the northwestern Plains. The procurement operation at the Hawken site forms a bridge between those of the earlier Paleoindian and the later post-Altithermal times. The bison recovered were an extinct

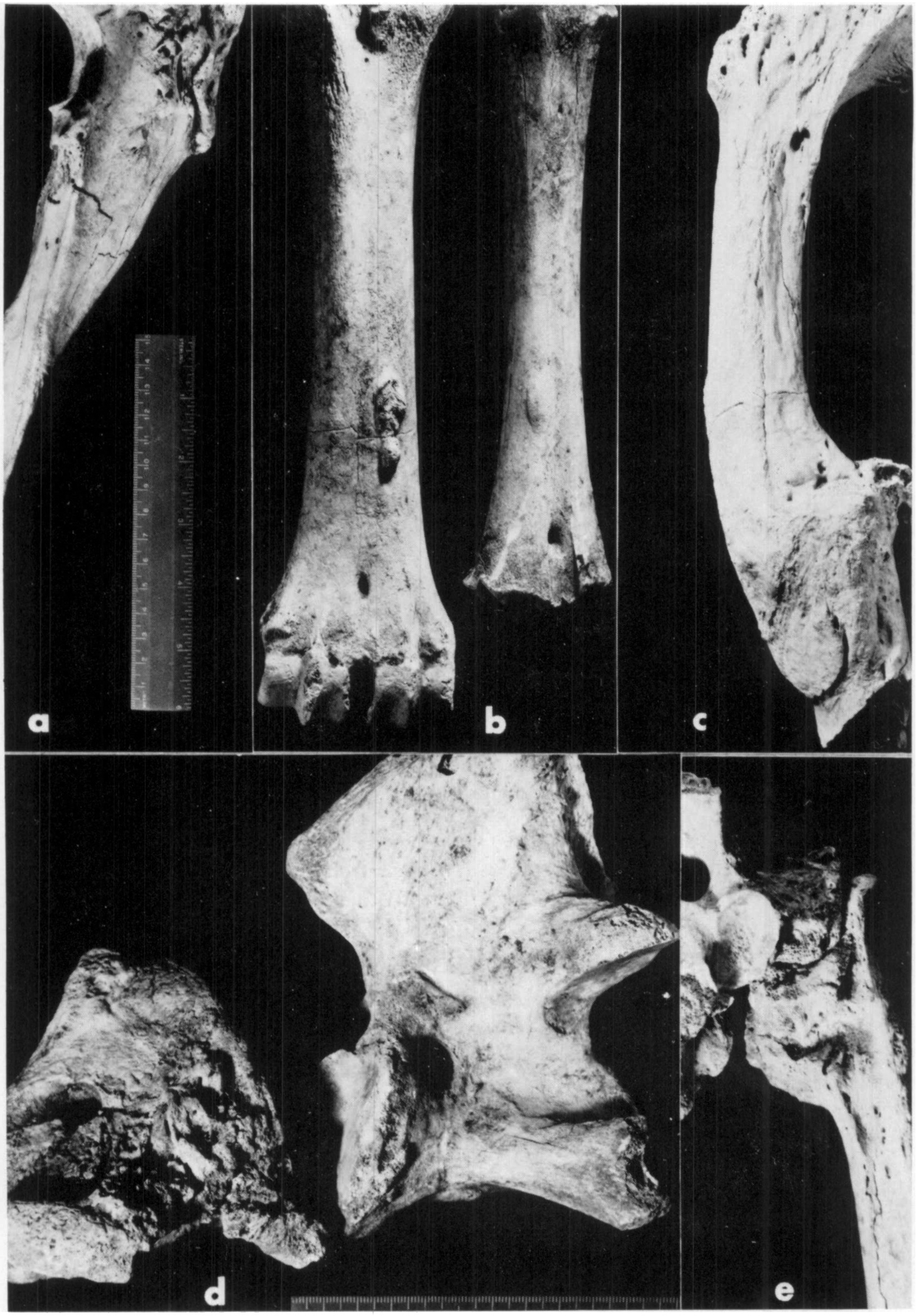

Fig. 18. Pathological bone from the Hawken site. See text for explanation.

form, *Bison bison occidentalis*, intermediate in size between the smaller *B. b. bison* that were present by at least 2500 B.C. (e.g., Lobdell 1973) and the larger *B. bison antiquus* that were present at 8000 B.C. (Wilson 1974b) in the same general area. The Hawken site bison are an important link and suggest that bison evolution during the Holocene was consistent and resulted in a gradual decrease in size until the modern form appeared (Wilson 1975). There is, however, a possibility that the gradient increased in the period around the end of the Altithermal. More data are needed to allow investigation of this process in late Altithermal times.

Seasonality of communal bison procurement is important to an understanding of the cultural systematics of prehistoric plains groups. Any large kill that contains a valid sample of the existing bison population or the "standing crop" can be used to determine the age structure and time of year when the animals were killed. Any large kill that contains a valid sample of any year's calf crop not yet mature will provide the basis for a time-of-year determination although closer determinations can be made if there are calves, yearlings, and two-year-olds. These kinds of studies have been used successfully by zoologists and paleontologists and are based on a large body of empirical data (e.g., Voorhies 1969; Deevey 1947; Kurtén 1953).

The Hawken site raises many questions as to the effect of the Altithermal period on Plains cultures. It suggests the early part may have had little effect, but it must be cautioned that the Black Hills is an oasis-like feature that may have supported significant numbers of bison when the surrounding Plains were not nearly as attractive. It does appear, on present evidence, that the Altithermal aridity may have restricted occupation of the open Plains.

The idea of a cultural hiatus on the Plains during the Altithermal has been controversial for some time (e.g., Reeves 1973). We now know that there was human occupation in the mountains and areas fringing the mountains during the Altithermal period in Wyoming and southern Montana. The evidence from Mummy Cave (Wedel and others 1968) and a number of other sites already mentioned bears this out. These human occupations are manifest in one way at least by an abrupt change in projectile point styles from those of the Paleoindian to the side-notched Altithermal styles. Regionally they are manifest also by what is called the Bitterroot phase in Idaho (Swanson and others 1964) which began about 5000 B.C. Dated evidence has appeared also further north in Alberta (e.g., Reeves and Dormaar 1972).

The cultural affiliations of the Hawken site bison hunters are not known and the projectile points do not give us that kind of information. The points could be regarded as nothing more than the late, local Paleoindian styles such as Fredrick and Lusk with added side-notches; and variations from this are the results of reworking broken specimens. Whether or not the Hawken site group was related to the Bitterroot phase to the north and west or the Mummy Cave group to the west, cannot be determined on comparisons between projectile points.

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Skeletal material collected from a number of modern bison herds was a great aid in analysis. We acknowledge Mr. George Crouse, Mr. Arthur Busskohl and especially Mr. "Bison Pete" Gardner for saving and donating their materials and time.

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The photographs are by Mr. C. Robert Swaim and line drawings and maps were done by Ms. Abbie Current and Ms. Mary Breckenridge.

Crew members during the 1972 field season were George Zeimens, foreman, Ross Hilman, Janet Tewksbury, Charles Reher, Kathy Buchanan, Lorraine Lambert, Charles Jefferson, Jack Lobdell, and Sandy Zeimens.

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