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Three buried carcass disposal pits, containing the bones of numerous large animals, primarily horse, plus smaller taxa, and a variety of associated artifacts, were unexpectedly discovered during 2006 as a result of earth moving activities associated with the construction of an addition to Memorial Union, Iowa State University, Ames. Over a period of 11 days, a program of archaeological excavation documented a remnant of one of these features. Pit 2 dates to ca. 1910-1912 and contains carcasses discarded from laboratory classes in anatomy taught in the Division of Veterinary Medicine at Iowa State College, as well as a variety of historical artifacts. The skeletal specimens include the remains of at least 19 mature to aged horses, plus a handful of cow, dog, pig, cat, chicken, and rodent remains. The intact portion of the bonebed was filled and buried over the course of a short time, probably less than a single year. Two organizationally distinct but contemporaneous debris streams contributed to Pit 2, incorporating carcasses from the Veterinary Medicine program as well as historical artifacts from inside the Veterinary Hospital. The discard of a diverse assemblage of historical items, including bottles with corks still in place, complete pieces of English ironstone china, a cut glass goblet, ceramic crockery, electrical insulators, oil lantern parts, and numerous small items including shell and bone buttons, was coordinated with the dumping of carcass portions, probably over the course of a single academic year taught by the Division of Veterinary Medicine at Iowa State College. Pit 2 is one of at least three similar features situated in a paddock located behind the Veterinary Medicine building, reflecting a long established tradition of carcass disposal in this area, probably dating to 1884-1885.

Keywords: historic zooarchaeology, vertebrate taphonomy, history of veterinary medicine, horse

INTRODUCTION

In late March 2006 earth moving activities related to the construction of an addition planned for the south side of Memorial Union at Iowa State University led to the unexpected discovery of three deeply buried pits containing the tightly packed skeletal remains of large animals, mostly horses, plus several smaller taxa, and a variety of associated artifacts dating to the earliest days of the University. The pits were impressive features, reminiscent of prehistoric multi-animal bison kill/butchery bonebeds on the Great Plains. In an attempt to recover as much information as possible concerning the early history of the University, Iowa State University President Gregory L. Geoffroy and Warren R. Madden, Vice President for Business and Finance authorized and funded a crew of highly experienced graduate and undergraduate students from the Department of Anthropology, supervised by professional personnel, to undertake an intensive program of archaeological research. Fieldwork was conducted between March 30 and April 9, 2006, and centered on a remnant of a single pit, Pit 2. This memoir reports on the excavation, analysis, and interpretation of the materials recovered from this unique site.

The project was organized and directed by Matthew G. Hill, Ph D., Assistant Professor, Department of Anthropology, Iowa State University. However, due to several off-campus commitments, Hill was unable to be present during the majority of the field work, and this responsibility was assumed by David J. Rapson, Ph D., Affiliate, Department of Anthropology. Hill and Rapson collaborated on the analysis and preparation of this report. Dr. George W. Beran, DVM, Ph D., Distinguished Professor *emeritus*, Department of Veterinary Microbiology and Preventive Medicine, and an authority on the early history of the College of Veterinary Medicine at Iowa State University, agreed to collaborate in the analysis and interpretation of the recovered materials. A number of other specialists and interested individuals assisted in the completion of the research, and their efforts are noted in the Acknowledgements.

Following standard reporting protocols, the site has been assigned an archaeological site number, 13SR216, by the Office of the State Archaeologist, Iowa City where information on all archaeological resources in the state is centralized. All artifactual and faunal materials recovered during this project, including related documentation, are curated in the Department of Anthropology, Iowa State University where they are available for interested scholars for further research.[1]

Summary of Results

The excavated pit (Pit 2) contains carcasses discarded from laboratory classes in domestic animal anatomy taught in the Division of Veterinary Medicine at Iowa State College. The pit was filled and buried over a short time frame, probably less than a year. It dates between 1910 and 1911-1912, based on a fine china bowl and an early telephone mouthpiece. At least 19 mature to aged horses and a handful of other animals, including cow, dog, pig, cat, chicken, and one brown rat are represented. Other contents of the pit are somewhat unexpected, including an eclectic assortment of rare, complete, and relatively expensive artifacts. The confluence of two organizationally distinct debris streams is the probable explanation, with one stream consisting of carcasses from the Veterinary Medicine program, and the other deriving from the discard of materials stored inside the former Veterinary Hospital until 1911-1912. A series of ‘clean-up’ events, associated with its transition to a Storage/ Carpenters Shop, occurring between 1910 and 1911-1912, offers the most probable scenario for the formation of Pit 2. Discard of the historical items appears to have been coordinated with the dumping of carcass portions during the course of one academic year by the Division of Veterinary Medicine at Iowa State College. The pit is one of three situated in a paddock located behind the Veterinary Hospital at this time, reflecting a long established tradition of carcass disposal here, probably dating to the original construction of the building in 1884-1885.

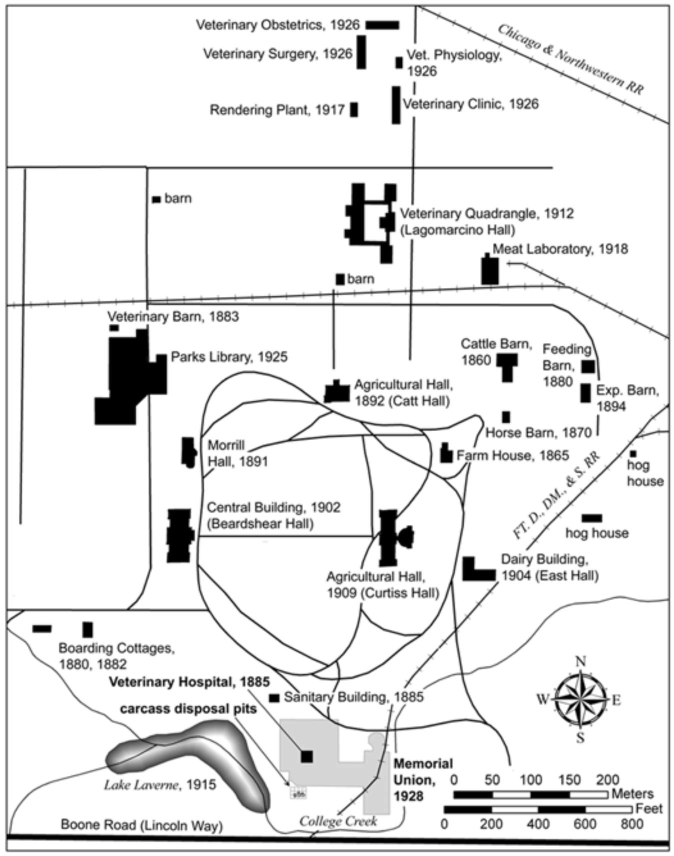

Figure 1. Map of selected building and features on Iowa State University campus in the early 1900s, with dates of construction (if known) for the buildings. Some of these buildings have since been razed.

Research and Sampling Strategy

Based on the limited time available for field work, a decision was made to concentrate excavation effort on Pit 2. Figure 1 shows the location of the site in relation to other, selected buildings on campus. Figure 2 illustrates the three pit features in profile, shortly after they were exposed by heavy equipment. The size and depth of Pit 2 offered the best fit in terms of capturing the maximum amount of relevant information within the allotted time frame. Figure 3 illustrates the 1-x-1 m alphanumeric grid system imposed over the remaining, intact portion of the pit. Teams of two excavators were responsible for the excavation of each 1-x-1 m unit (Figure 4).

Figure 2. View looking northwest at the Memorial Union bonebed excavation area showing the location of Pits 1-3 as they appeared shortly after being reported. Memorial Union is visible in the background.

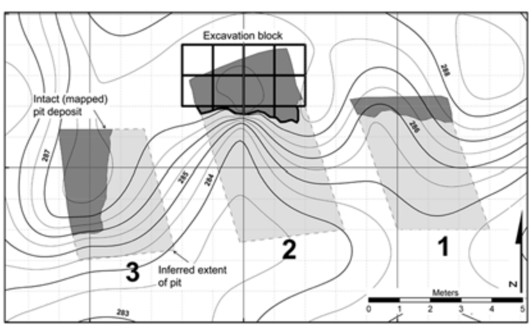

Figure 3. Topographic map of project area and Pits 1-3, including overlay of the 1-x-1 m grid system employed in excavations, shortly after being reported, and after it was modified by construction activities. Contour interval is 0.5 m.

Although the research presented here employs ideas and methods from a range of physical, biological, and cultural disciplines, it is organized in terms of a single overarching interpretive theme – the mosaic approach to bonebed formation. This approach seeks to evaluate rather than assume the sources of archaeological patterning, as well as considers how meaning is assigned to such patterns. It is grounded in the recognition that human actions represent only one among a number of agents and processes, acting over varying temporal and spatial scales, that together create the mosaic of materials and relationships we seek to explain in the archaeological record.

HISTORICAL CONTEXT

School of Veterinary Medicine

Iowa State Agricultural College and Farm was chartered in 1858, with instruction in veterinary medicine identified among the courses to be developed. Veterinary courses were first offered

Figure 4. View looking east at Pit 2 during excavations. Memorial Union is visible in the background, and in the upper right, Lincoln Way (Boone Road). The entire north wall of the original pit, as well as remnants of the east and west margins, are visible. From left to right, the persons working are Larry Van Gorden, Andrew R. Boehm, Andrew "Pat" Brummel, and David J. Rapson.

at the College in 1872 as part of the first senior class in agriculture (Stange 1929). Professor H. J. Detmers from Germany taught courses in anatomy, physiology, pathology and practical instruction during that year. In 1878, Dr. Milliken Stalker from Ontario, Canada was appointed head of veterinary work in the School of Agriculture. At that time, three private veterinary colleges were operating in the United States, with one in Canada[2] (Christensen 1963:642).

In 1879, the seventh veterinary College in the United States was founded at Iowa State College, the first land grant college created under the Morrill Act of 1862. Veterinary Medicine was initially a two year course, increased to three years in 1887, and to four years in 1903. The initial course of study was based on 13 credits in anatomy, dissection and clinics, primarily emphasizing the horse, with a single credit in comparative anatomy of the cow, chicken, dog, and cat. A total of 26 credits in zoology, chemistry, and physiology completed the basic science courses for veterinary medical students. These were followed by 29 credits in disease diagnosis, therapeutic, and clinical studies.

During the first five years of the new School of Veterinary Medicine under Dean Milliken Stalker, physical facilities were limited to the former house and stable of President Adonijah Welch and North Hall. In 1885, classroom instruction was moved to the first floor of the new Sanitary Building (Figure 5), which also served as the student infirmary located on the second floor. Instruction in veterinary anatomy, veterinary surgery, and animal care, as well as free clinics one hour each day for college and community animals, consisting primarily of farm (draft) and buggy horses, were located in the Veterinary Hospital, built in 1884-1885 (Figure 6). A six acre grass and clover paddock with water

Figure 5. The Sanitary Building served both student health and veterinary basic sciences. The second floor was the student infirmary with Dr. David S. Fairchild as college physician. The first floor served veterinary students with Dean Milliken Stalker and Dr. Fairchild teaching physiology, pharmacology, and basic veterinary infectious and parasitic diseases. Veterinary medicine moved in 1893 to Agricultural Hall (now Catt Hall), and the building was used exclusively as the student hospital; it later became Music Hall, and was razed in 1927. Courtesy Iowa State University Library/Special Collections Department.

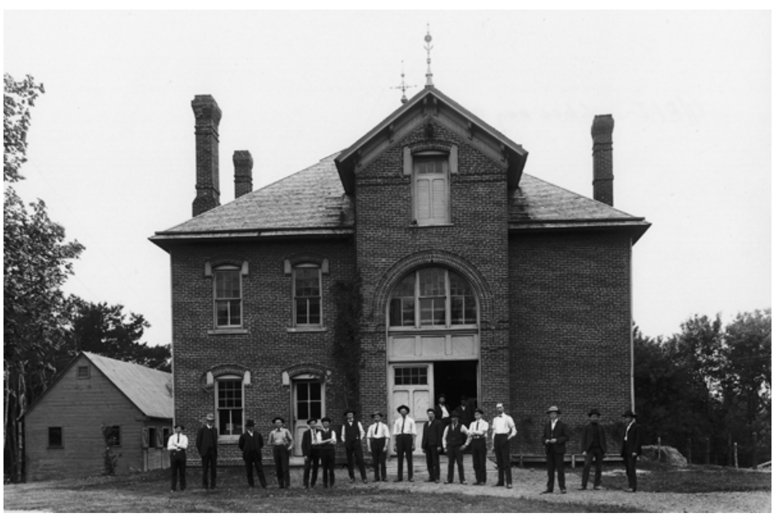

Figure 6. 'Veterinary Hospital Senior Class May 24, 1905' showing the north side of the Veterinary Hospital. The carcass disposal pits and paddock were located on the south (other) side of the building. The paddock fence is visible in the lower right-hand corner of the photograph. Courtesy Iowa State University Library/Special Collections Department.

from College Creek was located directly behind (south of) the hospital (Day 1980:453). It was used primarily for veterinary horses. The three bonebed pits discussed here were located in this paddock, presumably well fenced to keep marauding animals away.

Chronology

Figure 7 chronicles the construction and use histories of various buildings associated with the School of Veterinary Science at Iowa State College. Although classroom instruction was moved to Agricultural Hall (now Catt Hall) in 1893, the Veterinary Hospital was retained as the location for laboratory classes in anatomy until 1912, when the Veterinary Quadrangle (now Lagomarcino Hall) was completed. After 1912, the Veterinary Hospital was used as a Storage/Carpenters Shop until 1926, when it was razed to make way for construction of the Memorial Union, begun in April 1927 (Day 1980).

Laboratory in Anatomy

Student laboratories in veterinary anatomy operated in an unheated section of the Veterinary Hospital between 1885 and 1912. Animals were euthanized for anatomical studies, or carcasses were obtained from animals which had died of injuries or noncommunicable conditions; animals with infectious diseases, for example, glanders, rabies, brucellosis, or tuberculosis, were avoided. The horse was the primary focus of study, usually consisting of aged animals either sold or given by owners, including individuals that could not be returned to active work from the clinic. All carcasses were dissected as fresh tissues and

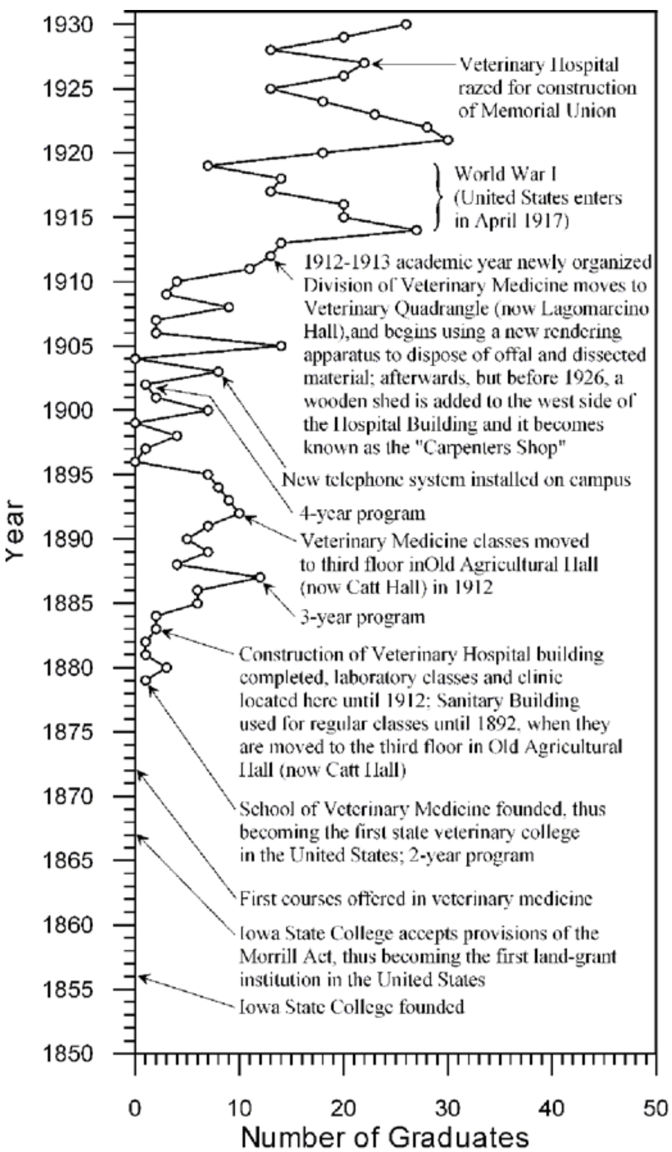

Figure 7. Chronology of key events associated with the early history of Iowa State University and the College of Veterinary Medicine arrayed against the number of graduates in veterinary medicine. All of the graduates are men; the first woman to earn a DVM from Iowa State University graduated in 1938. Information from Day (1980) and Stange (1929).

organs during cold weather months. Entire limbs, heads, vertebral columns and organ systems were each dissected by groups of three or more students working on a single carcass. These sections were then separated from newly available carcasses so that the dissecting groups could rotate and examine them. This procedure maximized the examination of fresh tissues before they were extensively decomposed. The dissected carcasses, tissues and organs were presumably disposed of by burial in pits dug adjacent to the hospital. A period photograph (Figure 8) illustrates two groups of veterinary students dissecting equine tissues and organs in the hospital laboratory.

The horse carcass was a basic component of the anatomy laboratory. Following completion of anatomical studies on the horse, brief comparative studies were carried out on other animal species. Cow carcasses, primarily from animals beyond reproductive age or condition, were studied for digestive, reproductive, and lactation systems differing from horses. Carcasses of chickens, dogs, and cats were readily obtained from owners or as undesired animals.

The first quarter century of veterinary medicine at Iowa State College is essentially encompassed by contents of Pit 2. Throughout this period, the horse represents the motive ‘engine’ powering agricultural development in Iowa and the western plains. Horses pulled the plows that opened virgin lands to the planting of corn, oats, beans, vegetables, and fruit trees, and to grasses, alfalfa, and clover. Horses pulled the planters, cultivators and harvesting equipment. Horses moved the wagons that transported the harvests within the farm, between farms, and to developing markets. These wagons hauled feed for cattle, swine and poultry, and then transported the animals and their products to nearby markets. Horses were fundamental in transporting men, women and children to schools, churches, and towns, or wherever farm and town dwellers desired to go by buggy.

Veterinary care of work horses and buggy horses was essential to their ongoing service, health, nutrition, and appearance. As disclosed by the contents of Pit 2, the anatomy of the horse was basic to veterinary knowledge, whether

Figure 8. Junior (first year) students performing horse dissections in the unheated anatomy laboratory in the Veterinary Hospital, ca. 1890. In the procedure shown here, a carcass has been cut into three major anatomical sections, and each section is assigned to a group consisting of several students for dissection, who then rotate to study the other dissections, thus providing maximum experience in the shortest possible time before the tissues decompose. Students sit on what they can find, wearing clothing chosen for warmth more than appearance or condition. The tall piece of equipment in the upper left is a surgical table in vertical position; it was used to immobilize the animal for euthanatizing. Courtesy Iowa State University Library/Special Collections Department.

through professional study or on-the-farm experience. In 1900, Iowa established licensing of veterinarians. Until 1885, Iowa State College had graduated only 13 veterinarians, but by 1900 the number of college graduate veterinarians granted licenses in Iowa was 162. In addition, 395 non-graduates who had gained their veterinary skills by experience and the independent study of texts such as the *Illustrated Stock Doctor and Livestock Encyclopedia* (Manning 1880), were also granted licenses, if they had practiced veterinary medicine for at least five years.

The anatomical study of horse carcasses, primarily aged individuals, provided an understanding of the basic structure and function of the limbs, teeth, respiratory and digestive systems, as well as the reproductive organs. These aged animals showed the effects of malfitted shoes, arthritis, degeneration of joints, long time respiratory diseases and abdominal parasites, plus healed lesions from various injuries and bruises. Dissection and anatomical study provided the necessary knowledge for the next level of veterinary medicine; physiology, pathology, surgery, obstetrics, and therapeutics. Such studies on the horse also provided the foundation for comparative studies on cattle, sheep, swine, chickens, and turkeys, as well as dogs and cats.

During this period, veterinary care was essentially focused on individual horses and other livestock, even individual poultry. For horses, great attention was placed on assessing lameness, the function of joints, abnormalities of walking, and injuries and infections to the hooves and limbs. Draining abscesses, cleaning wounds, corrective shoeing, application of liniments, caustics and acids were all used; the era of specific drugs for internal use was just beginning. Dental caries, injuries and malformations were examined; specific dental and trephine instruments were available and their application was an increasing part of veterinary surgery and care. Stethoscopes and instruments for administering medications and for assistance in foaling were available and becoming more widely used. The diagnosis of respiratory, digestive and reproductive illnesses and conditions was well established and treatments were rapidly being developed. Iowa State College Veterinary Short Courses for practitioners were conducted annually and were well attended. Medical treatments consisted predominantly of stimulants, tonics, counterirritants, poultices, laxatives, oils, expectorants and diuretics. Specific anti-parasite drugs were well developed, although anti-infection drugs were not yet fully understood. Nutritional counselling and the use of nutritional supplements was also increasingly important as a service of veterinarians.

VERTEBRATE TAPHONOMY AND THE MOSAIC APPROACH TO BONEBED FORMATION

Contemporary zooarchaeological research adopts the ideas and incorporates the methods engendered by a taphonomically-informed approach to the interpretation of archaeological remains. This approach is typified in the investigation of large animal bonebeds (Hill 2001; Kreutzer 1996; Meltzer et al. 2006; Todd 1987; Todd and Frison 1986). Taphonomy is "the field of study which focuses on the accumulation and modification of osteological assemblages from a site formation perspective, [it] provides a more holistic, multidisciplinary framework for investigation than do traditional paleontology and archaeology" (Bonnichsen 1989:1). Thus, a taphonomic history traces "the stages or phases in the formation of a faunal assemblage, spanning the death of an organism to the resulting faunal collection ultimately studied by the investigator" (Marean et al. 2000:201). It is based on a dynamic, interactive approach to the study of complex deposits such as bonebeds. Whereas traditionally, researchers have assumed a simplistic, one-to-one relationship between the patterning observed among faunal remains and human agency, a taphonomic perspective sees the archaeological record as a "complex, evolving, integrated system of biological [cultural, climatological] and sedimentological processes" (Behrensmeyer and Kidwell 1985:105). It offers the opportunity to evaluate, rather than assume, the sources for observed patterning, thereby encouraging detailed investigation into how meaning is assigned to such patterns. The approach is based on the recognition that human actions represent only one among a number of agents and processes, acting over varying temporal and spatial scales, that together create the mosaic pattern of materials and relationships we seek to explain in the archaeological record (Todd and Rapson 1999). By emphasizing the interaction of dynamic physical, biological, and cultural processes, such research focuses attention on the importance of "processes of preservation and how they affect information in the fossil [archaeological] record" (Behrensmeyer and Kidwell 1985:105).

In the case of Pit 2, research was designed to address several questions regarding the formational history of the bonebed, as well as investigating how this and the other nearby pits were integrated into the organizational framework and use of space at Iowa State College:

- What taxa are represented, and what is the age/sex mix?
- When were the pits used?
- Was Pit 2 excavated, filled, and buried over the course of several years, or does it represent a relatively rapid sequence of excavation, filling, and burial, perhaps within one year?
- What is the nature of the relationship between the skeletal remains and the artifactual remains?
- What is the nature of the associated cultural material?
- Do the artifacts represent a debris stream related exclusively to laboratory classes in veterinary anatomy, or do the materials derive from some other source? Alternatively, is the debris stream more complex, reflecting inputs from multiple sources? If so, can these sources be identified?

Since the bulk of faunal remains from the pit feature are horse, our analysis revolves largely around this animal, as did most veterinary medicine prior to World War I, when "essentially all transportation and farm power, and seemingly everything that moved, depended upon the horse" (Kester 1976:50). Prior to the war, the United States was home to some 27 million horses and mules, with the Army and Standard Oil owning the two largest fleets (Kester 1976; Miller 1963). Against this backdrop, it is no small wonder that Pit 2 is dominated by horse remains.

ANALYTICAL METHODS

Basic Documentation

All of the skeletal remains from Pit 2 were recorded using a nested series of bone codes describing each specimen. The coding format is a variant of a system that has proven useful in the excavation and analysis of faunal assemblages from prehistoric sites on the Great Plains and elsewhere (e.g., Hill 2001; Meltzer 2006; Niven 2006; Rapson 1990). The system is designed to accommodate modifications as needed in order to incorporate taxon-specific differences in skeletal structure, which in this case, involve primarily distal limb elements. Briefly, the first level of description refers to the general class of a specimen. In other words, is the item a faunal remain such as a horse, dog, or pig bone, for example, or a historic artifact manufactured from glass, metal, or rubber. The second level of description refers to the skeletal element (Table 1) or type of historic artifact; for example, is the faunal specimen a horse femur, dog vertebra, or pig scapula, or artifact like a bottle, horseshoe, or plate. The third level of coding refers to the portion of the specific element or artifact that is present. Since specimens can range from complete to extremely fragmentary, the portion code describes which areas of the specimen are present. The fourth coding level describes the segment present for each specified portion. For example, is the specimen a complete distal end of a femur, or is only the medial segment of the distal end present? Next, the element side is recorded. The final bit of information coded is the degree of epiphyseal union, for both proximal (cranial) and distal (caudal) ends of long bones, vertebrae, first and second phalanges. Obviously, some information, like element side and epiphyseal union, are not relevant to historic objects.

Table 1. Element Codes for Horse and Cow.

Axial		**Appendicular (Rearlimb)**	
CRN	cranium	AS	astragalus
HY	stylohyoid	CL	calcaneus
MR	mandible	FIB	fibula
AT	atlas vertebra	FM	femur
AX	axis vertebra	LTM	lateral malleolus
CE	cervical vertebra	IM	os coxae
CS	costal cartilage	MT	metatarsal
LM	lumbar vertebra	MT1	metatarsal I
MN	manubrium	MT2	metatarsal II
RB	rib	MT3	metatarsal III
SA	sacrum	MT4	metatarsal IV
SN	sternum	MT5	metatarsal V
TH	thoracic vertebra	MTS	metatarsal
XY	xiphoid	PT	patella
Appendicular (Forelimb)		PV	complete pelvis
CP1	1st carpal	TA	tibia
CP2	2nd carpal	TR1	1st tarsal
CP3	3rd carpal	TR2	2nd tarsal
CP4	4th carpal	TR3	3rd tarsal
CPA	accessory carpal	TR4	4th tarsal
CPF	4th carpal	TRC	central & 4th tarsal
CPI	intermediate carpal	TRF	1st tarsal
CPR	radial carpal	TRS	2nd & 3rd tarsal
CPS	2nd & 3rd carpal	**Appendicular (Other)**	
CPU	ulnar carpal	DEW	accessory phalanx
HM	humerus	PHF	1st phalanx
MC	metacarpal	PHS	2nd phalanx
MC1	metacarpal I	PHT	3rd phalanx
MC2	metacarpal II	PHF25	1st phalanx
MC3	metacarpal III	PHS25	2nd phalanx
MC4	metacarpal IV	PHT25	3rd phalanx
MC5	metacarpal V	SED	distal sesamoid
MCF	5th metacarpal	SEP	proximal sesamoid
RDU	radius-ulna		
SC	scapula		
UL	ulna		

Quantification

Several quantitative units are employed to explore faunal patterning and develop a taphonomic history for Pit 2. Each of these terms is defined below. First, however, it is necessary to make a distinction between what is meant by a 'skeletal element' and a 'specimen.' "Skeletal elements are anatomical units that may be represented by fragments or whole bones and are represented, partially or completely, respectively, by specimens" (Lyman 1994:100-101). To avoid redundancy, the terms 'skeletal part' and 'element' are used interchangeably with the terms 'skeletal element,' 'fragment,' or 'faunal remain.' The term 'piece' may also be substituted for 'specimen' or 'item.' The term innominate is used to refer to the left or right side of a pelvis, while a pelvis consists of both halves. As well, in order to make the text more compatible with the general practice of veterinary medicine, generic species names -- horse, pig, cow, dog, chicken, and cat -- are used in the description of the remains, as opposed to more scientifically proper terms (e.g., canid, equid, bovid).

Number of Identified Specimens

The number of identified specimens (NISP) describes the number of identified specimens per taxon (Klein and Cruz-Uribe 1984). It is also used to compare the incidence of various types of bone modifications.

Minimum Number of Elements

Minimum number of element (MNE) values are presented as comprehensive totals. That is to say, element side, overlapping anatomical features, and attributes such as age and overall size are employed in order to obtain the maximum justifiable minimum number of a given skeletal element necessary to produce the sample of specimens under study (Bunn 1986). Comprehensive MNEs for paired appendicular elements are summarized by side, and as the sum of left and right sides. When considered by side, these data can be read as MNI values. In addition, aggregate comprehensive MNEs can be read as maximal distinction MNI values (see below) (Niven and Hill 1998; Todd et al. 1996). Comprehensive MNE values are employed here to summarize the proportional representation of skeletal parts.

Minimum Number of Animal Units

Minimum animal unit (MAU) is an analytical unit designed to reveal assemblage-level patterning in the relative abundance of skeletal parts in a standardized, readily comparable format (Binford 1978, 1984). In calculating MAU, comprehensive MNEs are divided by the number of that element in a living animal. For example, for paired elements, the sum is divided by two since each animal has a left and right femur. Standardized or normalized MAU values (ratio MAU or percent MAU) are obtained by dividing each MAU by the highest MAU value for the taxon.

Minimum Number of Individuals

MNI is the minimum number of animals necessary to account for all the identified specimens per taxon in an assemblage. It is derived by separating "the most abundant element of the species…into right and left components and using the greater number as the unit of calculation" (White 1953:397). Traditionally, specimen age, size, or sex are not taken into account. In this study, however, specimen age, size, sex, and overlapping anatomical features have been taken into account. If metric and nonmetric attributes conclusively indicate that a left side specimen and a right side specimen are too dissimilar to be from the same individual, then they must represent two different individuals, and so on (Chaplin 1971). This observation is referred to as the maximal distinction MNI (mxMNI).

Bone Modification

In order to develop additional insights on the formation of the deposit, a series of cortical surface modifications were also recorded for each specimen. These modifications may be deemed cultural in origin (i.e., humanly produced), for example, cutmarks, sawing, chopping, spiral fractures, chemical deterioration, or noncultural in origin (i.e., produced by a non-human agent), for example, root etching, subaerial bone weathering, and carnivore or rodent gnawing.

Breakage

Determining the causal agent for bone breakage within archaeological deposits is critical to unraveling aspects of taphonomic history; unfortunately, it remains an imperfectly understood topic despite the tremendous amount of experimental, actualistic, and archaeological research attention it has received (e.g., Binford 1981; Bonnichsen 1979; Myers et al. 1980; Villa and Mahieu 1991). Bone breakage varies widely in extent (i.e., location, type), in intensity (i.e., fragment size and number), and in fracture type within archaeological assemblages. Spiral fractures are typically associated with fresh, nutritionally viable skeletal elements broken around the time of an animal's death, while transverse and longitudinal fractures are typically associated with dry breakage, occurring to non-nutritive, post-mortem bone specimens. The combined information obtained from such analysis is useful in determining when breakage and fragmentation occurred, as well as the responsible agents.

Subaerial Bone Weathering, Root Etching, and Chemical Deterioration

After the death of an animal, its skeleton undergoes a continuous process of deterioration and diagenesis, both above and below ground. Documentation of cortical surface weathering and root etching modifications provide important sources of information in assessing aspects of the formational history of faunal assemblages (Behrensmeyer 1978; Lyman and Fox 1989; Rapson 1990). Following Todd et al. (1987), weathering data are recorded in a series of stages designed to estimate the degree of preburial deterioration, while root etching stages document the percentage of cortical surface destruction occurring after burial (Todd 1993). Stage 1 weathering designates that a specimen is dry, not greasy, with no signs of surficial cracking, or deterioration. Stages 2 through 6 reflect increasing levels of cortical deterioration (Todd et al. 1987). Root etching is recorded (after Todd 1993), as an estimate of the percentage of surface coverage, varying from none to 100 percent (i.e., 0, 5, 10, 20, 30, 40, 50, and 60 to 100 percent coverage).

Chemical deterioration of bone surfaces, interpreted here as resulting from the application of lime to the Pit 2 deposit, was also recorded as being present or absent in order to extend our knowledge of the deposit's taphonomic history.

Cutmarks and Sawing

Human dissection activities such as skinning, disarticulation, dismemberment, and the removal of tissue and tendons with cutting tools such as knives, scalpels, and saws often impart cutmarks on faunal remains (Binford 1981; Fisher 1995). In assemblages where these types of marks are common, composite skeletal element templates provide an efficient method for summarizing patterns recorded for each element (e.g., Binford 1988; Bunn 2001). In this assemblage, sawing is recorded in this manner, in order to elucidate strategies of horse carcass disarticulation and creation of cross-sectional views (prosections) intended for classroom use.

Carnivore Modification

A large body of experimental and actualistic data has been generated addressing the actions of scavengers, particularly larger carnivores, and their role in modifying, dispersing, and destroying faunal remains in archaeological contexts (Binford 1981; Blumenschine 1986; Haynes 1983; Kent 1981; Marean and Spencer 1991). Since it is possible that scavengers played an active role in the taphonomic history of the Pit 2 deposit, information on carnivore modification to the faunal remains was gathered in order to objectively evaluate their extent and intensity. Commonly documented forms of carnivore damage to bone include tooth puncturing, furrowing, pitting, and scoring. If present, such damage is recorded for individual specimens and may also be summarized on skeletal element templates.

Burning

A variety of agents and processes can produce burning evidence on specimens within faunal assemblages. Intentional human actions such as burning for pest/odor control or refuse removal offers one possible scenario; however, unintentional burning through exposure to intense heat sources deposited along with the remains offers another. In the case of Pit 2, many specimens were burned by coal combustion residues (CCR).

CCR consists of ash and solids commonly referred to as clinker, the incompletely combusted mineral inclusions from the firing of coal in a furnace (Carlson and Adriano 1993). Macroscopic alterations in the surface color and texture of bone specimens are recorded in a series of stages that are indirectly related to the intensity and duration of heat exposure: carbonized (or blackened), calcined (completely oxidized, typically white to blue-grey in color), and a combination of carbonized and calcined (Stiner et al. 1995; Turner and Turner 1999; White 1992). Characteristics of the burned specimens, their spatial distribution, and their context of recovery are employed to shed light on dumping behaviors as they relate to the formation of the bonebed.

Documentation of Positional Attributes and Assessing the Three-Dimensional Fabric

Evaluating formational context within extremely complex archaeological deposits requires application of an intensive program of field documentation, in addition to problem-oriented laboratory analysis. Piece-plotting, or mapping of items in all three-dimensions, provides a core data set for this research, in combination with a variety of item-specific attributes. Although time consuming, such documentation must be completed during excavation, since once a specimen is removed from the ground, positional data are irrevocably lost. Provenience (i.e., location) and attribute data were recorded for all faunal and artifactual remains larger than 5 cm in maximum length and all smaller, but readily identifiable (e.g., sesamoid) or unusual (e.g., button) specimens. Due to time limitations, only a small sample of the numerous fragments of unburned coal, CCR, and burned wood were piece-plotted. All piece-plotted items were documented in terms of Cartesian coordinates – northing (N), easting (E), and elevation (Z), and referenced to actual Universal Trans Mercator (UTM) coordinates. A Sokkia Set 630 reflectorless electronic distance measuring device (EDM), in combination with a Sokkia data recorder (model SDR-33), was employed to capture these data to within ± 5 mm.

All specimens with a long axis greater than 5 cm in length were documented with two provenience points, referred to as positional pro-points ‘a’ and ‘b’. Positional pro-points are the terminal points at either end of the specimen’s long axis. By convention, each of these provenience points is taken at the base of the specimen in order to document the elevation of the ground surface upon which the item is resting. This series of six Cartesian coordinates (N, E, and Z for each end of the specimen) provides critical positional information describing the size and shape of each item in relation to the surrounding matrix. These include orientation (bearing) of the long axis, inclination (dip or plunge), and maximum length.

Information on positional attributes is used to examine the three-dimensional fabric of the deposit, that is the spatial arrangement and orientation of clastic particles (i.e., skeletal remains and artifacts) within the matrix (Potter and Pettijohn 1977:30) in order to analytically untangle the seemingly amorphous, undifferentiated mass of material. In the past, such an undertaking would have required a monumental effort, in fact, we are unaware of any other such project in the historical zooarchaeological and taphonomic literature. The recent introduction of Geographic Information Systems (ArcGIS) into archaeology, specifically, the ArcMap software package (ESRI), has changed this situation. Archaeologists now have at their fingertips a powerful data management, pattern recognition, and analysis tool with which to examine various forms of spatial data (e.g., D'Andrea et al. 2002; Holven 2006; Premo 2004; Spikins et al. 2002). In this regard, spatial statistics, such as Moran’s *I* (Cliff and Ord 1981; Upton and Fingleton 1985) are especially well suited to the analysis of complex spatial patterns within large three-dimensional matrices such as those being investigated here. Very significantly, Moran’s *I* can be used to objectively identify the extent of spatial autocorrelation by combining locational and attribute data, thereby allowing identification of local pockets of spatial dependence (i.e., autocorrelation).

TAPHONOMIC HISTORY

This section summarizes the evidence for a relatively rapid sequence of pit filling and burial for the excavated portion of Pit 2. By all indications, the excavated portion of Pit 2 was created and filled over a relatively brief period of time, on the order of several months to less than a year. However, since only a portion of one pit feature was investigated in detail, the possibility of multiple inputs occurring over time within unexcavated portions of this, or nearby pit features, cannot be discounted.

Figure 10. Pit 2 at the close of excavations on April 9, 2006. The overburden has been removed by heavy equipment, and shovel marks dating to when the pit was originally dug are visible in the north wall. Memorial Union is visible in the background.

General Description

As illustrated in Figure 3, only a remnant of the north end of Pit 2 remained intact at the onset of this research project. The original extent of each of the three visible pit features, including Pit 2 is unknown, although they appear to have been quite large. By our estimation, the extant portion of Pit 2 (~3 m east/west x ~2.75 m north/south x ~1 m deep) probably represents less than a quarter of its original size. The extant margins of Pit 2 are characterized by well defined, vertical sidewalls cut into intact, well consolidated glacial till with visible shovel marks (Figures 9 and 10). These shovel margins extend from the current surface (as exposed by construction equipment), to the base of our excavations, which exposed the entire northern wall of Pit 2, the northwest and northeast corners of the pit (each forming ~45 degree angle corners), as well as an area of about 7 m square of intact pit contents. Due to the increasing depth and density of bone, excavations were not completed in an area of 1.5 m square along the southern margin of the pit (Figure 10).

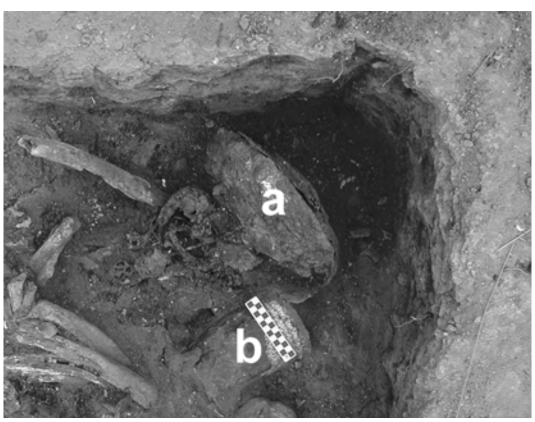

Figure 9. Northeast corner of Pit 2 showing the well preserved shovel marks delineating the original pit margins. Two historic artifacts are also visible in this photograph: a) crown belonging to a small potbelly stove; b) enamel pitcher or coffee pot. The white speckling on the faunal remains in the lower lefthand corner is lime.

Nearly 1,500 faunal remains were recovered from Pit 2, representing a minimum of 19 aged horses, 2 immature cows, 2 immature dogs, 2 neonatal pigs, 2 immature cats, 1 chicken, and 1 rat. Sprinkled among these remains were more than 100 miscellaneous historic artifacts, including bottles, short segments of wire and rubber, nails, and so on. It is overwhelming to consider that this sample of excavated material is but a small percentage of what the pit held when fully intact, and that Pit 2 was one of at least three such pits that existed on the hill slope overlooking College Creek.

As illustrated in Figures 1 and 11, the pits are located immediately south-southwest of the Memorial Union and the Veterinary Hospital. During the early 1900s, the topography of this area was dominated by the steep slope leading down to College Creek (note that College Creek is no longer visible in the foreground since it was rerouted underground in 1915 with the creation of Lake Laverne). It follows therefore, that these three pits were originally dug just over the edge of the slope leading downhill and away from the south side of the Veterinary Hospital and toward College Creek. Selection of this relatively low lying, vegetated area would have partially

Figure 11. View of the south side of the Veterinary Hospital in 1922 (then the Storage/Carpenters shop), with the approximate location of Pits 1-3. Courtesy Iowa State University Library/Special Collections Department.

obscured the pits from view. Also visible in Figure 11 is the well-established path documented in the 1904 and 1915 campus maps of Day (1980). This path provided access to campus from the residential area to the south (Boone Road/Lincoln Way). According to Day (1980), this and other footpaths leading south from the central campus area became more popular after the Old Main fire in 1902, due to the increasing number of students living in residences south of campus.

Sediments and Stratigraphy

Pit 2 was originally excavated through the topsoil and about 1 m into glacial till of the Des Moines Lobe (see Bettis et al. 1996). Prior to being removed by heavy machinery to expedite excavations, the topsoil was a heavily biologically- and mechanically-disturbed (Munsell color 10YR 2/1) sandy loam measuring 62 cm in thickness. Thus, at the time of excavation, the base of Pit 2 was 1.75 m below the ground surface. However, due to various construction and landscaping projects in this general area over the past century, we suspect this unit is not the same thickness as when originally dug. Significantly, the top of the pit was pristine in the sense that it was never sheered or otherwise damaged by subsequent activities (Figures 2 and 11).

The pit fill encasing the bonebed consists primarily of sandy loam, with occasional small rounded pebbles, a few larger cobbles, fragments of burned wood, lime nodules, and CCR (i.e., clinker). CCR occurs primarily as scattered fragments and ash, and in several mass concentrations, as illustrated in Figure 12. After deposition of the bonebed and associated artifacts, the pit was refilled with the local sandy loam, plus some glacial till material. This matrix would have significantly improved drainage within the pit after burial, in comparison to the surrounding glacial till deposit, which is extremely compact, with limited porosity. The location of Pit 2 on an inclined surface leading down to College Creek, combined with the presence of a sloping pit bottom, also undoubtedly improved drainage in the upslope portion of the pit – which is precisely the area of excavation (Figures 10 and 11). Improved drainage potential,

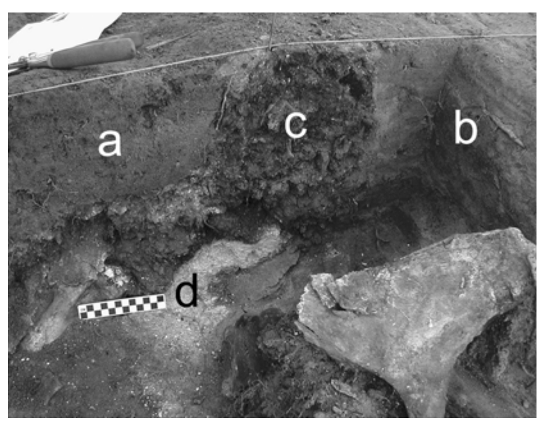

Figure 12. Excavation profile showing: a) tan-brown sandy loam fill; b) intact glacial till; c) concentration of CCR; d) white ash. Several horse remains are also visible, including a horse pelvis in the lower right hand corner.

along with other factors, including temperature, oxygen levels, burial depth, and pH, plus the addition of lime to the deposit, appear to have inhibited microbial decomposition rates within the pits (NABC 2004), thereby enhancing conditions for the unexpectedly good preservation of bone. Such favorable bone condition is unusual over a period of nearly 100 years, given the moist, hyper-seasonal environment of central Iowa, often characterized by the presence of acidic sediments that are incompatible with good bone preservation. The effect of liming the pits, by adding either calcium oxide (lime) or calcium hydroxide (a.k.a. slaked lime), is not clear. Some experts assert that the addition of slaked lime encourages carcass decomposition (Bilbo and Todd 1994; Winelander and Carter 1997), while others indicate that in fact, it inhibits such decomposition (USDA 1980). Whatever the case, liming of the pits acted to reduce acidity levels, while also acting as a desiccant.

The CCR concentrations represent discrete dumping episodes from an active furnace or pot-belly stove, perhaps the ‘furnace pit’ located in the basement of the nearby Veterinary Hospital, as illustrated in a 1921 floor plan sketch of the building. Extensive evidence of low-temperature burning is present on the faunal remains throughout Pit 2, indicating that CCR was dumped while still hot, thereby singeing, or lightly burning many of the remains. Numerous fragments of unburned coal were also noted during the excavation. These nodules contain significant impurities and based on visual inspection, are very similar to coal occurring in deposits around Boone, Iowa a major regional coal source in the early twentieth century, located roughly 24 km west of campus (Keyes 1894; Schwieder and Kraemer 1973).

No evidence of stratigraphic separation or layering in deposition was noted during the excavation. This lack of evidence for the interbedding of sediments, such as discrete sand, clay, and silt lenses, indicates that the pit was probably open for only a short period of time, probably less than one year. If it had been open for a longer period of time, we would expect to see clues of depositional processes associated with flowing water, either from rain or snow melt, producing stratigraphically distinctive sediment loads within the pit fill. This inference is supported by the pristine condition of the faunal remains, and the recovery of numerous conjoined specimens in acute, unstable inclinations.

Health and safety concerns associated with carcass disposal pits would also tend to influence the length of time such pits were left open. Addition of hot CCR, plus liming of the contents would reduce problems associated with carcass decomposition, including odors (gases), scavengers, and disease. Also, dumping and burial may have been seasonally restricted, occurring primarily near the end of the Spring semester at Iowa State College, thereby avoiding exposure of an open pit during warm summer conditions.

Three-Dimensional Fabric

Three-dimensional fabric analysis is arguably the most significant contribution of this research, whether for zooarchaeology generally, or for bonebed investigations particularly. The following discussion is based on the analysis of 1,567 items with positional provenience-point data (Table 2) using ArcMap 9.1 (ESRI).

Figure 13a illustrates all specimens recovered from Pit 2 with positional pro-point data as a series of vectors (for faunal remains) and spheres (for historic artifacts). The viewer’s perspective faces north-northeast. Each vector is a line in three-dimensional space describing the orientation, inclination, and maximum length for an individual specimen. Figure 13b provides an alternate view of these data, facing northeast and at a steeper angle. The locations of all historic artifacts are indicated by the spheres. Although at first sight, these data suggest a complex jumble of undifferentiated faunal and artifactual material, several observations are noteable.

First, the depositional context of the historic artifacts is indistinguishable from that of the faunal remains; or stated another way, there is no evidence of vertical or horizontal separation between the historic artifacts and the skeletal remains. This pattern supports the inference that these materials were deposited at the same time, as opposed to the cumulative product of a series of depositional events, occurring over an extended (multi-year) time frame. This conclusion is based, in part, on the consistently pristine,

Table 2. Coded and Provenienced Faunal Remains and Artifacts.

Faunal Remains	NISP Coded	NISP Prov.
horse	1,047	1,012
cow	137	136
pig	70	69
canid	123	121
cat	9	7
chicken	2	2
rat	1	1
unidentified large mammal	70	70
unidentified small mammal	8	8
subtotal	1,467	1,426
Artifacts		
bottle, complete	15	14
bottle, neck	11	11
bottle, fragment	32	31
vials	7	7
test tubes	3	3
corks/hose	7	7
subtotal	75	73
china/tablewares	8	8
Ball/Mason jars	2	2
miscellaneous	14	14
nails/wire/metal/glass/wood	26	26
coal/rock/lime	18	18
subtotal	68	68
TOTAL	1,610	1,567

unweathered nature of bone cortical surfaces, lacking evidence either of weathering or deterioration, a pattern that would not be expected under conditions of slow, accretional burial.

Second, positional information on faunal remains from large animal bonebeds has been documented and analyzed from a variety of time periods, including paleontological deposits (Hunt 1990; Todd 2003), prehistoric archaeological localities (Kreutzer 1988), and recent death sites (Burgett 1990). Although the majority of this research has focused on depositional settings characterized by fluvial processes, insights derived from this research can be applied to the humanly excavated (and backfilled) pit setting discussed here. For instance, although fluvial and related processes vary widely in their rate and magnitude of depositional energy, in cases where burial and preservation do occur, the majority of specimen inclinations created tend to be mechanically stable (Toots 1965), with values trending close to the horizontal, typically less than 30 degrees (Fiorillo 1988:65; Schick 1986:111). This is especially true in cases where the carcasses were initially deposited on a stable, flat ground surface and subsequently buried by one or more common forms of deposition (e.g., alluvial, eolian, colluvial, or mass wasting processes). Such deposition varies in rate from slow to rapid, and may occur either as discrete episodes, for example, a mass catastrophic accumulation occurring in a few minutes or hours, or over a series of events, for example, an accretional accumulation of material.

Table 3 summarizes the relative percentage of specimens with inclinations greater than 30 degrees at several archaeological and paleontological localities, including Pit 2. The low values recorded for Bugas-Holding, Harper’s Quarry, and Boney Springs are inferred to reflect deposition in low energy fluvial settings, while the higher values recorded for Bukwa II and Hazard Homestead are interpreted as the result of perimortem trampling by large animals. The unusually high percentage of steeply inclined specimens at Verdigree Quarry is believed to result from burial by high energy flowing water (Voorhies 1969). In the case of Pit 2, 14 percent of the specimens with positional pro-points are steeply inclined (greater than 30 degrees), sug-

Table 3. Percentage of Faunal Remains with Inclinations $\geq$ 30 Degrees at Selected Sites.

Site	%
Bugas-Holding	5.5
Harpers Quarry	8.0
Boney Springs	11.0
Hazard Homestead, 104A	15.0
Bukwa II	19.0
Hazard Homestead 104B	19.0
Verdigree	25.0
Pit 2, all faunal remains	13.5
Pit 2, fore- and rear-limbs	18.5

Note: Except for Bugas-Holding, a Late Prehistoric camp site in Wyoming, and Pit 2, all of the sites are paleontological deposits.

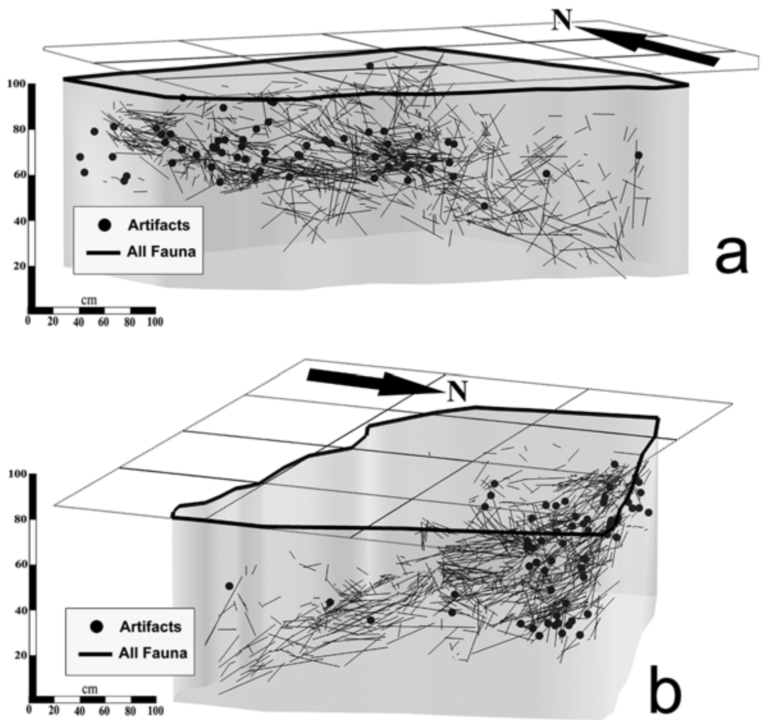

Figure 13. Three-dimensional GIS image of all piece-plotted items: a) view looking ~northeast; b) view looking ~southwest. Faunal remains are depicted as vectors, while the artifacts are depicted as spheres. Each vector represents a line in three-dimensional space describing the orientation, inclination, and maximum length of an individual specimen, based on its positional pro-points.

gesting a three-dimensional fabric with a significant percentage of mechanically unstable positions. Since the depositional context is not a stable land surface, but rather an artificially created pit feature, opened and used for only a brief period, it seems that discard of carcass parts was organized in terms of dumping sizeable quantities of material into a deep pit with vertical side walls, thereby maintaining the complex, three-dimensional fabric.

Third, rotating the image such that the viewer is facing southwest (Figure 13b) reveals that the materials are concentrated near the northern margin of the pit, suggesting that deposition of substantial amounts of these materials was initiated from the pit's northern perimeter. Such a pattern is not unexpected, if these materials were in fact being hauled from the Veterinary Hospital (or other nearby campus buildings), since all of these buildings are located north of the pit location. Also evident in Figure 13b is a tendency for items discarded near the intact edges of the pit to be more steeply inclined, following the similarly steep angle of the pit edge, which was still well-defined at the time of excavation. This pattern is again consistent with the dumping of substantial quantities of material into the pit at roughly the same point in time, thereby preserving the three-dimensional fabric of varied orientations and inclinations created during the dumping event. Had the material been introduced piecemeal over a longer period of time, the individual items would have settled into more mechanically stable inclinations (Toots 1965).

Fourth, Figure 14 illustrates locational information for conjoined horse limbs.[3] These conjoins are discussed in detail below, however, at this point it is only necessary to note that 44 different conjoins are represented, incorporating a combined total of 190 specimens with positional pro-points. These specimens were either recovered as articulated units (in their correct anatomical position), or analytically identified as elements belonging to the same individual, but recovered some distance apart, and then reassembled using a combination of osteometric and morphological analysis (see Hill 2001 for a discussion on skeletal reassembly).

Significantly, these conjoins reflect an unusually high percentage of steeply inclined specimens (19 percent, Table 3), comparable to extensively trampled deposits, as discussed above. Given the typically complicated, angular shape of articulated limb units and their considerable mass, it seems unlikely that these units were deposited piecemeal over an extended period of time. Once again, these observations support a context of rapid deposition, most probably occurring as a series of sizeable dump loads, since the

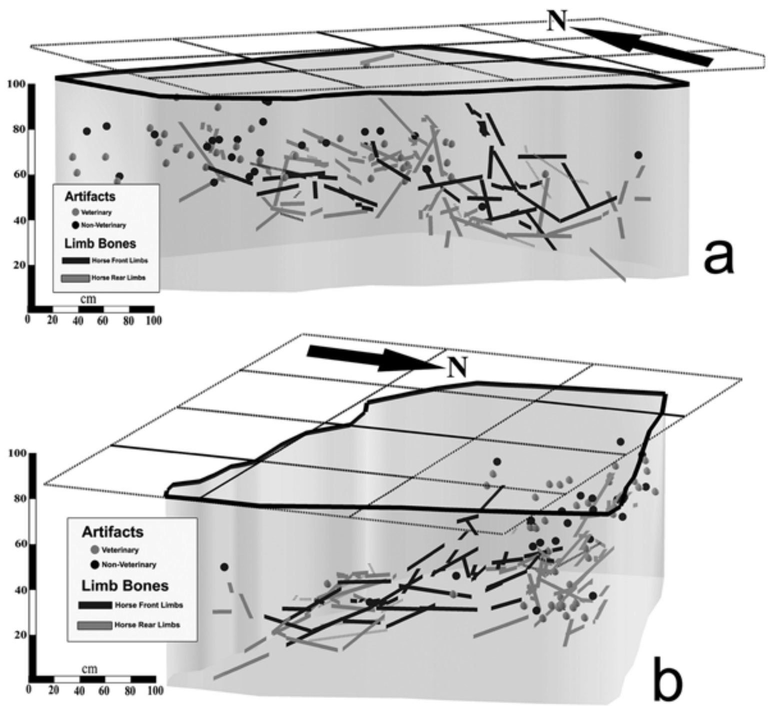

Figure 14. Three-dimensional GIS image of all conjoining limb elements for horse: a) view looking ~northeast; b) view looking ~southwest. Long bones are depicted as vectors, while artifacts are depicted as spheres. Each vector represents a line in three-dimensional space, based on its positional pro-points. Black and grey vectors indicate specimens with significant ($p < 0.5$) positive and negative spatial autocorrelation values, respectively.

observed three-dimensional pattern of orientations and inclinations is unlikely for limb units deposited on a stable land surface, or for specimens given the opportunity to settle individually over the course of an extended preburial phase.

Moreover, spatial analysis of the horse forelimb and rearlimb units in Figure 14 indicates the presence of several statistically significant clusters. These limb unit clusters are visible as concentrations of forelimb versus rearlimb vectors. The spatial clustering of limbs strongly supports the inference of rapid deposition of sizeable dump loads segregated in terms of forelimb versus rearlimb units. The presence of these distinct spatial clusters supports the inference of mass discard, occurring over a brief period of time. Such patterning points to the discard of complete limb units that had reached the end of their uselives as laboratory specimens.

Faunal Remains

A total of 1,467 faunal specimens were recovered from Pit 2. As summarized in Table 4, all of the remains belong to domestic animals, except for a mandible from a brown rat. Remains of very old, arthritic horses comprise the bulk of the assemblage, totaling 1,047 specimens and representing no fewer than 19 individual animals. The sample of cow remains includes at least 2 prime age individuals. Also represented are a minimum of 2 immature dogs, 2 fetal/newborn pigs, 2 immature cats, and 1 chicken, plus a number of fragmentary specimens identified generally as indeterminate large mammal, most of which are probably horse, or indeterminate small mammal, most of which are probably either dog or cat.

Table 4. Faunal Remains by Taxon.

Taxon	NISP	mxMNI
horse, *Equus caballus*	1,039	19
cow, *Bos taurus*	137	2
pig, *Sus scrofa*	70	2
dog, *Canis familiaris*	123	2
cat, *Felis silvestris catus*	9	2
chicken, *Gallus gallus*	2	1
brown rat, *Rattus norvegicus*	1	1
unidentified large mammal	70	-
unidentified small mammal	8	-
	1,459	

Note: Six fragmentary horse remains (1 flat bone and 5 indeterminate teeth) are not included in the horse NISP.

Horse Remains

Horse remains dominate the sample of skeletal material from Pit 2. An inventory of these remains is provided in Table 5, while the relative abundance of parts is displayed in Figure 15. As

Table 5. Horse Remains.

Element	NISP	MNE Side L	MNE Side R	MNE Side A	MNE	MAU	%MAU
CRN	41	0	0	4	4	4.0	33.3
MR	43	13	11	0	24	12.0	100.0
HY	14	2	2	0	4	2.0	16.7
AT	3	0	0	3	3	3.0	25.0
AX	3	0	0	3	3	3.0	25.0
CE 3-7	23	0	0	18	18	3.6	30.0
TH	35	0	0	35	35	1.9	16.2
RB	302	37	36	0	73	2.0	16.9
CS	48	0	0	48	48	1.3	11.1
SN	12	0	0	12	12	1.7	14.3
LM	37	0	0	26	26	3.7	31.0
SAC	18	0	0	6	6	6.0	50.0
CA	49	0	0	47	47	2.2	18.7
SC	9	4	5	0	9	4.5	37.5
HM	11	5	6	0	11	5.5	45.8
RDU	12	5	6	0	11	5.5	45.8
CPU	10	4	6	0	10	5.0	41.7
CPI	7	3	4	0	7	3.5	29.2
CPR	8	4	4	0	8	4.0	33.3
CPA	9	0	2	0	9	4.5	37.5
CP2	8	2	6	0	8	4.0	33.3
CP3	10	4	6	0	10	5.0	41.7
CP4	10	2	8	0	10	5.0	41.7
MC2	1	1	0	1	1	0.5	4.2
MC3	11	5	6	0	11	5.5	45.8
MC4	2	1	1	0	2	1.0	8.3
MC5	0	0	0	0	0	0.0	0.0
MC	0	0	0	0	0	0.0	0.0
IM	17	7	9	0	16	8.0	66.7
FM	18	8	10	0	18	9.0	75.0
PT	13	8	5	0	13	6.5	54.2
TA	19	9	7	0	16	8.0	66.7
FIB	9	1	1	0	9	4.5	37.5
AS	18	9	9	0	18	9.0	75.0
CL	18	10	8	0	18	9.0	75.0
TRC	18	10	8	0	18	9.0	75.0
TR1	18	9	9	0	18	9.0	75.0
TR2	0	0	0	0	0	0.0	0.0
TR3	15	10	5	0	15	7.5	62.5
TR4	18	10	8	0	18	9.0	75.0
MT2	1	1	0	0	1	0.5	4.2
MT3	18	9	8	0	17	8.5	70.8
MT4	12	5	7	0	12	6.0	50.0
MT5	0	0	0	0	0	0.0	0.0
MP2/4	2	0	0	0	2	0.0	0.0
PHF	16	7	7	0	15	3.8	31.3
PHS	15	6	7	0	14	3.5	29.2
PHT	15	5	6	0	14	3.5	29.2
SEP	32	4	3	0	32	4.0	33.3
SED	13	5	2	0	12	3.0	25.0
	1,041						

Note: MNE side = L (left), R (right), A (axial/not sideable); see Table 1 for element codes.

illustrated in Figure 15, all elements in the horse skeleton are represented, and excepting mandibles and sacra, appendicular elements outnumber axial elements.

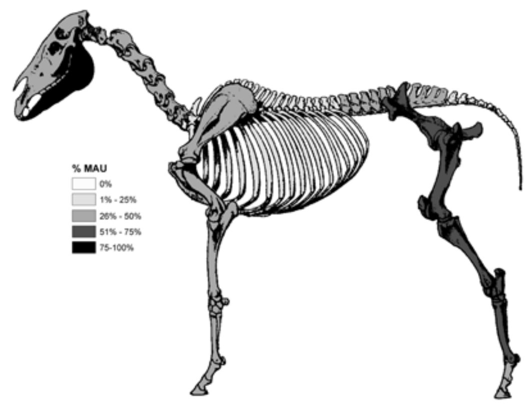

Figure 15. Relative abundance of horse remains expressed as percent MAU values.

All of the horse remains are from skeletally mature, aged individuals. Due to their advanced age, no attempt has been made to age the individual dentitions based on established schedules of dental eruption and wear (Getty 1975; Levine 1982), since this technique works best for aging younger animals (Habermehl 1961). That said, an age range of 15 to 25 years for these animals seems likely. They were probably well past reproductive age at the time of death, as indicated by the presence of numerous dental malocclusions and severe osteoarthritis.

Figure 16 illustrates two horse mandibles from aged individuals exhibiting significant malocclusions. Malocclusions are misalignments of the teeth and/or occlusal surfaces resulting from tooth loss, advanced occlusal wear, disease, and/or injury. Such conditions are often exacerbated in older age individuals due to increasingly uneven rates of dental abrasion and attrition (Hillson 1986). In the case of the mandible in Figure 17, the third molar has been worn down to the roots, and is in the process of resorption.

Another indicator of old age (and a lifetime of heavy work) apparent in this assemblage is the number of distal limbs displaying severe osteoarthritis. Table 6 is a summary of subjective assessments of remodeling of horse bone related to osteoarthritis. For the axial skeleton, the percentage of elements displaying arthritic remodeling

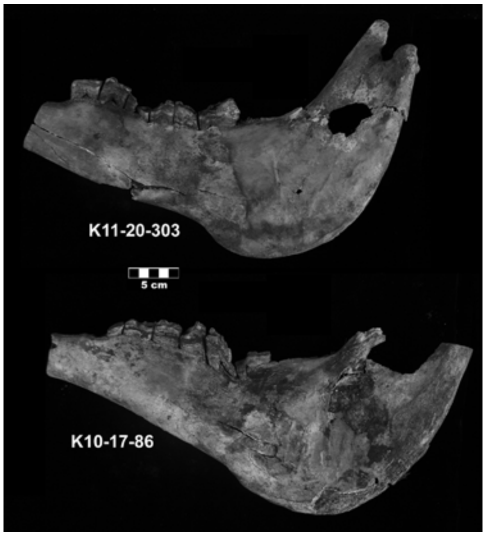

Figure 16. Horse mandibles with dental malocclusions.

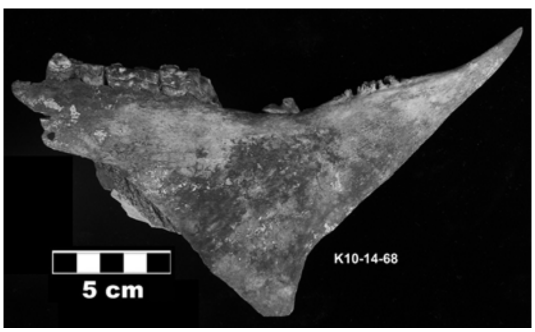

Figure 17. Horse mandible with resorption of the third molar.

Table 6. Horse Remains with Osteoarthritis.

		Condition				
Element	**NISP**	**L**	**M**	**S**	**F**	**%NISP**
AT	3	0	0	1	0	33.3
CE 3-7	23	1	1	0	0	8.7
TH	35	9	0	0	2	31.4
RB	302	2	0	0	0	0.7
LM	37	6	4	3	6	51.4
SAC	18	3	0	0	0	16.7
CA	49	4	0	0	0	8.2
HM	11	1	1	1	0	27.3
RDU	12	2	2	0	0	33.3
CP2	8	1	0	0	0	12.5
CP4	10	1	0	0	0	10.0
MC3	11	0	0	1	0	9.1
IM	17	1	0	1	0	35.3
FM	18	1	0	0	0	5.6
TA	19	0	0	3	0	15.8
AS	18	0	2	2	1	27.8
CL	18	4	3	0	1	44.4
TRC	18	0	0	1	11	66.7
TR1	18	0	0	0	12	66.7
TR3	15	0	0	0	8	53.3
TR4	18	1	0	2	6	50.0
MT3	18	4	0	1	6	61.1
MT4	12	0	0	2	0	16.7
PHF	16	5	0	0	1	37.5
PHS	15	1	0	1	1	20.0
PHT	15	0	0	1	0	6.7
SED	13	0	0	2	0	15.4

Note: L (light), M (moderate), S (severe), F (fused); %NISP is %NISP > none; see Table 1 for element codes.

increases from the thoracic vertebrae (31 percent) to the lumbar vertebrae (51 percent), then decreases with the innominates/pelves (35 percent). Percentages for the forelimb are moderate and relatively consistent throughout the limb, whereas the rearlimb pattern is more complex. Upper rearlimb elements, including the femur (6 percent), and tibia (16 percent), display minimal signs of osteoarthritic remodeling, while the elements of the lower rearlimb display consistently elevated levels, often severe to fused in nature, with the percentages for several tarsal elements reaching 67 percent. In many cases, remodeling of lower rearlimbs extends to the phalanges.

The metatarsals illustrated in Figure 18 are of particular interest. In each of these specimens, severe osteoarthritis, apparently including the development of bone sclerosis and marginal osteophytes (Cantley et al. 1999), has fused tarsals to the 3rd metatarsal. Such bone remodeling is not unusual in older horses, especially among draft horses and mules, whose lower limb joints are exposed to periods of heavy stress (Goodrich and Nixon 2006).

Two additional examples of remodeled horse joints are also noteworthy. Figure 19 shows a conjoining phalanx unit. The advanced degree of bone remodeling, including apparent osteophyte development, is visible here, fusing the distal sesamoid to the third phalanx, with extensive remodeling of the second and third phalanges. The conjoin unit in Figure 20 displays fusion of

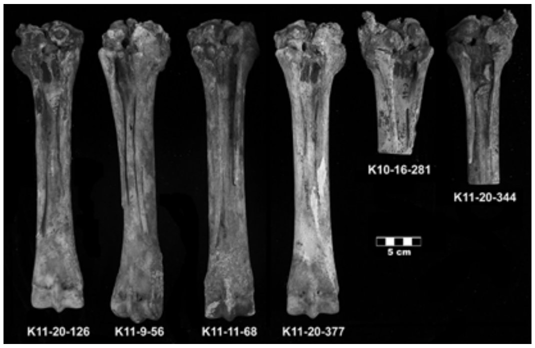

Figure 18. Horse metatarsals with fusion of tarsals to the proximal articular surface. The two specimens on the right have been sawn at midshaft by a powered band saw.

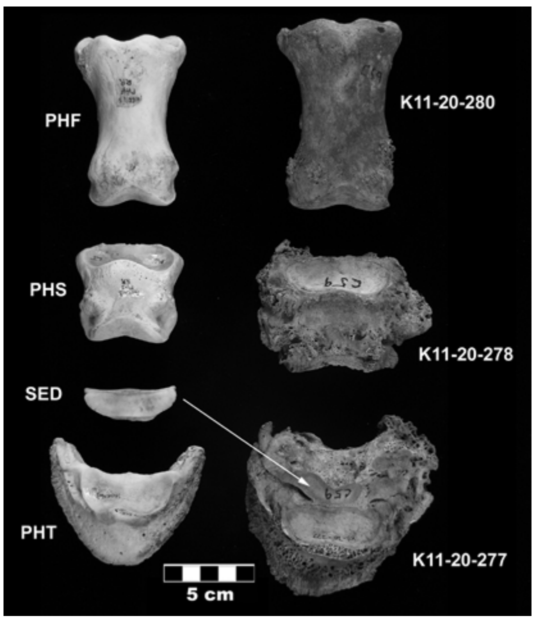

Figure 19. Horse phalange conjoin unit (right) displaying severe osteoarthritis, including fusion of the distal sesamoid to the third phalange, compared to modern, unaffected reference specimens (left).

the first and second phalanges, as well as extensive remodeling of all three elements.

About half (42 percent, NISP = 432) of the horse remains were recovered in a series of 76 conjoining units. Limb conjoins are discussed above. Axial element conjoins consist primarily of vertebral units (n = 11), plus cranial/mandibular units (n = 6), two rib units, a sternal unit, and a caudal unit. In addition, two large conjoining units include portions of the posterior vertebral column, the complete pelvis, and both femurs. Conjoin 19 is the largest, consisting of the 10th through the 18th thoracics, a series of articulated ribs from both sides of the thorax, lumbars, sacrum, pelvis, and both femurs (Figure 21). Conjoin 77 includes the 4th through the 6th lumbars, sacrum, pelvis and both femur.

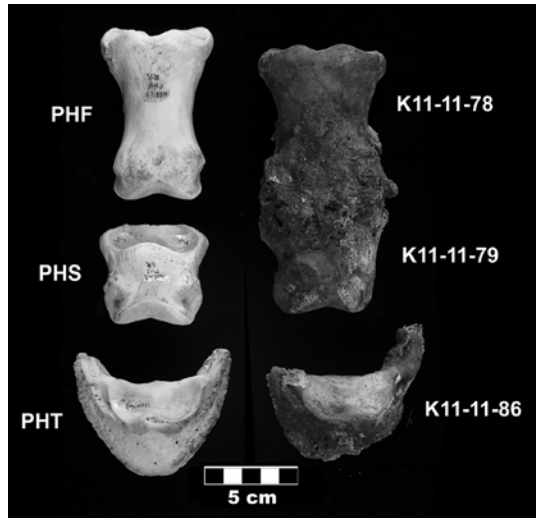

Figure 20. Horse phalange conjoin unit (right) displaying severe osteoarthritis, including fusion of the first and second phalanges, compared to modern, unaffected reference specimens (left). Light singeing on the archaeological remains is due to contact with hot CCR (i.e., clinker).

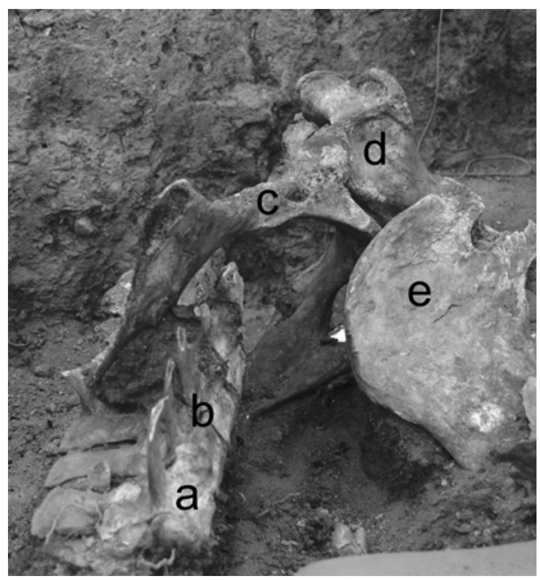

Figure 21. Portion of horse conjoin unit 19 in situ, showing: a) lumbar vertebrae 3-6; b) sacrum; c) pelvis; and d) one (of two) femurs. A steeply inclined horse mandible (e) partially obscures the pelvis and femur.

Cow Remains

Two cows are represented among a sample of 137 specimens (Table 7). One-third (33 percent, NISP = 45) of these remains were recovered in two axial conjoins. Conjoin 10 contains all of the cervical vertebra from the atlas vertebra to the sixth thoracic vertebra, plus a series of ribs. Conjoin 51 begins with the eighth thoracic vertebra and extends to the sacrum, including a series of ribs derived primarily from the left side of the thorax. These conjoins represent the remains of two prime age individuals, varying slightly in their degree of skeletal development. Unlike the horse remains, both cows are skeletally immature, with one slightly older than the other, based on differences in the size of their respective elements. Both cervical and thoracic vertebrae are incompletely fused, while all appendicular elements are fully fused. Although the timing of epiphyseal closure for cow vertebrae is somewhat variable, these animals were 4-5 years of age at death.

Other cow conjoins include matched mandibles, two upper forelimbs (scapula-carpa), a femur-tibia unit, a carpal-metacarpal unit, a metacarpal-phalanx unit, a tarsal-metatarsal unit, a tarsal unit, and a phalanx unit.

Although less common and less severe than that recorded for horse, several cow remains also display osteoarthritis. This information is summarized in Table 8, and is not discussed further.

Dog Remains

Pit 2 also yielded 123 dog remains. At least two individuals, both skeletally immature, are represented as indicated by incompletely fused long bone and vertebra epiphyses, open cranial sutures, and unworn teeth. About half (NISP = 67) of the specimens are conjoined. Conjoin 52 consists of an entire axial skeleton (Figure 22). Conjoin 58 may reflect the lower rear limbs of this same animal, as it consists of left and right paired tarsals and metatarsals, from an animal of the same general size and morphology. However, without the intervening femur and tibia, this identification remains ambiguous. Conjoin 70 includes the sixth and seventh lumbars, sacrum, and pelvis of a second individual. Conjoin 78 consists of a complete cranium with both mandi-

Table 7. Cow Remains.

		MNE Side					
Element	**NISP**	**L**	**R**	**A**	**MNE**	**MAU**	**%MAU**
CRN	1	0	0	1	1	1.0	50.0
MR	3	1	1	0	2	1.0	50.0
HY	0	0	0	0	0	0.0	0.0
AT	1	0	0	1	1	1.0	50.0
AX	1	0	0	1	1	1.0	50.0
CE 3-7	5	0	0	5	5	1.0	50.0
TH	15	0	0	12	12	0.9	46.2
RB	17	8	4	0	12	0.5	23.1
CS	0	0	0	0	0	0.0	0.0
SN	0	0	0	0	0	0.0	0.0
LM	6	0	0	6	6	1.0	50.0
SA	1	0	0	1	1	1.0	50.0
CA	0	0	0	0	0	0.0	0.0
SC	3	1	2	0	3	1.5	75.0
HM	4	2	2	0	4	2.0	100.0
RDU	3	1	2	0	3	1.5	75.0
CPU	3	2	1	0	3	1.5	75.0
CPI	3	2	1	0	3	1.5	75.0
CPR	2	2	0	0	2	1.0	50.0
CPS	3	2	1	0	3	1.5	75.0
CPF	3	2	1	0	3	1.5	75.0
CPA	3	0	1	0	3	1.5	75.0
MC	5	2	1	0	3	1.5	75.0
MCF	0	0	0	0	0	0.0	0.0
IM	2	1	1	0	2	1.0	50.0
FM	2	1	1	0	2	1.0	50.0
PT	2	1	1	0	2	1.0	50.0
TA	2	1	1	0	2	1.0	50.0
LTM	1	1	0	0	1	0.5	25.0
AS	2	1	1	0	2	1.0	50.0
CL	2	1	1	0	2	1.0	50.0
TRC	2	1	1	0	2	1.0	50.0
TRS	2	1	1	0	2	1.0	50.0
TRF	0	0	0	0	0	0.0	0.0
MT	1	1	0	0	1	0.5	25.0
MTS	0	0	0	0	0	0.0	0.0
PHF	9	4	5	0	9	1.1	56.3
PHS	7	4	3	0	7	0.9	43.8
PHT	7	3	3	0	7	0.9	43.8
SEP	10	0	0	0	10	0.6	31.3
SED	4	0	0	0	4	0.5	25.0
	137						

Note: MNE side = L (left), R (right), A (axial/not sideable); see Table 1 for element codes.

Table 8. Cow Remains with Osteoarthritis.

		Condition				
Element	**NISP**	**L**	**M**	**S**	**F**	**%NISP**
CE 3-7	5	1				20.0
TH	15	1				6.7
RDU	3	1				33.3
CPU	3		1			33.3
CPS	3		1			33.3
CPF	3		1			33.3
TRC	2	1			1	100.0
TRS	2	1			1	100.0
MT	1		1			100.0

Note: L (light), M (moderate), S (severe), F (fused); %NISP is %NISP > none; see Table 1 for element codes.

Figure 22. Dog axial skeleton conjoin unit, including the cranium, a complete thorax (all vertebrae and ribs), and the left upper forelimb.

bles. These specimens could be associated with either of the above individuals. Finally, Conjoin 94 consists of the unfused diaphysis and proximal epiphysis of a tibia.

Pig Remains

Seventy pig remains were also recovered, mostly appendicular elements, and representing no fewer than two fetal/newborn individuals. Crania, mandibles, and other axial elements are absent, with the exception of a sacrum and a conjoin consisting of a series of nine ribs and a section of sternum.

The relative lack of conjoins among the pig remains may be related to the extremely young age of the animals, a condition that enhances their potential for post-depositional deterioration, disarticulation, and scattering. Based on the size and morphology of the remains, most appear to derive from a single individual. The second individual, slightly more advanced in development, is represented by matched scapulae.

Cat, Chicken, and Rodent Remains

At least two domestic cats are represented among nine specimens. Both individuals are skeletally immature, as indicated by the presence of incompletely fused long bone epiphyses and unworn dentitions (Figure 23). One chicken is represented by a fragmentary fused sacrum and a right tarsometatarsus (Figure 23). A mandible belonging to a brown rat represents the only rodent remain from Pit 2, as well as the only non-domestic taxon that was recovered (Figure 24).

Figure 23. Cat (left) and chicken (right) remains.

Figure 24. Brown rat mandible. Scale is in millimeters.

Unidentified Faunal Remains

Seventy-eight fragmentary remains could not be securely identified to taxa, and are classified generally either as unidentified small (NISP = 8) or unidentified large (NISP = 70) mammals. Most of the unidentified large mammal remains are probably horse, while most of the unidentified small mammal remains are probably either dog or cat.

BONE MODIFICATION

Breakage

Excepting sawn specimens, the vast majority of all faunal remains are complete, unbroken specimens. Looking specifically at horse, 82 percent (NISP = 553) of the long bones are complete, unbroken specimens. More informative, however, is the high percentage of unbroken fragile, irregularly-shaped elements like scapula, vertebra, and ribs. Certain cranial elements (e.g., nasals), costal cartilage, and sternal elements fall into this general category as well. All of these elements are especially prone to fragmentation and disintegration by any one of a number of taphonomic processes. This observation provides another line of evidence supporting the relatively rapid pace and uninterrupted sequence of pit creation, filling, and burial since their preservation would not be expected under conditions of accretional burial.

That said, horse, cow, dog, and cat crania are consistently crushed in situ throughout the deposit, displaying extensive dry bone breakage and fragmentation (Figure 25). Compared to other elements, crania, especially those belonging to immature animals with incompletely fused sutures, do not withstand excessive compression, making them extremely susceptible to post-depositional, sediment-profile crushing (Brain 1981; Todd and Rapson 1991, 1999). This pattern is consistent with post-depositional backfilling of the pit, creating significant compaction forces on the relatively fragile, low density cranial elements.

A proximal cow humerus displays a fracture outline and angle consistent with green bone breakage (Figure 26). This specimen is interesting in that, although the fracture surface is fresh

Figure 25. Horse cranium in situ.

and well preserved, it has been chipped and abraded in a manner consistent with a catastrophic pre-mortem fracture resulting in the dislocation of the humerus at mid-shaft. If this inference is accurate, the modification resulted from a massive fracture in which the injured animal continued to use the limb for a short period of time prior to death, with damage reflecting end-to-end contact of the proximal and distal halves of the broken element (Rakestraw 1996). Unfortunately, the distal portion of the humerus, which could have offered significant additional information on this question, was not recovered.

Subaerial Bone Weathering, Root Etching, and Chemical Deterioration

The cortical surfaces of all faunal remains from Pit 2 are uniformly intact, unweathered, and display no root etching. Under conditions of prolonged surface exposure of perhaps several years, a significant proportion of specimens displaying more advanced weathering stages would be expected. These data support a relatively quick and unpunctuated burial history, with sufficient depth of burial to prevent significant root intrusions (although a few small plant roots were noted within the bonebed during excavation, no surface damage to bone was observed). Although the exact depth of the pit after burial is unknown, it was covered by 62 cm of sandy loam before the start of excavation. For modern carcass disposal pits, a minimum of 4-6 feet of overburden is recommended to reduce emission of decomposition

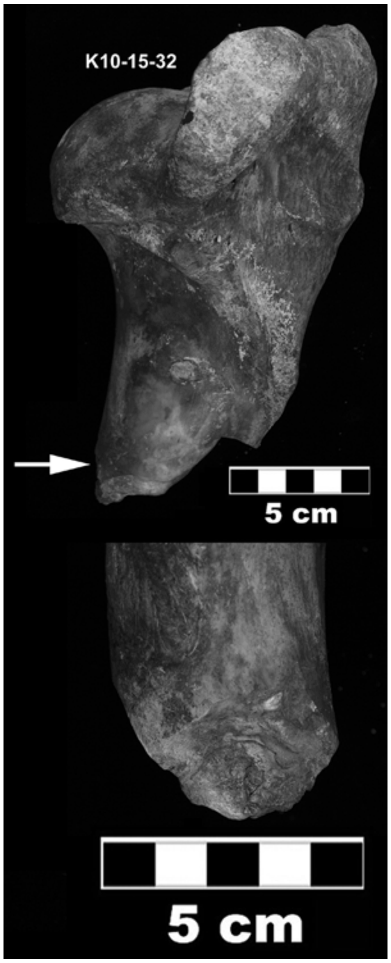

Figure 26. Cow humerus with spiral fracture. Arrow points to area of chipping on fracture edge that is visible in the detail view (bottom).

odors and gases, groundwater contamination, and disease transmission (NABC 2004).

Evidence for the addition of lime to the deposit, either calcium oxide (lime) or calcium hydroxide (a.k.a. slaked lime), is provided by the recovery of seven such nodules. As well, the cortical surfaces of 273 specimens, or 19 percent of the remains, display chemical deterioration consistent with exposure to lime. Slaked lime is a strong chemical base that acts to reduce acidity, as well as providing a desiccant effect. During initial carcass decomposition, organic acids are typically produced, decreasing the pH. Addition of slaked lime can increase these pH values, enhancing conditions for microbial decomposition. However, the addition of lime can also act to retard carcass decomposition in cases where the pH is already relatively high (NABC 2004).

Also noteworthy here is a horse metacarpal stained bright green by an unknown chemical. This chemical appears to have been dumped into the pit since identical staining was observed on a number of nearby specimens. As discussed in greater detail below, several bottles were recovered with corks in place, including two containing liquid, thus indicating that partially full bottles with unknown fluids were discarded along with the faunal remains.

Burning

Low-temperature singeing and/or burning of specimens occurs throughout the deposit. Nearly one third (32 percent, NISP = 463) of the faunal remains are lightly burned on at least some portion of their cortical surface. Undoubtedly, CCR is the agent responsible for burning the remains (Figure 12).

Figure 27 is a plan map summarizing the locations of all burned specimens in the pit as a series of three-dimensional vectors. Black vectors represent burned specimens, whereas grey vectors are unburned. The thick black and grey vectors highlight the only two statistically significant clusters identified by the Moran's *I* statistic ($p < .05$) for burned versus unburned specimens. Interestingly, each of the clusters of the thick black and grey vectors represent concentrations of *unburned* remains, indicating that with the exception of these two clusters, burning is randomly distributed in the bonebed.

Investigating these two unburned bone clusters in additional detail is facilitated by rotating the assemblage in all three dimensions simultaneously, thereby allowing alternative views of their relative depth, in addition to their horizontal position within the deposit (Figure 28). Doing so reveals the deep vertical position of the thick grey cluster, located near the base of the pit, whereas the thick black cluster is situated quite close to the top of the deposit, in the northwest corner. Although interpreting these unburned clusters is somewhat problematic, the addition of attribute-based locational information such as this is useful, making it possible to infer a more limited exposure to heat/fire, due either to deep burial

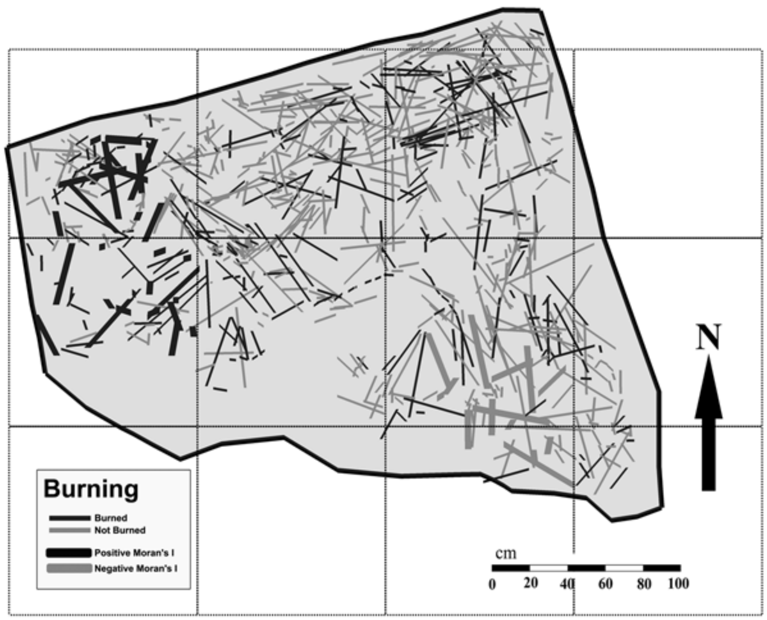

Figure 27. GIS plan view of all burned versus all unburned faunal remains. Long bones are depicted as vectors, based on their positional pro-points. Thick black and thick grey vectors indicate specimens with significant ($p < 0.5$) positive and negative spatial autocorrelation values, respectively.

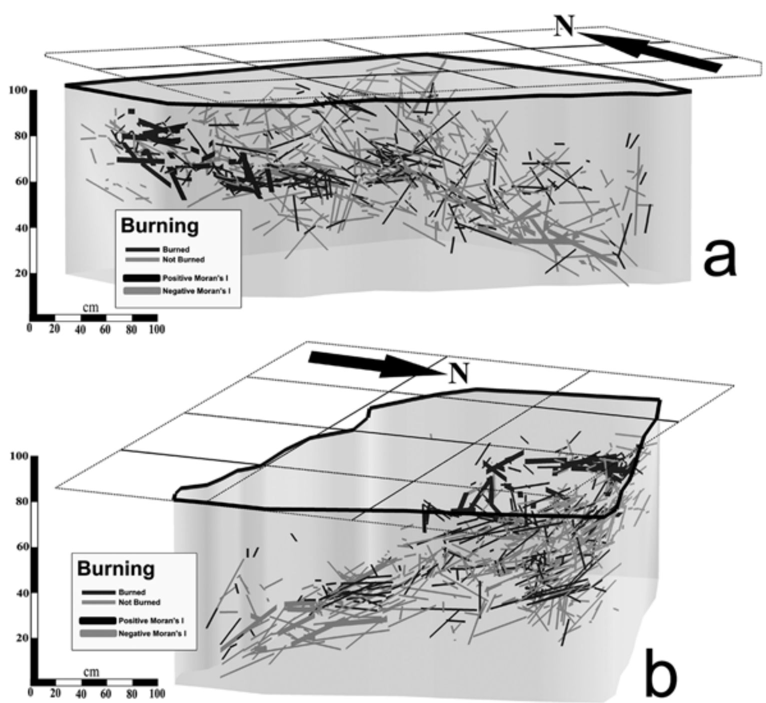

Figure 28. Three-dimensional GIS image of all burned versus all unburned faunal remains: a) view looking ~northeast; b) view looking ~southwest. Long bones are depicted as vectors, based on their positional pro-points. Thick black and thick grey vectors indicate specimens with significant ($p < 0.5$) positive and negative spatial autocorrelation values, respectively.

(thick grey cluster), or to deposition near the top of the pile (thick black cluster), occurring shortly before backfilling and burial. Despite the interpretive uncertainty concerning these two unburned clusters, the overall pattern of random burning indicated here supports the formational scenario outlined above; that is, rapid inputs of CCR occurring essentially simultaneously with the discard of carcass parts and artifacts, probably over a period of a year or less.

One potential factor influencing the frequency of burning within this deposit, and its distribution on individual specimens, involves the insulating effect potentially conferred by any adhering flesh and connective tissue, especially under conditions of incomplete roasting or combustion, as seems probable for the contents of Pit 2. However, in this case, the potential insulating effects of any such adhering soft tissue appears limited, at best, since, as argued above, carcass portions would have been introduced into the pit only after their use-lives as laboratory specimens had ended. Given this extended time frame (potentially weeks or months in a setting lacking refrigeration or the use of embalming fluids), it seems probable that any adhering flesh would have been stiff and dessicated, thereby limiting its potential insulating properties and resistance to burning.

Carnivore Modification

Evidence for carnivore scavenging of the discarded carcass parts is absent on the faunal remains, however, this is not entirely unexpected. The paddock was fenced (Figure 6), and contemporaneous disposal of hot CCR with dissected material, coupled with frequent human presence in the immediate vicinity of the pit, likely created an inhospitable environment for scavengers. Moreover, the application of lime reportedly dissuades scavengers (Friend and Franson 1987).

Carcass Dissection and Processing

Trephination Disks

Among the most interesting faunal remains recovered from Pit 2 are four small bone disks, each with round drill holes in their centers (Figure 29). Two different diameters are represented by two specimens each (7/8-inch and 3/4-inch). In all four cases, the bone is thin and compact with an artificially smoothed or planed exterior surface, resulting from the drilling action that produced the specimens. The bone interior is rougher, more wavy, and lacking in cancellous tissue. Based on their size and unique morphology, these specimens are undoubtedly bone disks produced by a trephine tool such as those illustrated in Figure 29. This instrument is employed in a surgical procedure referred to as trephination in which a circular section of bone from the crania is removed to expose the dura mater.

The practice of trephination is an ancient one (Panourias et al. 2005). It has traditionally been conducted on human subjects as well as domestic animals, with forensic evidence extending into the prehistoric archaeological records of both the Old and New Worlds (Froeschner 1992; Stone and Miles 1990). Historically, it was employed to cure a variety of ailments, including migraines, epileptic seizures, and mental disorders. In modern times, its use is largely limited to the treatment of epidural and subdural hematomas. Whether the specimens represent student practicum conducted on laboratory cadavers, or the treatment of live animals by veterinarians at the Veterinary School clinic is unknown.

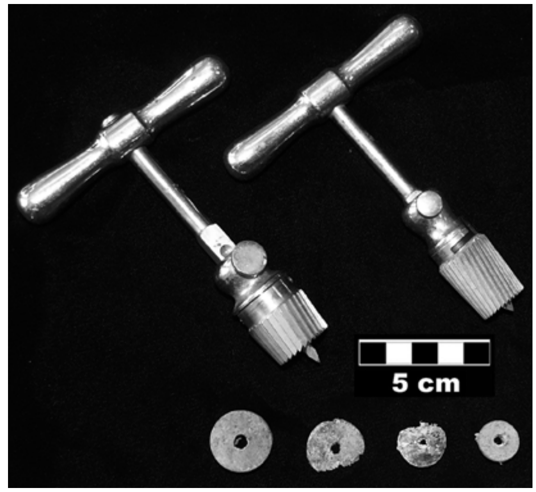

Figure 29. Trephination disks and modern trephine tools.

Band Sawing

Use of a powered band saw is indicated for virtually all of the sawn horse and cow remains (Table 9). These saw cuts are characterized by smooth surfaces, regularized patterns of damage, and straight-cut lines, with saw tooth marks visible on some specimens. The sawn small animal remains, on the other hand, display only cuts made by a hand-saw.

As might be expected, horse and cow specimens are sawn in consistent patterns, reflecting regularized patterns of carcass disarticulation, while creating cross-sectional prosections of selected elements for more detailed analysis (Figure 30). In the case of the axis, cervical, lumbar, and caudal vertebrae, sawing occurs perpendicular to the long axis of the vertebral column, thus separating these elements into cranial and caudal portions. This pattern of damage appears to reflect the preferred method for segmentation of the axial skeleton, with sawing across the axis-cervical joint severing the head from the axial skeleton, while sawing across the lumbars, near their articulation with the sacrum, severs the pelvis and rear limbs from the vertebral column.

In the case of the mandible in Figure 31, transverse cuts were likely made with the mandible still in articulation with the cranium, thereby producing a cross-section of the nasal cavity and associated cranial structures (see Getty 1975:Figure 15-121). The absence of evidence for compa-

Table 9. Sawn Horse and Cow Remains.

Element (Horse)	NISP	Sawn	%	Orientation of Sawing PR	DS	TR	LG	OB	MU
CRN	41	3	7.3	0	0	0	0	0	0
MR	43	15	34.9	0	0	9	0	0	3
AX	3	2	66.7	0	0	1	1	0	0
CE 3-7	23	6	26.1	0	0	3	3	0	0
TH	35	3	8.6	0	0	0	0	3	0
RB	302	25	8.3	20	1	0	0	0	1
LM	37	15	40.5	0	0	7	6	0	2
SAC	18	12	66.7	0	0	0	12	0	0
CA	49	8	16.3	0	0	1	7	0	0
RDU	12	2	16.7	0	1	0	0	0	0
MC3	11	3	27.3	0	1	0	0	0	0
MC4	2	1	50.0	0	0	1	0	0	0
IM	17	6	35.3	0	0	0	5	0	0
PT	13	1	7.7	0	0	0	1	0	0
TA	19	4	21.1	1	0	0	0	0	0
MT3	18	4	22.2	0	0	0	0	0	0
MT4	12	1	8.3	0	0	1	0	0	0
PHF	16	2	12.5	0	0	0	2	0	0
PHS	15	2	13.3	0	0	0	2	0	0
PHT	15	5	33.3	0	0	1	2	0	0
SED	13	2	15.4	0	0	0	2	0	0
FB	1	1	100.0	0	0	0	0	0	1
VT	3	2	66.7	0	0	0	0	0	0
Element (Cow)									
MR	3	1	33.3	0	0	1	0	0	0
IM	2	1	50.0	0	0	0	1	0	0
FM	2	1	50.0	0	1	0	0	0	0
TA	2	1	50.0	1	0	0	0	0	0

Note: PR (proximal), DS (distal), TR (transverse), LG (longitudinal), OB (oblique), MU (multiple); see Table 1 for element codes.

rable transverse cuts across anterior crania is best attributed to in situ crushing, as discussed above. We suspect such cuts exist, but given the extremely fragmentary condition of the crania, they are simply too difficult to recognize.

Longitudinal sawing cuts made along the midline of axial elements indicate the separation of the left and right sides of the thorax, producing mirror-imaged carcass portions for study and dissection. In the case of the phalanges, longitudinal cuts are typically made to entire articulated units (Figure 32). This exposes the interior of these elements, allowing study of the structure and function of cortical versus cancellous (trabecular) bone, marrow cavities, cartilage, and so on (see Getty 1975:Figure 15-113).

Forelimb Removal

Horse forelimbs were removed from the axial skeleton in a highly regularized fashion, typically separated from the thorax at the proximal scapula. There is also a strong pattern of forelimb disarticulation occurring just below the distal metacarpal, at the first phalanx joint. These

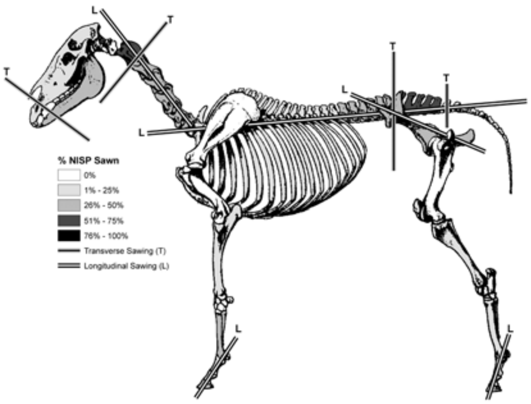

Figure 30. Percentage of horse remains with sawing modifications, including orientation of the cuts.

Figure 31. Horse mandibular symphysis sawn transversely.

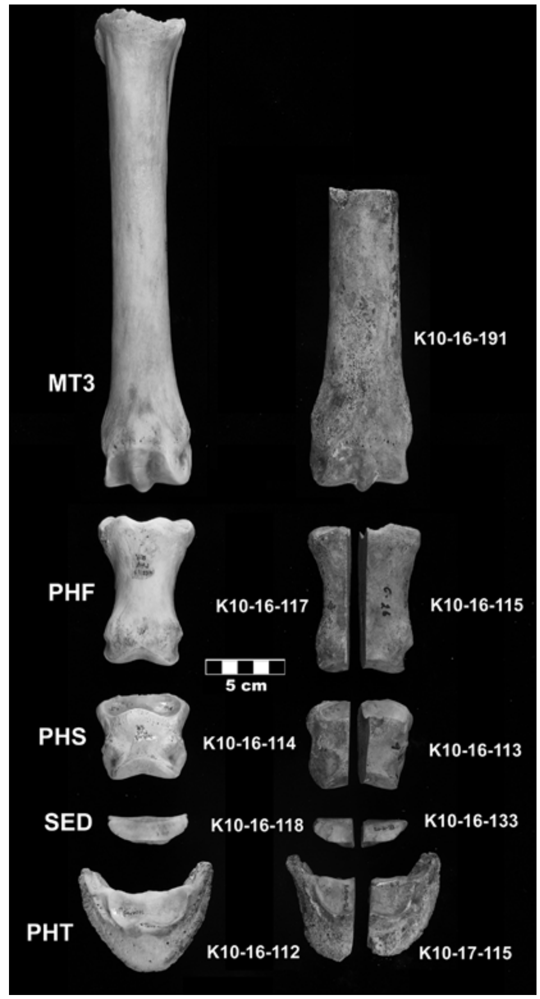

Figure 32. Horse distal limb conjoin unit sawn longitudinally (phalanges and distal sesamoid) and transversely (metatarsal), compared to modern reference specimens.

forelimb units were eventually discarded without further disarticulation, reflecting (apparently) the final stage of study and dissection devoted to this portion of large animal anatomy. Although the cow sample is quite small, it appears to mimic the pattern observed for horse. An important historical photograph (Figure 33) provides additional insight on the organization of laboratory instruction in large animal anatomy during this period. The photograph, entitled ‘Dissecting Room Veterinary Hospital, Iowa State College 1907, R. R. Dykstra, Assistant Professor’ illustrates several complete horse limb and thorax units during the process of dissection and study by students. The complete nature of the limb units pictured here is wholly consistent with the character of the conjoining limb units recovered from Pit 2. This photograph also supports the inference, discussed above, that teams of students focused their attention on various portions of the horse skeletal anatomy simultaneously, thereby maximizing the utility of each carcass in a setting lacking refrigeration or other preservational techniques.

Rearlimb Removal

Rearlimb disarticulation differs slightly from the forelimb pattern. Removal occurred together with the pelvis, most often by disarticulation of the last lumbar vertebra from the

Figure 33. 'Dissecting Room, Veterinary Hospital, Iowa State College 1907, R. R. Dykstra, Assistant Professor'. Courtesy Iowa State University Library/Special Collections Department.

sacrum. This created a series of 'innominate/pelvis down' articulations. Removal of phalanges below the distal 3rd metatarsal is also somewhat less common for the rearlimb, in comparison to the fore. One of these conjoining units incorporates essentially the back half of an entire animal, consisting of thoracic vertebrae 10-18, associated left and right ribs, all lumbar vertebra, sacrum, pelvis, and both femurs (Conjoin 19). In this case, the rearlimb pattern reflects a dissection strategy based on sawing transversely through the vertebral column at, or near the union of the last (18th) thoracic vertebra with the sacrum, thereby disarticulating the pelvis and both rear limbs. It seems clear that in all of these cases, the pelvis was considered an integral element of the rear limb in terms of the structure of laboratory study for students.

Rib Removal

Twenty of 25 sawn rib specimens are sawn near the rib neck, while another 28 ribs display green bone fractures located either on the proximal blade, or near the neck (Table 9). These regular damage patterns are interpreted to reflect a thorax disarticulation strategy based on the manual manipulation and 'snapping back' and/or sawing of complete ribs, held by the blade and twisted up and away from the thorax cavity. Parenthetically, a similar pattern of rib removal is documented for bison carcasses processed at the ca. 10,000 year old Casper site in Wyoming (Todd et al. 1997) and at the 9,000 year old Clary Ranch site in Nebraska (Hill 2005).

Hand Sawing

Interestingly, in all cases, sawing of dog and cat carcasses was done using a hand-saw. These cuts are typically oriented transversely across the mid-shaft of long bones, exposing the structure of the cortical bone, as well as the medullary cavity.

Hack Marks

Hack marks occur on the anterior crest of a cow tibia and the anterior mid-shaft of a cow metacarpal (Figure 34), and were likely produced by blows from an axe, hatchet, or machete.

Cutmarks

Although not documented in detail, surficial scalpel-type knife cutmarks were observed on some of the remains. Cutmarks are most common on horse remains, although their presence was noted occasionally on the cow and small mammal remains. No marks of any kind were noted on any of the fetal/ newborn pig remains. This may be a function of the uneven, rough character of the cortical bone associated with these specimens.

Conjoining Skeletal Elements

Ninety-five groups of conjoining skeletal elements were identified during excavation and analysis. Not surprisingly, the majority of these involve horse remains. Conjoining specimens occur in three differing contexts. The most common conjoin type consists of two or more elements recovered in correct anatomical position, with no gaps between the conjoined specimens. A second, less common type includes skeletally adjacent elements recovered short distances apart during excavation that have been identified analytically as portions of the same individual, based on a combination of metric and morphological attributes, combined with their spatial proximity. These specimens are inferred to have been discarded and buried as articulated units, with disarticulation and scattering occurring at some point after burial (Figure 35). The third type is rare, in fact, only one example was identified; it consists of manually reassembled (or refit) fragments of a single specimen that were recovered some distance apart.

Articulations

Thirty-eight conjoins are comprised of horse appendicular elements. In order to evaluate the nature of these conjoins in greater detail, and to allow comparison with other assemblages, a technique originally suggested by Hill (1979; Hill and Behrensmeyer 1984), and later refined by Todd (Todd and Frison 1992), is employed here. It compares the observed number of articulated-joints to the potential number possible, based on their respective MNE values. Thus the percentage of potential articulations is derived from the relative frequencies of the various elements making up each joint, compared to the number actually articulated (Table 10).

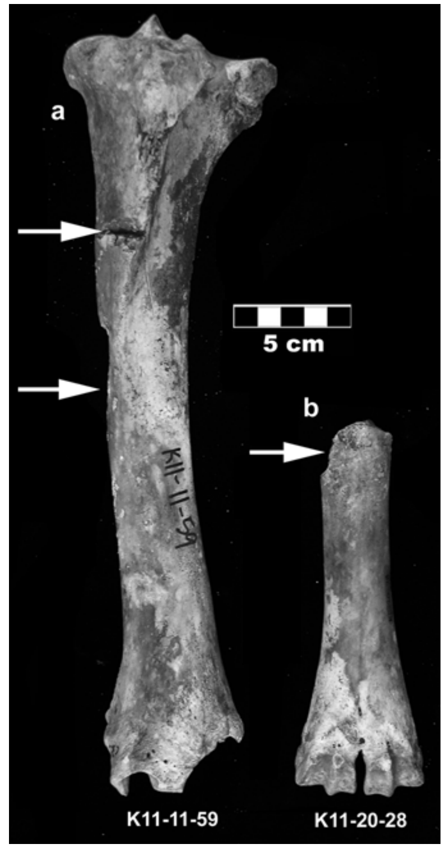

Figure 34. Cow tibia (left) and metacarpal (right) with hack marks.

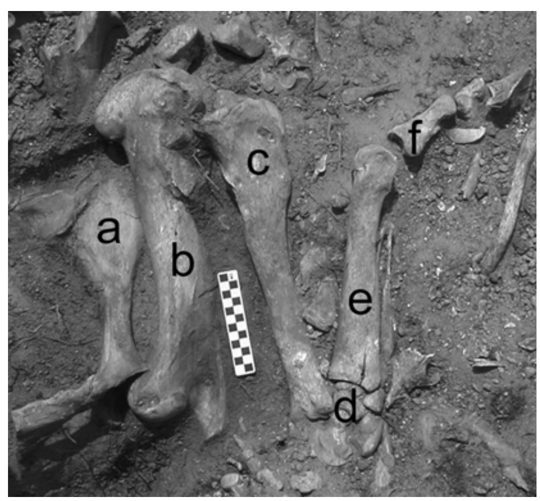

Figure 35. Complete horse rearlimb conjoin unit in situ: a) pelvis; b) femur; c) tibia; d) tarsals; e) metapodial; and f) phalanges.

Table 10. Articulation Information for Horse.

Forelimb	MNE	Joint	PA	RA	%PA
THX	6				
		THX-SC	6	0	0.0
SC	9				
		SC-HM	9	4	44.4
HM	11				
		HM-RDU	11	7	63.6
RDU	11				
		RDU-CP	8.9	5	56.2
CP	8.9				
		CP-MC3	8.9	7	78.7
MC3	11				
		MC3-PHF	6	1	16.7
PHF	6				
		PHF-PHS	6	4	66.7
PHS	6				
		PHS-PHT	5	4	80.0
PHT	5				
Rearlimb					
SAC	6				
		SAC-IM	6	3	50.0
IM	16				
		IM-FM	16	8	50.0
FM	18				
		FM-TA	16	6	37.5
TA	16				
		TA-TR	15	11	73.3
TR	15				
		TR-MT3	15	12	80.0
MT3	17				
		MT3-PHF	8	3	37.5
PHF	8				
		PHF-PHS	7	6	85.7
PHS	7				
		PHS-PHT	6	4	66.7
PHT	6				

Note: PA (potential articulations), RA (recorded articulations), %PA (percent potential articulations); see Table 1 for element codes.

As illustrated in Figure 36, the percent potential articulations data for horse fore- and rear-limbs are similar overall, both having remarkably high percentages of intact, articulated upper limb joints. The highly consistent character of these patterns indicates that horse limbs were removed from the axial skeleton in a highly regularized fashion, with forelimbs typically separated from the thorax at the scapula. Rearlimbs were removed together with the pelvis, most often by disarticulating the last lumbar vertebra from the sacrum. Figure 36a also reveals a strong pattern of forelimb disarticulation occurring just below the distal metacarpal, at the first phalanx joint. A similar pattern exists for the rearlimb (Figure 36b), though it is less well defined.

Only a few articulations exist among the non-horse appendicular elements, all of which are comprised of cow remains, including four forelimb groups and two rearlimb groups. The forelimb joints reflect a pattern that is similar to that observed for horse, with proximal disarticulation occurring at the thorax-scapula and distal disarticulation occurring at the carpals-metacarpal. Due to the small sample size, rearlimb patterning for cow limbs is unclear.

Historical Artifacts

A substantial collection of artifacts attributed to domestic-type activities, as well as to the practice of veterinary medicine in the early twentieth century was recovered together with the faunal remains. These specimens are critical to developing a taphonomic history for the bonebed. First, they serve as time-sensitive indicators by providing the *terminus post quem* (earliest possible date) and the *terminus ante quem* (latest possible date) for the deposit. As discussed below, it appears that the pit was filled sometime between ca. 1910 and 1912. Second, the material reveals that at least two distinctive debris streams were involved in the filling of the pit. The most obvious source of material is that associated with the teaching and practice of veterinary medicine. The source of a second, more ephemeral debris stream is manifested by the recovery of a number of unexpected domestic-type items.

Bottles and Glassware

Figure 37 provides a representative sample of the types of glass bottles recovered from Pit 2. One bottle, Figure 37a, retains an intact cork and still holds a fluid similar to varnish. Figure 37c represents one of the more commonly recovered

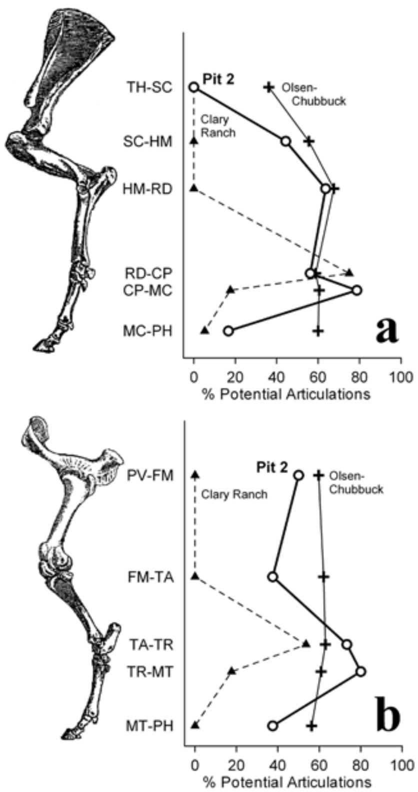

Figure 36. Percent Potential Articulation information for horse forelimbs (a) and hindlimbs (b), including the same data for bison from the Clary Ranch site (Hill 2001, 2005) and Olsen-Chubbuck site (Wheat 1972); see Table 1 for element codes.

bottle types (five examples of this size, as well as a variety of larger sizes). These bottles are embossed with a ‘W’ maker’s mark on the base and are similar to mass-produced items offered for sale to various manufacturers of chemicals and patent medicines during the early 1900s. Although missing at the time of recovery, these bottles would have been supplied with a paper label specifying the contents, maker’s name, and other information.

Only a single bottle retains a portion of the original label, a wide-mouth chemical bottle (Figure 37j). A close-up photograph of this label is provided in Figure 38. It reads ‘Mallinckrodt Chemical Works - Ferric Subsulfate.’ Ferric subsulfate is a styptic, or blood coagulant agent, rarely used in contemporary veterinary medicine. Also visible is a reference to the Pure Food and Drug Act of June 30, 1906. This landmark legislation, passed by the United States Congress, marked a sea change in the rules and regulations surrounding the manufacture, sale, and labeling of foods, drugs, medicines, and liquors. Although originally intended to regulate labeling, thereby controlling the fraudulent adulteration of products, the act was subsequently expanded to address the safety and efficacy of all foods, drugs, and medicines sold in the United States (Goodwin 1999). This bottle is also especially critical since it serves as the *terminus post quem* for the deposition of material in Pit 2, which had to occur at some point after June 30, 1906.

Vials, Test Tubes, Corks, and Rubber

Figure 39 illustrates a representative sample of the vials and associated glassware. Figure 39a appears to be a fragmentary syringe plunger of a type employed in veterinary medicine during this general time period. Figure 39b is a medicine dropper. Figure 39c is a medicine vial with metal crew cap, while three specimens are small, flat-bottomed medicine vials (Figure 39d-f). Although not illustrated here, several fragmentary test tubes were also recovered, in addition to a number of loose bottle corks and several short segments of red rubber hosing. All of these are consistent with laboratory/clinic materials that would have been employed by the Veterinary Medicine program during this general time period (ca. 1910-1912).

Ball/Mason Fruit Jar and Other Diagnostics

A pint-size Ball/Mason fruit jar was also recovered (Figure 37o). Unfortunately, due to its fragmentary nature, only a portion of the diagnostic embossed lettering is present. A partial ‘S’ is visible, as well as the letters ‘ON,’ reflecting the later half of the embossed ‘MASON’ trademark. According to Davis (personal communication 2006), these jars were mass-produced between 1896 and 1910 by the Ball Company. The piece is either a 3L or a 2L style jar with a base made on an F. C. Ball type machine.

The specimens shown in Figures 37p-q are long neck soda bottles of a type common during the early 1900s. Figure 37r is a tomato ketchup bottle of a type definitely made before 1910 but most probably manufactured earlier, during the

Figure 37. Various bottles and glassware.

1890s. Figure 37s is a whiskey bottle with cork of a type made before 1910.

These glassware pieces differ from the materials discussed above in the sense that they are not clearly associated with the teaching and practice of veterinary medicine, reflecting instead, more domestically oriented activities. Additional non-veterinary medicine artifacts are discussed below.

Fine China and Tablewares

Figure 40 provides overall and close-up views of two pieces of fine china dinnerware. One specimen (Figure 40a) is an English ironstone china plate, tea leaf pattern, made by Alfred Meakin over a period of many years, beginning in 1897 (Robinson, personal communication 2006). The second specimen (Figure 40b) is a bowl manufactured by Taylor, Smith, and Taylor in West Virginia, between ca. 1910 and 1920 (Fredericksen and Page 1996; Gonzalez 2004). Although this particular pattern is quite rare, the maker's mark is consistent with a date of manufacture between ca. 1910 and 1920 (Robinson, personal communication 2006).

Figure 41 illustrates two additional pieces of tableware. One specimen is a white ceramic crockery bowl, and the other is a cut-glass goblet. Tablewares such as these were mass-produced and widely available throughout this period.

Other Materials

A diverse series of other historical artifacts are illustrated in Figure 42, including a fragmentary wick holder from an oil lamp, the spout from a metal water sprinkler, a piece of telephone wire, a telephone mouthpiece, and a machinery or gate pin. Also shown is a horseshoe, two porcelain insulators for electrical wiring, a coal nodule, and three buttons. A small basal fragment of a red ceramic 'flower pot' was also recovered.

The telephone mouthpiece is of particular interest (Figures 42d and 43). Based on its color and morphology, this is a Kellogg-style mouth-

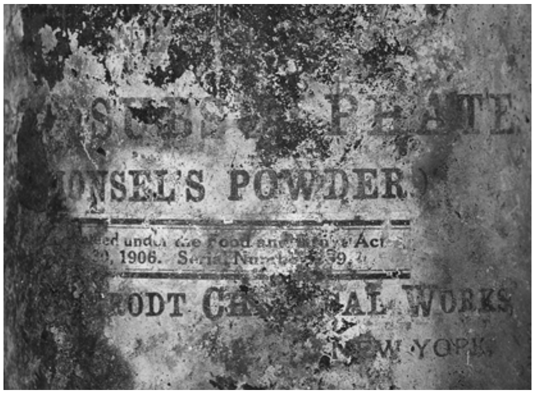

Figure 38. Close-up of label on Mallinckrodt Chemical Works, Ferric Subsulfate' bottle (see Figure 37j).

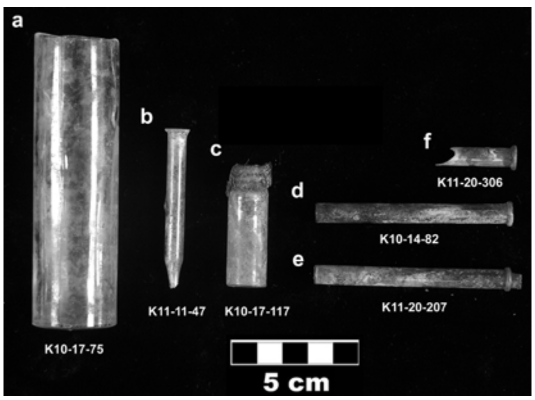

Figure 39. Various glassware: a) 1" diameter syringe plunger; b) medicine dropper; c) metal screw top vial; d) small flat-bottomed vial; e) small flat-bottomed vial with stopper; f) fragmentary vial.

piece, either from a desk stand set (candle stick type) or a metal wall hotel unit, made by the Kellogg Switchboard and Supply Company, Chicago between 1897 and the late 1930s. The brown color of this particular specimen suggests it may be a special Postal Services model, made exclusively for sale to the U. S. Postal Service as well as to private entities, beginning ca. 1910 and continuing until the late 1930s (Neale, personal communication 2006). Iowa State College contracted with several different providers for telephone service during the period 1903-1913 (Day 1980:91), making it impossible to determine who actually owned this specimen, although it was probably not the college.

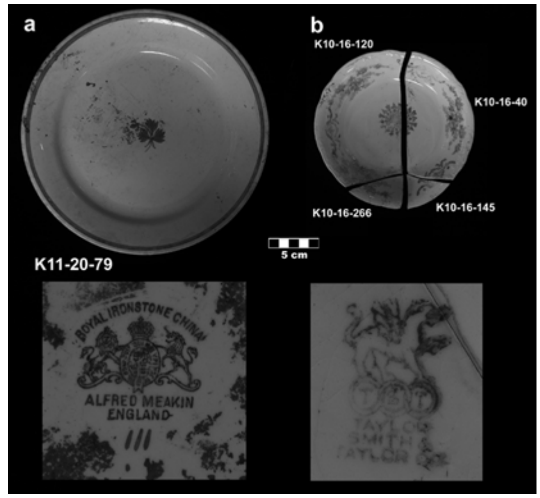

Figure 40. Fine china tableware, including close-up images of maker's marks on reverse side: a) Alfred Meakin, English ironstone, tea leaf pattern; b) Taylor, Smith, and Taylor.

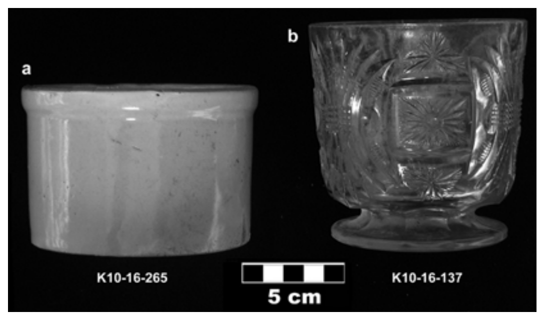

Figure 41. Tableware: a) crockery bowl; b) cut-glass bowl.

Metal Items

Three large metal artifacts were also recovered (Figure 44). Of special interest here is the large metal instrument tray with handles. This metal tray is identical to one pictured in use by students in an undated photograph, originally published in Stange (1929:32). This photograph is captioned "Clinic in the Veterinary Hospital," and probably dates before 1900, based on the presence of Professor Milliken Stalker (standing at right), who served as Professor and Dean of the Veterinary Medicine program from 1879 to 1900 (Stange 1929).

Also illustrated in Figure 44 are an enamel pitcher or coffee pot and a decorative crown from a potbelly stove. Other items, not pictured here, include a series of nails (both round and square headed), wire bundles, and various fragments of heavily oxidized metal, as well as broken frag-

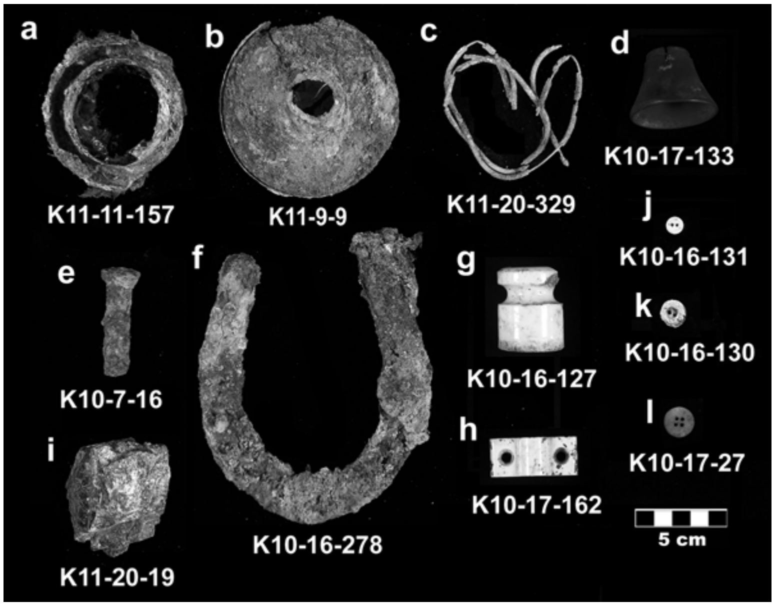

Figure 42. Various artifacts: a) oil lamp wick holder; b) sprinkler head; c) telephone wire; d) Kellogg telephone mouthpiece; e) metal pin; f) horseshoe; g) electrical insulator; h) electrical insulator; i) chunk of coal; j) shell button; k) shell button; l) bone button.

Figure 43. Kellogg-style telephone mouthpiece.

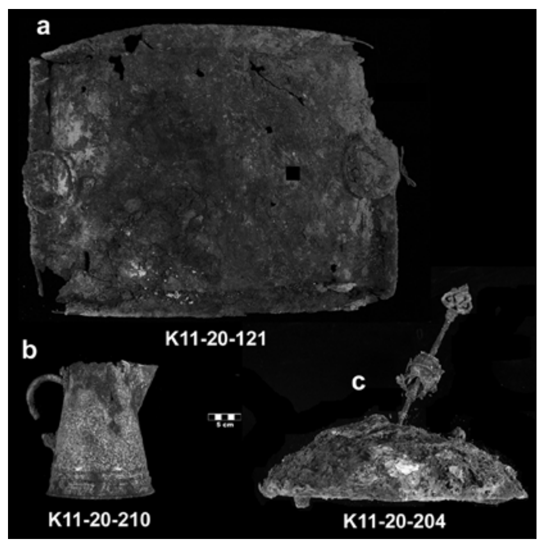

Figure 44. Large metal artifacts: a) instrument tray; b) enamel pitcher or coffee pot; c) crown to potbelly stove.

ments of plate glass, small pieces of burned and unburned wood, and numerous pieces of burned and unburned coal.

Pit 3 Bottles

Figure 45 illustrates two bottles recovered near the base of Pit 3 on the first day of the project. Although no excavation was conducted in this pit, these two specimens were mapped and collected after they were exposed by earth moving equipment. One specimen is an aqua beer bottle base ("ROOT" maker's mark) of a type manufactured between ca. 1901 and 1932, while the other specimen is a small medicine bottle, identical to the one shown in Figure 37a from Pit 2.

AGE AND DEBRIS STREAMS

Although historical artifacts with well established dates of manufacture from Pit 2 total only nine items, the specimens span at least 30 years of manufacture, from ca. 1880 to the 1910s. The tomato ketchup bottle (Figure 37r) probably dates to the 1890s, while the Kellogg telephone mouthpiece (Figure 43) and the fine china bowl by Taylor, Smith, and Taylor (Figure 40b) were not manufactured before ca. 1910, or somewhat later. This pattern is quite unexpected, based on the formational history of the pit, which indicates a rela-

Figure 45. Pit 3 bottles.

tively rapid sequence of pit creation, filling, and subsequent burial; in other words, a single debris stream consisting of the materials generated by the Veterinary Medicine anatomy laboratory and clinic, occurring over a period of a few months to less than one year. However, this pattern becomes considerably more understandable if, in fact, a significant portion of these artifactual materials reflect a second, organizationally distinct debris stream source.

Based on the research conducted here, the contents of Pit 2 were deposited between ca. 1910 and the 1911-1912 academic year. The unexpected diversity in non-bone artifacts discarded in the pit at this time appears to reflect the move by the Veterinary Medicine program to its new location at the Veterinary Quadrangle, combined with the changing function of the space that formerly housed the Division of Veterinary Medicine (now a Storage/ Carpenters Shop), which was razed in 1926. Thus, the discard of so many bottles with corks still in place, including several still holding fluids, along with complete, serviceable and expensive artifacts, including English ironstone china, a cut glass goblet, and crockery, suggests a second, organizationally distinct debris stream composed of an accumulation of materials from the former Veterinary Hospital (or other nearby buildings) aggregated over a period of years (ca. 1885-1912). These materials were ultimately discarded together with the dissected carcass portions from the anatomy laboratory. This scenario implies either a series of building 'clean-ups' related to its new role as a Storage/ Carpenters Shop, or perhaps a final 'clean-out' occurring around 1911-1912.

Source of Carcasses

Pit 2 contains carcass remnants discarded from laboratory classes in anatomy taught in the Division of Veterinary Medicine at Iowa State College. These skeletal specimens include the remains of at least 19 mature to aged horses and a handful of other animals. Undoubtedly, these animals were provided, perhaps for a small fee, to the Veterinary Medicine program by local residents (Ames and surrounding communities), for use in teaching – after they were no longer considered useful as draft animals. In this regard, the Division of Veterinary Medicine Bulletin for 1909-1910:6 is revealing: "The College being located in a rich stock growing section of the country, is supplied with an abundance of clinical material for daily demonstration."

Such animals would have been introduced to the paddock as live animals, and then euthanized. Although the method employed in euthanation is unknown, chloral and magnesium sulfate were possibly administered intravenously to achieve the desired result (Dr. Nani Ghoshal, personal communication, 2006). The intact portion of the bonebed is not a long term, accretional deposit. Instead, the pit was filled over the course of a relatively short time frame, probably less than a year, and then buried. The *terminus post quem* is 1910, based on a fine china bowl (Figure 40b), and an early telephone mouthpiece (Figure 43). The *terminus ante quem* is the 1911-1912 academic year, after which time a rendering apparatus in the new Veterinary Quadrangle (now Lagomarcino Hall) was used to dispose of dissected material and offal.

Historic Artifacts

The diverse nature of the artifact assemblage is somewhat unexpected. Not only are the objects and materials unusual in themselves, their time depth is unexpectedly broad, spanning a period from ca. 1880s to the 1910s. Clearly, this conflicts with the robust inference developed above that Pit 2 was created and buried in less than one year. This observation suggests instead that two distinct, but contemporaneous debris streams flowed into this pit. Following this scenario, the headwater of the most obvious debris stream was the Veterinary Medicine anatomy laboratory program, while the source of a second, more ephemeral debris stream was the Storage/ Carpenters Shop (formerly the Veterinary Hospital) located only about 100 feet to the north of the site (Figure 1).

Artifacts include 58 complete or fragmentary chemical or medicine bottles, five with corks still in place, plus various medicine vials, test tubes, and a syringe plunge dating from the earliest days of Iowa State College (ca. 1880s-1910). Also present is a metal instrument tray with handles that is identical to one pictured in use by Veterinary Medicine students just prior to the end of the nineteenth century. These observations are congruent with the timing of the move to the Veterinary Quadrangle beginning in the 1912-1913 academic year by Veterinary Medicine. However, less easily understood are the complete, imported and domestic fine china, glass, and ceramic tableware pieces, as well as the other non-Veterinary Medicine related materials, discarded along with these items. This pattern is perhaps best explained by some form of cleaning or refurbishing behavior, focusing on materials left behind by Veterinary Medicine after their move to the Veterinary Quadrangle. Artifacts such as an oil lamp wick holder, a water sprinkler metal spout, a bundle of telephone wire, an early telephone mouthpiece, porcelain electrical insulators, an enamel pitcher or coffee pot, a crown of a potbelly stove, and so on, represent an array of well-used, but still serviceable or potentially useful materials no longer deemed appropriate to retain, given the buildings newly designated function as a Storage/ Carpenters Shop.

CONCLUSION

The application of a mosaic approach to bonebed formation has substantially enhanced our ability to understand the formational context of this deposit, while providing a number of novel insights on the apparent incongruities in the nature of the bone and artifact assemblages. The establishment of a rapid, uninterrupted formational sequence for Pit 2 provided the background for a series of important insights on the changing use of space associated with the Veterinary Hospital and its paddock during the earliest days of Iowa State College. Also important here are a number of insights on how subtle differences in the organization of disposal activities or debris streams are reflected in the archaeological record. Use of a taphonomic perspective, together with a truly ‘analytic’ approach addressing the dynamic and interactive nature of this deposit, has allowed us to isolate and identify the agents responsible for pattern formation within Pit 2. This approach demonstrates the interconnected nature of interpretive principals (for assigning meaning to patterns) and methods (utilizing appropriate techniques of data collection and analysis). Although the methods employed here are certainly time-consuming and technology-intensive, it is no overstatement that the vast majority of our concluding statements could not have been made without them. It is also true that insights such as these are unique to archaeology, since no other research discipline specifically addresses the interaction of dynamic physical, biological, and cultural processes over such time depths. In short, only holistic archaeological research can provide the unique forms of interpretation developed here. Based on this research, each of the analytical questions originally posed in the introduction can be addressed as follows.

Formational History

Several lines of evidence indicate a very rapid sequence of excavation, filling, and burial for Pit 2, most probably within an academic year. No evidence of stratigraphic separation or depositional layering was noted during the excavation. In addition, the depositional context of the historical artifacts is indistinguishable from that of the faunal remains. Three-dimensional GIS analysis of long axis positional information for faunal remains and other artifacts indicates that the dumping of substantial quantities of material occurred at roughly the same points in time. Numerous complete and conjoined skeletal elements support this interpretation, as does the unweathered condition of the bone surfaces.

Pit Contents and Debris Streams

Remains of very old, arthritic horses dominate the faunal assemblage, representing the remains of at least 19 individual animals. Other species are less common, reflecting portions of 2 prime age cows, 2 immature dogs, 2 fetal/newborn pigs, 2 immature cats, and 1 chicken, plus a brown rat. Careful examination of Figure 33, the historical photograph entitled 'Dissecting Room Veterinary Hospital, Iowa State College 1907,' indicates a series of collecting vessels or buckets located on the floor of the laboratory work area. If these vessels were employed as containers for the discard of small or fragmentary carcass portions, with their contents eventually added to the Veterinary program's debris stream, this process would enhance the potential for inclusion of small items within the fill of the pit features. This inference, in turn, implies that the relative absence of the remains of smaller species in the Pit 2 assemblage is not primarily a function of their size. Instead, horse was the primary focus of study and research for students in Veterinary Medicine at Iowa State College during this period. Although other species are represented, they are rare and appear to represent important comparative *ad hoc* specimens. This is not unexpected, since by 1918, it is estimated that there were some 27 million draft horses and mules at work in America agriculture. Until after World War I, the horse was truly the dominant 'engine' of work and transport in America.

A substantial and varied assemblage of non-bone artifacts was also recovered from Pit 2. Not surprisingly, the majority are associated with the practice and instruction of veterinary medicine. These include numerous chemical and medicinal bottles, some with corks still in place, as well as a variety of vials, syringes, and associated glassware. Also present are a variety of loose bottle corks and several segments of red rubber hosing. All of these items are consistent with laboratory/clinic materials employed in the practice of veterinary medicine during the early 1900s. However, a series of other materials are less expectable in this setting. They reflect various domestic activities and include: English ironstone china, a cut glass goblet, ceramic crockery, electrical insulators, oil lantern parts, a telephone mouthpiece, a decorative crown from a potbelly stove, and numerous small, but complete items including shell and bone buttons. These materials are interpreted as representing an organizationally distinct debris stream that ultimately was dumped alongside the numerous carcass portions over the course of one academic year at Iowa State College. They reflect either a series of building 'clean-ups' associated with the new role of the Veterinary Hospital as a Storage/Carpenters Shop (around 1912), or a final 'clean-out' of the building occurring at this time. Pit 2 is one of three similar features situated in what was at the time a paddock behind the Veterinary Hospital. The excavation and use of these pits reflects a long established tradition of carcass disposal in this general area, probably dating to the construction of the Veterinary Hospital in 1884-1885.

In summary, the distinctive character of the artifactual materials recovered from Pit 2 is best explained by the significant changes in space use occurring in the Veterinary Hospital around 1912. This major shift in building function, from Veterinary Medicine to Storage/Carpenters Shop, induced concomitant adjustments to storage, cleaning, refurbishment, and discard behaviors, which in turn, generated a discrete debris stream that became commingled with the carcass remnants in Pit 2. Small, but complete items like buttons, nails, electrical insulators, and metal objects likely reflect such organizationally distinct materials, deposited alongside the carcass segments from the Veterinary Anatomy laboratory, but functionally associated with periodic floor sweepings or other *ad hoc* clean-up activities.

ACKNOWLEDGMENTS

The Memorial Union bonebed project couldn't have gone any more smoothly. This once-in-a-lifetime-research opportunity was made possible through the dedicated efforts of a large contingent of involved, supportive, and enthusiastic contributors. Whether involved in the day to day aspects of the research process or active in other areas, the contributions of each of these individuals was essential to the timely completion of the project. In the next several paragraphs, we acknowledge the individuals, organizations, and businesses that helped bring this research program to fruition. We also extend our sincere apologies to any we may have forgotten.

First is the dedicated field crew, comprised of seven undergraduate and three graduate students in the Department of Anthropology, including: Jared M. Avelar, Northwood; Andrew R. Boehm, Wadena; Andrew P. "Pat" Brummel, Des Moines; Erik Otarola-Castillo, Long Island, New York; Larry Van Gorden, Des Moines; Jeremy N. Hall, Missoula, Montana; Adam C. Holven, Waterloo; Valerie K. Mayer, Ankeny; Scott F. Sinnott, Albia; and Matthew W. Wisniewski, Moville.

On a moment's notice during a busy time of the semester, these individuals demonstrated their passion and commitment to archaeology by rescheduling appointments, canceling other plans (hopefully, not including skipping classes!), and sacrificing consecutive weekends to participate in the excavations. Bonebed archaeology is a very specialized form of archaeology and, in this regard, we are fortunate that the entire crew – except for Avelar and Wisniewski – were seasoned veterans in this line of work prior to the discovery at the Memorial Union, having worked with us previously on similar prehistoric sites. Without their knowledge and experience of the excavation methods, recording protocols, and osteology, this project would not have happened. For these reasons, we shall never forget your contributions to this research. Thank you.

Following excavations, two of our graduate students provided additional assistance, for which we are most grateful. Over the course of the last two weeks of May, Jeremy Hall cleaned, stabilized, and catalogued the entire assemblage in preparation for our analysis and subsequent storage of the collection. Erik Otarola-Castillo applied his expertise in ArcGIS to prepare the maps and the illustration of the horse skeleton that appear herein. Professional quality images of the excavations were also kindly provided by Dave Gieseke, Public Relations Manager, College of Liberal Arts and Sciences.

We are also indebted to several individuals who answered our questions and supplied additional information on a number of topics. Russell Holven of Waterloo saved us a significant amount of time in providing invaluable data on the bottles and related glass and ceramic artifacts. Jonathan Baker, graduate student, Department of Anthropology, University of Tennessee identified the avifauna. Dr. Holmes Semken, Professor *emeritus*, Department of Geosciences, University of Iowa, identified the brown rat mandible.

Wolfgang Weber and Dr. Nani Ghoshal, College of Veterinary Medicine, Iowa State University, put us in touch with the early literature related to equine veterinary medicine and techniques related to the preparation of specimens for teaching purposes. It would be remiss if we did not acknowledge that it was Wolfgang who first suggested that our "bone disks" might, in fact, be trephination disks removed from horse crania; we are now convinced that he is correct.

Mike Parsons, construction manager in Facilities Planning and Management (FPM), effectively initiated the project early on the morning of Thursday, March 23, 2006 by bringing a box of bones from the site to Hill's office in Curtiss Hall for identification. Although our excavations threw a very large wrench into the spokes of the project he was overseeing, he was nothing but patient, affable, and helpful, as was his colleague at FPM, Dean McCormick. We also thank Miron Construction Co., Inc., Cedar Rapids and Keith Cooper and Sons, Inc., Ames for accommodating our field work and for putting the safety of our students first.

Two others who were instrumental in making the project happen are Douglas Jones and Daniel Higginbottom of the State Historic Preservation Office in Des Moines. Over the course of several phone conservations and two on-site visits, Doug and Dan answered many questions related to the preservation, protection, and significance of the site. The citizens of Iowa are fortunate to have these two individuals serving as stewards of its past. Incidentally, Doug and Dan are both alumni of Iowa State University, having earned their undergraduate degrees in Anthropology and History, respectively.

During analysis, several expert sources were consulted via the internet in order to help identify and provide date of manufacture information for three critical historical artifacts. Mike Neale, a member of the Antique Telephone Collectors Association (Member no. 3885) and an expert on the history of Kellogg telephones, provided invaluable assistance in identifying the telephone mouthpiece recovered during this excavation. For the Taylor, Smith, and Taylor china bowl, Ms. Jamie Robinson, curator at Replacements, LTD provided date of manufacture information. And for the Ball/Mason jar, Nick Davis III helped with the style and dating of this important piece. To all three of these individuals, a very special thank you. Their efforts via cyberspace are greatly appreciated.

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NOTES

1. An electronic copy of the data base is available upon request by contacting Hill (mghill@iastate.edu).
2. Veterinary College of Philadelphia, est. 1852; Boston Veterinary Institute, est. 1854; New York College of Veterinary Surgeons, est. 1857; and Montreal Veterinary College, est. 1866.
3. Although the terms refit, articulation, and conjoin are conceptually similar, each has a distinct and interrelated definition, as employed here. Refits occur in two forms, either as *mechanical refits*, consisting of two or more fragments of a larger, single specimen that are mended together like the pieces of a puzzle, or as *anatomical refits*, spatially disassociated, but anatomically adjacent or paired elements from an individual animal, identified through anatomical carcass reassembly (Todd 1987). *Articulation* refers only to specimens excavated in correct anatomical position with actual physical contact between articular surfaces. *Conjoin* is a more comprehensive term, encompassing all three refit types -- articulation, mechanical, and anatomical -- in any combination.