A RE-EXAMINATION OF CREMATED REMAINS 
FROM THE ARCHAEOLOGICAL RECORD: 
AN EVALUATION OF THE PROCESS 
AND APPLICATION OF 
CURRENT METHODS

by 
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A THESIS

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ABSTRACT

Cremation is a burial practice that has been adopted by numerous cultures throughout time. In the past, the fragmented nature of cremated remains gives them the reputation of being difficult and time consuming to analyze. Thus, in archaeological literature such as site reports, data collected about cremated remains is largely lacking. The effect of heat on bone was not originally well understood and it has taken years for research to be conducted on heat altered bone. However, through research in both archaeology and forensic science a good deal is now understood about cremations. This study includes an extensive literature review of studies from both archaeology and forensic science. From these studies, a method was developed to analyze the cremated human remains housed in the University of Alabama’s Laboratory of Human Osteology. This research resulted in an increased understanding of the age, sex, health, and cause of death of cremated individuals within this collection. It is hoped that this study’s methodology will be replicated to analyze other collections of prehistoric cremated remains or used as a basis for future research to improve the methodologies used in this study.
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CHAPTER 1

INTRODUCTION

This study seeks to advance the understanding of cremated remains recovered from a number of archaeological sites whose materials are curated in the laboratory for Human Osteology at the University of Alabama. In doing so, this study encompasses an extensive literature review which is utilized to develop a methodology for analyzing the remains of cremated individuals. A record of the burials compiled by Charles Snow in the late 1930s and early 1940s and records from recent Native American Graves Protection Repatriation Act (NAGPRA) inventories indicate the collection contains at least 46 cremated individuals. In general, the fragmented and charred nature of cremations has made the analysis of them difficult and time consuming in the past, and thus analyzed cremations are lacking in the osteological literature. Even more lacking is literature on the techniques used to analyze the trauma and pathology seen in cremated remains.

Like grave goods, the discovery of cremated remains at archaeological sites has historically led to an interest in the archaeological mortuary record. According to Stewart (1979), the first useful information dealing with prehistoric cremations was presented by archaeologists instead of forensic scientists. In America, cremation experimentation began in the 1930s with Krogman (1943a, 1943b) and continues until the present day (Stewart 1979). This experimentation refers to the systematic study of cremated remains through controlled experiments in order to understand the ways in which bone burns, the effects of heat on the bone, and how these changes affect the determination of demographic information, traumas, and
pathologies on the bone. Krogman’s first studies focused on the effects of heat on dry bone, fresh (fleshed) bone, and the cadaver (Stewart 1979). Anthropologists such as Baby (1954), van Vark (1970), and Binford (1972) had established methods for determining if bones were burned dry or green (fleshed) and at what temperature bone shrinkage occurs. Bone shrinkage occurs when the organic components are eliminated from the bone resulting in recrystallization of the hard matrix (Fairgrieve 2008). The restructuring of the hard matrix weakens the bone’s structure which then allows the bone to shrink, warp, or crack. The weight (in grams) of cremations became increasingly important in the 1990s due to Warren and Maples’s (1997) study which correlated burned bone weight with sex and age. Despite these experimental contributions to the literature, the determination of trauma and pathology in cremated remains was largely ignored until the turn of the 21st century.

Currently, advancements in the field of forensic science have led to more studies concerning trauma in cremated skeletal remains. In trying to better understand fire-related cases, forensic scientists have developed new techniques to study trauma on human bone. What applies to skeletal remains in forensic science is applicable to human remains recovered from archaeological excavations (Stewart 1979). By applying new methods in forensic anthropology to the study of prehistoric cremated remains, it is possible to better understand the health of the prehistoric individual and perhaps prehistoric mortuary procedures.

By combining methods of analysis from both physical anthropology and forensic science there is an increased understanding of the age, sex, health, and cause of death of cremated individuals housed in the osteological collection at the University of Alabama. It is hypothesized that if bone color correlates with bone temperature, then bones burned at lower temperatures will show signs of trauma and pathology more frequently that those burned at higher temperatures. In
addition, I propose that if there is localized intraburial burning, then the cremation was due to ritual or accidental fire. The results derived from this study will be important because it will provide more detailed information on prehistoric individuals that was previously lacking due to inadequate methods for analysis and weak descriptive literature. Therefore, this study hopes to lead to an increased understanding of prehistoric health and mortuary customs.

In Chapter Two a literature review will discuss the history of cremations as a burial practice and early cremation studies conducted by archaeologists, as well as more recent literature describing studies in the field of forensic sciences.

Chapter Three provides a detailed description of the methodology utilized for this study. More specifically, this section describes how the sample for this study was chosen. In addition, the methodology was derived from the studies of several other individuals who were discussed in Chapter Two. Therefore, a description of these studies and how they were employed is provided in this chapter.

Chapter Four discusses the results that were concluded from this study. These results for the entire sample are presented as demographic and descriptive information. The term demographic refers to the age and sex of the individuals and whether or not trauma or pathology exists. The descriptive information consists of nine variables that were designed to understand the treatment of the body and associated artifacts which can provide a more complete understanding about the burial practice of cremation. Then the results for four site comparisons are described in this chapter, which were designed to detect site differences surrounding the burial practice of cremations.

Lastly, Chapter Five consists of a discussion of the results presented in the previous chapter. This discussion includes interpretations of both the demographic and descriptive data.
Followed by this discussion for the entire data set (N=46), the four site comparisons are described and possible unique cultural attributes are discussed (if present) for the individual sites. In addition, this chapter points out the limitations for this study, as well as the need for future research on both other collections of cremated remains and the methodologies involved in their analysis.
CHAPTER 2
LITERATURE REVIEW

Emergence of Cremations

The term cremation can “refer to the complete process of reducing a corpse to ashes, or it can be partial due to design or accident, with only parts of the body involved or the body may be subject to only cooking, roasting, or charring (Binford 1963; Williams 2008: 241). The reason people chose to cremate their dead is not well understood. Some scholars trace the reasons for cremations to sun worship, fear of the dead, sanitary conditions, or the need to transport individuals easily (Prothero 2001). Cremations were referenced frequently in classical literature, such as Homer’s *Iliad* and the ancient writings of Pliny, Virgil, Ovid, and Pindar (Prothero 2001). Cremations also were affiliated with religious groups in Italy, Syria, and much of Europe during the Bronze Age. Cremation hymns in India can be traced back as far as the second millennium BCE (Prothero 2001). The exact reason why the Hindu adopted cremation is unknown. However, it is suggested that cremations serve as a means of purification, a transitory symbol to society, a way to dispose of the dead without crowding the country, and a means to stop the spread of disease (Iserson 1994). From the Hindu Grihya-Sutras is this saying: “On this day I shall go to my father and fulfill the sacrament of the cremation” (Iserson 1994: 273). Likewise, Bendann (1969: 47) reports that the Vedic Hindu cry out “Away, go away, O Death! Injure not our sons and our men,” when cremating their dead. Cremation does not hold the same meaning for every culture. The Vedic and Siberian regions believe that if the flames go straight
up, the soul will reach heaven, but in the Australian and Melanesia groups, the flames keep the
death from shivering, or provide a light to enter into the new world (Bendann 1969). Despite the
variable reasons behind cremations, the archaeological record shows that numerous cultures
practiced this method of disposing of their dead.

According to Rosen (2004) cremation started in what he calls the Archaic period (6000-
3000 BCE) at the Caribou Lake Complex in North America. The site contains a cremation pit,
fragments of charred skeletons, and the remains of tooth enamel that radiocarbon dated to about
3900 BCE. At the same time in Europe, circa 3900 BCE, pottery urns found in Russia turn up
which contain ashes and bone fragments from human beings.

By the Bronze Age (2500-100 BCE), cremation appears to have moved west to the
British Isles and what is now Spain and Portugal (Rosen 2004). According to Rosen (2004),
human remains were burned over funeral pyres that were rarely hot enough to incinerate an
entire body, therefore cremation cemeteries begin to spring up in Hungary and northern Italy
where the remaining bones and ashes were interred.

Archaeologists have long been concerned with the reasons why cremations became a
standard mortuary practice. Robinson and Sprague (1965) proposed diffusion as a possible cause
for the spread of cremation practices. For example, they suggested that the Hohokam, who lived
in the Tucson Basin, may have had some influence on the cremation mortuary practices of the
people at the Point of Pines site in Arizona (Robinson and Sprague 1965).

Turner and Turner (1992) associated burned skeletal remains with cannibalism among the
prehistoric Anasazi. It has been suggested that they roasted their victims before they ate the flesh
and organs. Turner and Turner (1999) also conducted an extensive study on cannibalism and
violence in the American Southwest, where they documented numerous cases of cremated
remains. For example, they report that of the collection of human remains at the Museum of Northern Arizona, 1 out of 12 Anasazi individuals were cannibalized (Turner and Turner 1999:413). In another study on a small settlement of the Anasazi living on the San Juan River, Flinn et al. (1976) felt that individuals resorted to cannibalism out of necessity due to starvation rather than a ritual ceremony. In South America, research conducted on an Amazonian group, the Wari, found that cremations were used in conjunction with cannibalism. The Wari would roast and eat the internal organs and then cremate the inedible parts of the body including the hair, nails, and genitals (Conklin 1995). This thesis does not suggest that burned bone alone indicates cannibalism, but that analysis of burned bone can be used in addition with other evidence to suggest cannibalism.

Despite the unknown origin for the use of cremation, the custom has spread all over the world. It is plausible to think diffusion played a role in spreading this practice to so many diverse groups; however, independent innovations of cremation also were likely, with no outside influence. For example, it is possible that cremation was a better way of handling rotting bodies, so different cultures in different parts of the world began the practice independently.

**Decline of Cremations**

With the exception of Judea, where bodies were buried in sepulchers, and Egypt, where bodies were embalmed; cremation was the preferred method of body disposal in what is now the Middle East (Rosen 2004). The belief in an afterlife made cremation a blasphemous act in the eyes of the Egyptians, but in Greece during the same era cremations were accepted. Among the Greeks, “only suicides, unteethed children, and persons struck by lightning were denied the right to be burned” (Rosen 2004:32).
Rosen argues that two main events in the Middle East and Europe shifted the public’s view of the once popularized cremation back to burial of the entire body. The first is the story of Jesus. Modern scholars believe that Jesus was born between 6 BCE and 4 BCE around the end of the reign of Herod the Great and was crucified sometime between 31 and 33 CE (Rosen 2004). Jesus was accused of claiming to be the King by the Roman governor of Judea, Pontius Pilate, who sentenced Jesus to death on the cross. Following his crucifixion, Jesus was entombed and his burial place was guarded by Roman guards. Three days after Jesus died his followers were going to anoint his body, but when they arrived the stone to the tomb was rolled away and his body gone. The Resurrection of Jesus became the cornerstone of Christianity (Rosen 2004:33). The New Testament of the Holy Bible speaks of the Second Coming of Christ where he will return to resurrect the bodies of his followers to meet their souls. John quotes Jesus saying:

“Verily, verily, I say unto you, The hour is coming, and now is, when the dead shall hear the voice of the Son of God: and they that hear shall live. For as the Father has life himself; so hath he given to the Son to have life in himself; And hath given him authority to execute judgment also, because he is the Son of man. Marvel not at this: for the hour is coming, in the which all that are in the graves shall hear his voice, And shall come forth; they that have done good, unto the resurrection of life; and those that have done evil, unto the resurrection of damnation” (King James Bible 1995: John 5:25-29).

Faith in these teachings emphasizes the importance of the body to life in the hereafter, which shifted burial practices away from the trend of cremation.

Secondly, during Constantine’s rise to be sole ruler of the Holy Roman Empire, he was converted to Christianity. While facing the Battle of Milvian Bridge in 312 CE, a war that would decide who would rule the western half of the Roman empire, Constantine had a dream to place the sign of Christ, the Cross, on all of his soldiers’ shields (Rosen 2004). He won the battle and became a lifelong Christian following the battle. For the rest of his career, he urged the people to practice earth burials over cremations by declaring cremations as pagan-like (Rosen 2004).
Therefore, unless there were too many bodies to bury in instances such as plague and war, the Holy Roman Empire practiced earth burial which almost completely replaced cremation (Rosen 2004).

**Reemergence of Cremations**

For several hundred years, cremations were far removed from European’s ideas. Around 1658, some 40 to 50 Bronze Age burial urns were discovered in Norfolk, England. Sir Thomas Browne became interested in the burials because the urns contained ashes along with charred human remains. Browne (1658) was so fascinated he wrote, “Hydriotaphia, Urn-Burial; or a Discourse of the Sepulchral Urns Lately Found in Norfolk” (Rosen 2004). Browne’s awe of the urn burials made him accept cremations as a dignified method of disposing of the death; a matter that would not occur to the rest of the public for another two centuries (Rosen 2004).

In the 1670s, Anton van Leeuwenhoek, a Dutch amateur lens grinder, used a magnifying lens to observe microscopic organisms for the first time. Though he was unaware of it, he was looking at germs, and his discovery played a huge role in society accepting cremation as a legitimate form of disposal over the next 200 years (Rosen 2004).

By the 1860s, the French scientist Louis Pasteur developed the germ theory of disease, which was based on the microorganisms van Leeuwenhoek had seen under his magnification lens (Rosen 2004). This led Pasteur to argue that the dead should not be buried in populated areas. He felt that rotting corpses were breeding grounds for germs and diseases and that exposure to the public risked large-scale contamination. According to Rosen (2004), during Pasteur’s time cemeteries were built on beautiful grounds so people assembled their homes around them.
Understanding the need for reform in the name of public health, Sir Henry Thompson would become a key advocate in legalizing cremations. Thompson understood that in order for cremations to take place in modern times, the centuries-old funeral pyre method would need improvement (Rosen 2004). In 1873, the latest inventions were placed in the Machinery Hall of the Vienna Exposition at the world’s fair. One of the ten rooms showcased the first modern furnace built for cremation by Dr. Bruno Burnetti of Italy, but Burnetti’s model could not be tested because cremation was illegal (Rosen 2004). However, the first modern cremation did take place in 1874, in Dresden, Germany in another furnace built by Frederick Siemens (Rosen 2004).

By 1878, Sir Henry Thompson was President of the Cremation Society of Great Britain, and he wanted to build a crematorium. The Cremation Society of Great Britain wanted a smaller crematorium than those proposed by Burnetti and Siemens. Fortunately, Professor Paolo Gorini of Lodi, Italy developed just that; they bought it and Gorini supervised the furnace’s construction (Rosen 2004). The Cremation Society of Great Britain also obtained a piece of land near the city’s cemetery in Woking, but the neighborhood surrounding it was in dispute. The town refused to legalize cremations (Rosen 2004).

Issues concerning the legality of cremations according to Western law first appeared in 1884 when Dr. William Price, a surgeon in Great Britain, cremated his five-month-old son and was charged with committing a “blasphemous pagan act” (Smillie 1999:1635). Price was later acquitted of all charges after arguing that cremations do not take up useful land or cause pollution which would endanger people’s lives (Smillie 1999). Justice Stephen held the trial in 1884 and this argument proved to be strong enough to legalize cremations; he pronounced the verdict: “Not guilty” (Rosen 2004:50). To appease the police department who feared cremations would be used to cover up crimes, the Cremation Society of Great Britain offered to only
conducted cremations once cause of death was clearly determined. Finally, on March 26, 1885, the Woking Crematorium got its first candidate, Mrs. Jeannette C. Pickersgill. From this point forward, the practice of cremation grew in England and spread to the United States (Rosen 2004).

Even though Native Americans had practiced cremations in North America for centuries; Prothero (2001:9) says cremation came to the United States as a “renaissance rather than revolution.” By 1874, American newspapers eagerly followed both local and European debates concerning cremations. Like the Europeans, American debates discussed the cleanliness of cremations because they did not pollute wells or take up space (Prothero 2001).

Baron De Palm emigrated from Austria to New York in 1875. Once there he befriended Colonel Henry Steel Olcott. Olcott served as a Union investigator of fraud and corruption during the War Between the States. Afterward, he had a career in law, and then added journalism in order to report on spiritualistic phenomena (Rosen 2004). By this time, Olcott was a free thinker and found De Palm to be of like mind (Rosen 2004).

According to Rosen (2004), De Palm had arrived in New York ill, and his health continued to decline. Before his death, he asked Olcott to arrange his funeral in “accordance with the rites of Eastern religions;” afterward, he wanted to be cremated (Rosen 2004:58). Following De Palm’s death, cremation was still not legal in the United States. Therefore, Olcott had Baron De Palm embalmed and waited for change in hopes of fulfilling De Palm’s wishes (Rosen 2004).

Fortunately for Olcott, Dr. Samuel LeMoyne was making preparations to conduct cremations in the United States. Dr. Samuel LeMoyne, the town doctor of Washington, Pennsylvania, noticed that several of the town’s residents continued to come down with the same symptoms. He felt certain it was due to the burial practices which were contaminating the town’s
wells and streams. He therefore became an advocate for cremations in order to prevent diseases from leaching into the soil and water. Even though he offered to donate the money to build the city’s crematorium, Dr. LeMoyne built the crematory on his own land in 1876 with no help from the city (Rosen 2004). Upon seeing news of this new crematorium in the *New York Herald Tribune*, Olcott contacted Dr. LeMoyne and told him he had his first candidate for cremation. After making the legal arrangements, Olcott transported De Palm’s body to Washington, Pennsylvania on December 5, 1876 (Rosen 2004).

On December 6, 1876 the first body “went up in flames” in Pennsylvania, and thus was dubbed the first modern cremation in North America (Prothero 2001:15). The cremation of Baron Joseph Henry Louis Charles De Palm left reporters divided; some wrote it up as a tragedy while others as a comedy (Prothero 2001) (Figure 1.1). According to Prothero (2001:41) “one *Times* reporter lamented that ‘there were no religious services…not one iota of ceremony’.”

Figure 1.1. Cremation of Baron De Palm. Retrieved from: http://scottbeveridge.blogspot.com/2007_07_01_archive.html
Early Cremation Research in Anthropology/Archaeology

Although archaeologists and physical anthropologists have been uncovering and analyzing cremated remains for years, a standardized method for analysis has been lacking. For example, Buikstra and Ubelaker’s (1994) book on the standards for skeletal analysis does contain a form for the analysis of cremated human remains, but lacks detailed methods describing how to conduct the analysis. Lack of such forms, techniques, or methods of analysis have resulted in cremated remains being largely ignored in skeletal analysis.

Wilton M. Krogman (1943) is considered to be the first United States anthropologist with enough interest in cremations to conduct bone burning experiments in order to learn more about the effect of heat on bone (Stewart 1979). In 1926, while digging the Ohio I Indian Mound, Krogman (1943) unearthed a cremated burial. As a result, he conducted studies concerning the effect of heat on dry bones, fresh (fleshed) bone, and the cadaver (Stewart 1979). Likewise, Webb and Snow (1976) in 1945 were reporting on the burial practices of the Adena people. The Adena, like the Hopewell, used cremation as a burial practice. In hopes of distinguishing the differences in this practice between the two cultures, Webb and Snow sent Krogman two samples of the Adena and Hopewell bone. Krogman’s testing found that the Adena practiced cremation of fleshed bodies and the Hopewell burned defleshed or dried bones (Symes et al. 2008; Stewart 1979; Webb and Snow 1976).

Ten years after Krogman’s findings, Baby decided to re-evaluate the Hopewell cremation practices. He, too, used both examination and experimentation which led him to disagree with Krogman’s findings. Baby’s research indicated that green bone, fleshed or defleshed, will “exhibit deep cracking, warping, reduction of compact bone, and transverse and diagonal fracture” (Personal Communication to Stewart, February 18, 1976; cited in Stewart 1979:61). He
also found that heated dry bone “exhibits superficial checking, longitudinal striae, deep longitudinal fracturing, or splintering, and no warping” (Baby 1954:4).

Baby’s dispute with Krogman’s experiment led Binford (1972) to further the study of burned bone. He felt that the rate at which the bone cooled could affect the pattern seen on the bone. Using selected dry bone or defleshed, from a 1500 year old burial and the head, left arm, and feet of a green monkey cadaver, Binford (1972) burned the bone on a charcoal fire and then cooled half of each sample by quickly dousing the bones with cold water. In the end Baby’s (1954) theory was confirmed, which provided both forensic scientists and archaeologist with criteria to determine if bones were fleshed or defleshed when burned.

Stewart (1979) reports that European archaeologists, unlike American archaeologists, were only concerned with determining age and sex of cremated individuals because they thought cremations only occurred with fleshed bodies. In the beginning, large numbers of female cremations were reported, which according to Stewart (1979), resulted from the lack of understanding concerning bone shrinkage due to heat. To clarify, normally unburned bones of the female skeleton tend to be smaller and more gracile than the bones of male skeletons; therefore, heat induced shrinkage can cause larger male bones to appear to be female.

In 1970, experiments were carried out by van Vark (1970) to determine the correlation between temperatures and bone shrinkage. Using cortical fragments of the femur and spongy tissue from the mandible and the patella, he measured the dimensions of the bones after the bone was heated every 100°C, with the temperature ranging from 200°C to 1500°C (Stewart 1979). He determined that bone shrinkage occurs between the 700°C-900°C, and shrinkage may vary up to 25 percent of the original length on each bone (Stewart 1979). Ubelaker (1978) agrees with van
Vark (1970) in saying that bones fired at higher temperatures should be linked with a shrinkage rate of 25 percent, which affects age and sex estimates.

Ubelaker (1978) further discussed the challenges heat induces by causing bone shrinkage. A problem with Ubelaker’s procedure was that he failed to mention the color of bone as an important detail to record. Bone color and fire temperature are related. The colors that can be present on a bone can range from dark yellow to shades of brown, to gray and black, and then to a bluish or white color (Ubelaker 1978; Shipman et al. 1984; McCutcheon 1992; Thomas 2003). Therefore, the color of cremated bone can indicate the temperature of the fire used to burn the bone. For example, bones that are dark yellow or brown in color are associated with the lower temperature fires, while bones that are white in color are associated with the higher-temperature fires.

Ubelaker (1978:33) outlined four main goals for excavating cremations, including the following: “identification and removal of all skeletal remains, documentation of each bone fragment position, determination of the location the cremation took place, and documentation of details providing information on how the cremation occurred.” He also supported the use of photographs and diagrams as a supplement to the final report (Ubelaker 1978).

The observations mentioned above are all practical and necessary for the study of human skeletal remains. Unfortunately, as Stewart (1979) and Gejvall (1975) pointed out, each set of observations only assisted in determining the age, sex, and minimum number of individuals. At that time, Stewart (1979) also admitted there were no methods available to help them detect if trauma occurred perimortem or antemortem. So methods needed to be developed to be able to detect foul play in skeletons both as a part of forensic anthropological investigation and the cause
of death in prehistoric people. Fortunately, by the late 1990s and early 2000s forensic scientists developed some new methods for studying burned human remains.

Interested in the weight of burned bone, Trotter and Peterson (1955) attempted to find a patterned consistency with little success. However, through cadaver experimentation Warren and Maples (1997) loosely correlated the weight of cremated remains, also known to some researchers as cremains, with variables such as cadaver stature and estimated skeletal weight (Adams and Byrd 2008). From these experiments, it was found that the average cremation weight of an adult is 2430 grams (Warren and Maples 1997:418). The ash weight of a cremated adult female can range from 876 grams to 2750 grams and a cremated adult male’s weight can range from 1887 grams to 3784 grams (Warren and Maples 1997:418). While using this method, if the weight of the cremains exceeds the expected range then the cremation might contain more than one individual. On the other hand, if the weight of the cremain is less than expected, it could be indicative of a child. This method also assumes that the entire cremation is present (Warren and Maples 1997). Despite the obvious benefits of being able to estimate variables such as minimum number of individuals (MNI) within cremations, this methodology is controversial. More research on the topic has been called for due to the inconsistencies in cremation weights found by the research of Birkby (1991) and Bass and Jantz (2004), which Adam and Byrd (2008) suggest could be due to variations in equipment and procedure at crematoriums.

Some early archaeological reports indicate that pathology and trauma can be identified on burnt or cremated bones (Baby 1954). In his study of the Hopewell people, Baby (1954) found incidence of arthritis and healed fractures. He also noted inflicted sharp force trauma, or cutting, due to processing on the upper cervical vertebrae and in the knee joints indicating dismemberment of the bodies before cremation. Bond (1996) located butchery marks such as
chop marks and knife marks on cremated animal bones buried in an Anglo-Saxon cemetery including pig, sheep, and horse animal remains. However, these reports resulted in little description of the methods the analysts used for processing cremated remains, consequently resulting in hardly any duplication of the methods in future studies.

**Recent Cremation Studies in Forensic Science**

The methods discussed previously largely involved the study of cremations to better understand archaeological sites. However, federal acts like the Native American Graves Protection Repatriation Act (NAGPRA) have made studies of skeletal remains difficult and have limited the types of studies that can be done on archaeological collections. Consequently, cremation research of archaeological skeletal collections has decreased and there has been a movement toward understanding cremations that result from modern forensic cases. The early archaeological research on cremations serves as a foundation for the more recent forensic studies that have been leading to new methodologies for analyzing cremated remains. These recent studies have used faunal remains and cadavers as their subjects for testing, and present data concerning issues such as how bone color correlates with the temperature a bone was exposed to when burned. This correlation is an indicator of the amount of shrinkage that has occurred to the bones. These characteristics aid in gathering accurate age, sex, and stature information.

**Bone Shrinkage/ Bone Color**

Early research by van Vark (1970) and Ubelaker (1989a) suggested that bones can shrink up to 25 percent at temperatures of 700°C or higher. More recently, Byers (2002) also researched the correlation between fire temperature and bone shrinkage. He found that there was minimal to two percent bone shrinkage at temperatures less than 700°C. Bone shrinkage between one and two percent was almost always present between the temperatures of 700°C and 800°C. Finally,
temperatures ranging over 800°C caused bones to shrink between ten and 15 percent; however, a percentage of 25 percent has been recorded by Maples and Browning (1994), which is consistent with van Vark (1970). Thomas (2003) reports that long bones such as the femur and tibia can shrink up to one-quarter their size and ribs can shrink to small stubs.

These studies signify that bones burned at lower temperatures will undergo little to no shrinkage, meaning that the methods used in assessing age, sex, trauma, and pathology are still relatively accurate. Fairgrieve (2008) points out that bone color helps to indicate the varying stages of cremation, meaning that bone color can indicate the severity of a cremation, which in turn can signify the amount of shrinkage that has occurred. In the past, the changes in bone color during burning have been described as a progression in color from yellow to brown, to gray and black, and then to a bluish or white color (Ubelaker 1978; Shipman et al. 1984; McCutcheon 1992; Thomas 2003). Unfortunately, color can be seen differently by multiple observers. The description alone lacks a standardization of method for future analysts. Munsell soil charts have been used in previous studies to help describe the colors seen by the analyst (Shipman et al. 1984; McCutcheon 1992). Initially, Munsell color charts were used to describe the color of soil in different stratigraphic layers. There is some error involved in this method because Munsell color charts still rely on the observer’s eye; however, the charts create a way for future researchers and readers to understand the exact color to which the analyst was referring. McCutcheon (1992) burned two sets of artiodactyl (even-toed ungulate such as a deer or pig) bone and used a Munsell color chart to document the color of bone burned at varying temperatures. In order to explain the Munsell “measurements,” I will refer to the description by McCutcheon (1992:353):

“The Munsell measurements are defined as follows: (1) the hue notation of a color indicates its relation to red, yellow, green, blue, and purple; (2) the value notation indicates its
lightness; and the chroma notation indicates its strength (Munsell Color Company, Inc. 1954). In each Munsell measurement, the hue is noted first, followed by value and chroma [e.g., 10YR(hue) 7 (value)/2 (chroma), or 10YR 7/2]."

The results from his study concluded that unheated bone is pale yellow (2.5YR 8/4) to white (2.5Y 8/2) in color (McCutcheon 1992:354). At temperatures of 130 to 240°C the bone begins to turn pale brown (10YR 8/4) to reddish yellow (7.5YR 6/6) (McCutcheon 1992:354). The bone then goes from dark reddish brown (5YR 2.5/2) to black (5YR 2.5/1) to a very pale brown (10YR 7/3) when temperatures ranging from 240 to 340°C are reached (McCutcheon 1992:354). At 440°C a light brownish gray (10YR 6/2) color is exhibited and from 600°C on, the sole color was a neutral white (N 10/0) (McCutcheon 1992:354).

Unfortunately at 600°C when a bone becomes calcined the observer is unable to deduce exactly what temperature the bone reached with the naked eye. To explain, when a bone becomes calcined it appears white in color and this indicates that all organic material has been depleted by the fire, which happens around 600°C. At that point the bone will continue to stay white in color even if the temperature increases. Therefore, an analyst cannot determine with certainty the amount of shrinkage that occurred because after calcination a bone’s shrinkage rate ranges from 2-25 percent between the temperatures of 600°C and 800°C. Calcined bone is the most difficult burnt stage to analyze because of this wide range of shrinkage and because the bone has a tendency to both warp and crack. However, bones burned at any temperature below ~700°C can be analyzed with some degree of accuracy.

Determining Sex

Despite the difficulties caused by shrinkage Mayne Correia and Beattie (2002) feel that sexing a cremation is still possible. They feel the analyst should use the pelvis and skull, as both Stewart (1979) and Ubelaker (1989a) also suggest. It has been common practice for physical
anthropologists to use morphological characteristics of the skull and pelvis to estimate sex. Therefore, as in the examination of unburned bone, it is recommended that in analysis of burned bone the analyst should observe the size and shape of the mastoid process, the presence or absence of an occipital protuberance, the degree of sharpness of the supraorbital rim, the size of the brow ridges, the shape of the mandible, the sciatic notch in the pelvis, and measurements from the head of the humerus and femur (Mayne Correia and Beattie 2002). Males are generally found to be more robust than females. Therefore, pronounced cranial features such as the brow ridge or the occipital protuberance would be indicative of a male. Furthermore, men have a more pronounced nuchal crest due to their muscle attachment, while females do not exhibit a large protrusion on the occipital bone (Buikstra and Ubelaker 1994; after Acśadi and Nemeskéri 1970). The head of the femur can be measured and is a good indicator of sex. Stewart found that measurements for white female femur heads were less than 42.5mm while measurements for white males were over 47.5mm (Byars 2002). Bass similarly found that femur measurements for African American females were less than 40mm and African American males measured over 47mm (Byers 2002). Measurements taken from the humeral head by Stewart (1979) indicate that values below 43mm are likely female and measurements over 47 mm are likely male. It should also be noted that a measurement ~1mm greater than the average female humeral head measurement is still most likely a female. Likewise, a measurement that is ~1mm less than the average male femur head or humeral head measurement is still most likely male.

Wahl (2008) also argues that techniques used for sexing unburned skeletal remains are applicable to cremated individuals; however, the cranium and pelvis often do not survive cremations. Furthermore, Wahl (2008) maintains that because the slope of the frontal, the shape of the eye orbits, the greater sciatic notch, and the pubic angle can seldom be analyzed in
cremations, the supraorbital crest, mastoid process, occipital protuberance, and prearicular sulcus can be used more frequently. Another sexing method uses femur and humeral head measurements, as was demonstrated in a study by Warren and Maples’s (1997). Analysis of burned human remains produced femoral head measurements with an average of 44.2mm for males and 38.2mm for females; the humeral head averaged 45.8mm for males and 38.16mm for females (Warren and Maples 1997). In the examination of unburned bodies, Stewart (1979) found the femoral head measurement average to be 49.68mm for males and 43.84 for females and the humeral head averaged 48.76 mm for males and 42.67mm for females. The deviation between Warren and Maple’s (1997) and Stewart’s (1979) measurements could be a product of the degree of shrinkage that occurs when a bone is heated (Stewart 1979). Therefore, it is proposed that the measurements of humeral and femoral heads gathered by Stewart (1979) are more accurate when analyzing bones that are unburned or only slightly heated where little or no shrinkage has occurred. Consequently, bones that are burned should be compared to the humeral and femoral head measurements collected by Warren and Maples (1997) because they account for shrinkage. This will likely produce a more accurate assessment of sex because the analyst is making an allowance for shrinkage. Despite this argument, the deviation between the measurements of Stewart (1979) and Warren and Maple’s (1997) could be due to variation in the populations studied rather than heat-induced shrinkage.

Even though some methods have been developed concerning the sex of subadults, none have yet to produce reliable accuracy. The differences that can be seen in skeletal remains between males and females first occur during puberty. Therefore, it is best to not try to sex a prepubescent skeleton (Fairgrieve 2008).
Determining Age

Age is much harder to deduce in cremated remains because of the bone shrinkage and fragmentation that occurs. In general, in an unburned set of remains the younger the person, the more easily an age can be assessed. This is because subadults and children have more aging criteria because teeth are developing and erupting and bones are growing and their various epiphyseal parts are fusing. All these age criteria correlate to a specific age. The age of a fetus is best measured based on long bone length. In cremated bone, shrinkage occurs with bones of a fetus in the same manner that it does with adults. Fairgrieve (2008) calls for a conversion factor to be applied to the long bone measurements to account for the amount of shrinkage that has occurred. Specifically, he suggests taking the actual measurement and calculating the age, then recalculating the age based on bone shrinkage (Fairgrieve 2008:107). By combining the data from studies conducted by Huxley (1998) and Petersohn and Köhler (1965), Fairgrieve (2008:104) compiled a chart of data showing the differences in the average percent shrinkage of specific bones by lunar age group (Table 2.1). These percentages can be used as a conversion factor to calculate the age of the individual.

<table>
<thead>
<tr>
<th>Skeletal Element</th>
<th>4 LM</th>
<th>5 LM</th>
<th>6 LM</th>
<th>7 LM</th>
<th>8 LM</th>
<th>9 LM</th>
<th>10 LM</th>
<th>Newborn</th>
</tr>
</thead>
<tbody>
<tr>
<td>Humerus</td>
<td>9.13 (6)</td>
<td>5.39 (47)</td>
<td>3.37 (14)</td>
<td>2.24 (8)</td>
<td>1.45 (4)</td>
<td>1.68 (6)</td>
<td>1.75 (12)</td>
<td>2.03 (2)</td>
</tr>
<tr>
<td>Radius</td>
<td>9.73 (3)</td>
<td>5.79 (37)</td>
<td>4.30 (14)</td>
<td>2.24 (6)</td>
<td>2.41 (4)</td>
<td>1.90 (6)</td>
<td>1.70 (12)</td>
<td>0.39 (2)</td>
</tr>
<tr>
<td>Ulna</td>
<td>9.23 (3)</td>
<td>5.65 (31)</td>
<td>3.46 (9)</td>
<td>2.25 (7)</td>
<td>2.21 (4)</td>
<td>1.82 (5)</td>
<td>3.09 (11)</td>
<td>1.06 (2)</td>
</tr>
<tr>
<td>Femur</td>
<td>13.85 (6)</td>
<td>4.59 (44)</td>
<td>3.56 (14)</td>
<td>2.46 (8)</td>
<td>2.28 (4)</td>
<td>1.67 (6)</td>
<td>1.72 (10)</td>
<td>1.48 (1)</td>
</tr>
<tr>
<td>Tibia</td>
<td>12.35 (3)</td>
<td>5.82 (44)</td>
<td>3.44 (14)</td>
<td>2.51 (8)</td>
<td>2.93 (4)</td>
<td>1.94 (6)</td>
<td>1.69 (12)</td>
<td>1.19 (2)</td>
</tr>
<tr>
<td>Fibula</td>
<td>6.27 (1)</td>
<td>7.18 (16)</td>
<td>2.77 (7)</td>
<td>2.07 (3)</td>
<td>1.82 (4)</td>
<td>1.59 (6)</td>
<td>1.46 (10)</td>
<td>1.52 (2)</td>
</tr>
</tbody>
</table>

Table 2.1. Comparison of Shrinkage Rate (%) by Skeletal Element for Fetuses between 4-10 Lunar Months and Newborns with Sample Sizes in Parenthesis (from Table 7, Huxley 1998; reprinted by Fairgrieve 2008:106)

Color of the bone should be analyzed to assess the temperature at which the bone burned. This helps to indicate the amount of shrinkage that took place (Fairgrieve 2008). Warped bones
should not be used to age a fetus. According to Fairgrieve (2008), Fazekas and Kosa (1978) have the most extensive database for fetal bone size and age (both gestational and lunar), so the assessed measurements should be compared to their findings.

Subadults can be aged based on the measurement of complete long bones (Fairgrieve 2008; drawn from Petersohn Köhler 1965; Huxley 1998), tooth formations and dental eruption sequences (Ubelaker 1978: Fig 71; Bass 2005), and epiphyseal unions (Buikstra and Ubelaker 1994; after Krogman and İşcan 1986; McKern and Stewart 1957; Redfield 1970; Suchey et al. 1984; Ubelaker 1989a, 1989b). All of these methods of aging should be used to derive an estimate of age (Fairgrieve 2008).

According to Wahl (2008), one can use the same aging methods used for unburned skeletons when determining the age at death for cremated individuals. These methods include cranial suture closure (Buikstra and Ubelaker 1994; adapted from Mann et al. 1987; Baker 1984; Meindl and Lovejoy 1985; Todd and Lyon 1924, 1925a, 1925b, 1925c), fusion of the long bone epiphyses (Buikstra and Ubelaker 1994; after Krogman and İşcan 1986; McKern and Stewart 1957; Redfield 1970; Suchey et al. 1984; Ubelaker 1989a, 1989b), tooth eruption (Ubelaker 1978: Fig 71; Bass 2005), and wear patterns on teeth (Lovejoy 1985). In addition, Mayne Correia (1997), Mayne Correia and Beattie (2002), and Fairgrieve (2008) add the analysis of rib ends (İşcan et al. 1984a, 1985b, 1985; Bass 2005:136-141), osteophytic lipping, auricular and pubic symphysis patterning (Buikstra and Ubelaker 1994; drawn from Lovejoy et al. 1985; Meindl and Lovejoy 1989: 140, 165; Ubelaker 1989a:81; Bedford et al. 1989), and epiphyseal closures as aging methods applicable to cremated remains (Buikstra and Ubelaker 1994; Komar and Buikstra 2008; Suchey et al. 1986; Ubelaker 1978; Ubelaker 1989a, 1986b).
However, there is some debate over the use of ecto- and endocranial suture closure as an aging method (Mayne Correia 1997). Mayne Correia (1997) reports that some researchers (Buikstra and Goldstein 1973; Lisowski 1968) argue that suture closure is of limited use when determining the age of cremated individuals because crania will tend to fragment along the suture lines, except in older individuals whose cranium bones are fused. Naturally the effectiveness of these aging methods depends on the extent of bone burning. For example, tooth enamel begins to lose its structure around 300°C, but this change is not recognizable until around 700°C at which point it falls apart and dental wear is hard to assess. (Fairgrieve 2008; Shipman et al 1984). Consequently, teeth burned at lower temperatures can be analyzed more accurately than those that are burned at higher temperatures.

**Determining Stature**

Literature describing methods for determining the stature of burned individuals is lacking. Fairgrieve (2008) suggested Trotter’s (1970) humerus length regression formula to determine height. Trotter’s (1970) formula can be best explained in Fairgrieve’s (2008:115) model using a humerus for an example:

\[
\text{Stature} = 3.80 \times \text{Hum} + 70.45 \pm 4.05
\]

If we measure an unburned humerus to be 32 centimeters and utilize a 95 percent confidence interval, the formula would be as follows:

Low end of range = 3.80(32) + 70.45 – (4.05×2)  
= 183.95 centimeters = 6 feet 0.5 inches

High end of range = 3.80(32) + 70.45 + (4.05 × 2)  
= 200.15 centimeters = 6 feet 6.8 inches

This results in a range of 6.3 inches between the two estimates. However, if we were to now do the same calculation, but alter the original measurement of 32 centimeters by a factor of 10 percent due to shrinkage and warping in an extreme cremation scenario the measurement would be as follows:
32cm – (32 × 0.10) = 32cm – 3.2cm = 28.8cm

If we now substituted in this new cremation length value for the humerus, with everything else being equal the following result is yielded:

Low end of range = 3.80(28.8) + 70.45 – (4.05 × 2)
= 171.79 centimeters = 5 feet 7.7 inches

High end of range = 3.80(28.8) + 70.45 + (4.05 × 2)
= 187.99 centimeters = 6 feet 2 inches

The resulting range once again is 6.3 inches; however, the actual estimate in stature has shifted from a minimum possible height (at 95 percent confidence) of 6’0.5” to a low of 5’7.7”, a difference of 6.61 percent. In the case of the maximum possible stature, the shift was from a height of 6’6.8” to 6’2”, a difference of 6.08 percent."

Essentially by applying the humerus regression formula developed by Trotter (1970), the stature estimate for an individual whose bones were heated until there was a 10 percent shrinkage in bone length is six to seven percent shorter than the actual estimate if uncharred dry bones were used (Fairgrieve 2008). Hummel and Schutkowski (1989) found that compact bone shrinks by 5 percent at 1000°C; in addition, research by Buikstra and Swegle (1989) indicates a 10 percent long bone shrinkage rate at temperatures of 1000°C (Fairgrieve 2008). Furthermore, Grupe and Herrmann’s (1983) work done on compact bone, reported that spongy bone located on the articular ends of long bones can shrink up to 12 percent when exposed to heat (Fairgrieve 2008). Therefore, to obtain the actual stature of an individual that has been cremated, all of the following must be considered: the 5 percent shrinkage rate of compact bone, the 10 percent shrinkage rate of long bone shafts, and the 12 percent shrinkage rate of the articular ends. And, all must be factored into the calculation. This task would be almost impossible because the severity of bone shrinkage is dependent on the temperature. To reiterate, the higher the temperature the greater amount the bone can shrink. Fairgrieve (2008:116) asks if this goal to determine stature is necessary due the extreme variation in calculating a minimum and maximum
stature. To explain, the best way to estimate stature is to assume an extreme shrinkage rate of ten percent and to calculate a minimum stature and a maximum stature using the measurement of the cremated bone (Fairgrieve 2008). In the example explained above using the humerus, this formula yielded a minimum stature of 5’7.7” for burned remains and a maximum stature of 6’6.8” for unburned remains which gives a range of 11.1 inches for the same individual. The reason these statures vary so greatly is because the minimum stature accounts for the a ten percent shrinkage rate caused by the burning of bone, whereas the maximum stature assumes the bone is unburned meaning no shrinkage occurred. This is a huge range and would hardly be discriminating enough to solely use this method to identify a person in forensic work. However, it can be used as a guide to search missing persons files (Fairgrieve 2008). In addition, any estimated stature information is useful when dealing with the remains of prehistoric individuals. Therefore, estimating the stature of cremated prehistoric individuals by assuming a ten percent shrinkage rate, as suggested by Trotter (1970), is more useful for the field of anthropology than not attempting to determine stature.

*Heat Induced Fractures*

Determining antemortem trauma from heat induced fractures (HIFs) requires a good knowledge of fracture patterns. Piekarski (1970) conducted extensive work on fracture patterns. Fairgrieve (2008) referenced Piekarski’s (1970) findings in explaining the fracture patterns on bone resulting from both inflicted trauma and heat. To begin, bone microstructure plays an important role in how a bone withstands stress. Blood vessels, lacunae, and canaliculi can all play a role in alleviating stress within the bone, and can affect the ways in which a bone cracks (Figure 2.1). For instance, a crack that intersects a lacuna, which is a space within which an osteocyte resides, will be slowed down because much of the force will be absorbed by that
lacunae (Fairgrieve 2008:120). In addition a fracture should travel between the concentric lamellae of an osteon because of the weakness of the structure in those areas. According to Fairgrieve (2008:120), “blood vessels are surrounded by concentric lamellae and, as such, the stress of a crack propagating is oriented in the direction of the long axis of the cylindrically oriented osteons.” The energy behind the propagation of the crack determines the length and severity of the crack. Therefore, cracks resulting from high energy, such as blunt force trauma, would spread through all microstructures and not be “channeled along the interface of lamellae or alter their direction upon passing through a lacuna” (Fairgrieve 2008:120).

![Cross Section of Bone Shaft](http://boneandspine.com/wpcontent/uploads/2009/09/osteon.jpg)


At lower temperatures, a heat induced fracture tends to travel along the sites of the weakest interfaces between the microstructures (Fairgrieve 2008). Like Piekarski (1970), Herrmann and Bennett (1999) examined fractures and determined that exposure to intense heat causes bone to fracture in patterns similar to those resulting from high energy forces (Fairgrieve 2008).
From this, Fairgrieve (2008:122) concludes “cremated bone does not have the same energy absorbing forces as uncremated bone.” Alteration of the microstructures due to the heat could account for this behavior of the bone. As a result, it is difficult to distinguish heat induced fractures from traumatic injury based on fracture patterns alone.

Herrmann and Bennett (1999) discovered that heat-induced fractures appear to have very smooth surfaces, with cleanly sectioned vascular canals, when compared to both burned and fresh traumatic fractures when analyzed under transmitted light (Fairgrieve 2008:122). Despite evidence suggesting a clear way to differentiate the types of fractures, Herrmann and Bennett (1999) state that a bone heated while still intact may fracture from a buildup of medullary fluid which would result in a slow propagating fracture. The fracture would, therefore, appear to be of traumatic origin rather than from a heat induced fracture (Fairgrieve 2008:124). To summarize, the clearly defined heat induced fractures are fast propagating fractures that “appear smooth under transmitted light” and have “cleanly sectioned vascular canals,” whereas slow propagating fractures result in rougher edges that have a similar appearance at the site of the crack, making them much harder to distinguish from a traumatic injury (Fairgrieve 2008:122).

Recent research by Symes et al. (2008) has focused on describing patterned thermal destruction. The purpose of this publication was to stress the need for systematic methods for studying burned remains and to discuss data from previous studies. In their discussion, Symes et al. (2008) suggested three things which must be understood by an analyst in order to accurately analyze burned bones. The first involves body position and body tissue that shields the bone (Symes et al 2008:50). Secondly, the color change in thermally altered bone and lastly the fracture mechanics of burned bone should be understood (Symes et al 2008:50).
Exposure to heat causes the muscles in the body to contract, and the body curls into a pugilistic position. Where muscle and ligament contraction causes the limbs to curl and pull in toward the body because all humans have the same basic body structure, burn victims will exhibit this pugilistic position. Therefore, Symes et al. (2008:30) argue that burn patterns on bone should be relatively predictable. This predictability is dependent on the fact that the curled position a burning body assumes protects certain portions of the body from the fire. Based on this information Symes et al. (2008:32-33) created an anterior and posterior chart color coding the initial, secondary, and final areas to illustrate burning on bone. This chart also provides lines showing common fracture areas (Appendix A).

As discussed previously, bone color does help determine the degree of heat to which a bone was exposed. Consequently, this indicates the amount of bone shrinkage that occurs. Symes et al. (2008) say that bone color also provides information on the thermal destruction and burn pattern of the bone. Variation of tissue depths, protection of the proximal and distal ends of bones by joint structures, and shielding due to the body’s position causes most bones to burn unevenly. Symes et al. (2008:35) point out that in the past it has been suggested that various colors on a single bone “are of little use for diagnosing fire dynamics” (Mayne Correia 1997: 276-277). However, it is argued that because “bones burn from the outside to the inside (before the shaft is compromised), with the lighter calcined bone being external and the black charred (protected) bone internal” these variations in color pattern only further indicate the exact thermal pattern in which the body burned (Symes et al. 2008:35).

Over the years, numerous anthropologists have studied the various types of thermal fractures which are now known as heat induced fractures or HIFs. Heat induced fractures must be understood in order to distinguish between inflicted trauma and trauma caused by the heating
of bone. Over the years several different classifications have been suggested for these HIFs (Krogman 1939, 1943a, 1943b; Baby 1954; Binford 1963; Mayne 1990; Symes et al. 1996). Based on these studies, Symes et al. (2008: 42-43) compiled a comprehensive list of these classifications and grouped the types of heat induced fractures into seven different categories (Table 2.2). In order to show examples of each heat induced fracture as described in the chart compiled by Symes et al. (2008), examples of each HIF found in his study was illustrated by David Reimer (Figures 2.2-2.5, 2.7). In each illustration, the heat induced fracture described in the caption is indicated by a red arrow. Since transverse fractures are described by Symes et al. (2008) as making up step fractures, there is not a separate illustration for the transverse fracture. An example of the burn line fracture was not present in the sample used for this study; therefore, an illustration found in Symes et al. (2008:36) will be used to illustrate this fracture type (Figure 2.6).

In order to understand heat induced fracture of the teeth, the basic structure of a tooth must be understood. Teeth are considered the most indestructible things in the human body because they are made up of three strong materials, enamel, dentine, and cementum. The enamel surrounds the crown of the tooth. Beneath the enamel is the dentine, and it surrounds the pulp cavity. The cementum is much like the enamel, but it is found on the root of the tooth instead of the crown. The dental pulp is of particular interest in cremation cases. In forensic cases, where DNA evidence is gathered, samples of the pulp can be taken to help identify an individual using both nuclear and mitochondrial DNA (Fairgrieve 2008). The pulp cavity is protected not only by the tooth’s structure, but also by the bone of the mandible and maxilla, which often will preserve the pulp cavity. Specifically, the molars are considered to be the most insulated teeth in the body (Fairgrieve 2008).
<table>
<thead>
<tr>
<th>Fracture Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Longitudinal</td>
<td>Longitudinal fractures in long bones are probably the most common of major burn fractures, occurring regularly and predictably. As a shaft heats to the point of evaporation and protein denaturalizes, the bone matrix shrinks, facilitating the structural failure. These longitudinal failures appear to originate in similar locations, commonly following the grain of bone, parallel to the osteon canals, although the longitudinal fractures can take a somewhat helical path down the long axis of the bone.</td>
</tr>
<tr>
<td>Step</td>
<td>These fractures are often associated with longitudinal fractures. A step fracture will extend from the margin of the longitudinal fracture transversely across the bone shaft, through the compact bone, fracturing the bone shaft at the intersection of another longitudinal fracture.</td>
</tr>
<tr>
<td>Transverse</td>
<td>Transverse fractures differ from longitudinal fractures in that they transect haversion canals. Transverse fractures are also common, since fire consumes most long bones transversely as it progresses up the shaft. Increasing tissue thickness and pugilistic posture can hamper this progression on one side, while the exposed side consumes at a faster pace. These are very similar to or make up step fractures.</td>
</tr>
<tr>
<td>Patina</td>
<td>These superficial fractures, seemingly less destructive than other fracture types, appear as a fine mesh of uniformly patterned cracks similar to those seen in old china or an aged painting (Krogman 1943a, 1943b). This pattern is somewhat difficult to interpret but is often observed on flat areas of postcranial bones, and may be the result of a broad area receiving uniform amounts of heat, compelling superficial cortical bone to shrink evenly over the surface. Others have suggested that patina patterns are due to the incineration of thin protective soft tissues. These are probably related ideas. Patina also appears on epiphyseal ends and cranial bones.</td>
</tr>
<tr>
<td>Splintering and Delamination</td>
<td>These fractures are characterized by the splitting away of cortical bone layers from cancellous bone, the separation of the inner and outer tables of cranial bone, or the exposure of cancellous bone on epiphyses.</td>
</tr>
<tr>
<td>Burn Line Fracture</td>
<td>These fractures follow the burn borderline, seen clearly in reconstructions; it separates burned and unburned bone.</td>
</tr>
<tr>
<td>Curved Transverse Fractures</td>
<td>The classic curved transverse fracture is a result of bone heating, then cracking as protective soft tissues and periosteum shrink, pulling the brittle surface of the thermally altered bone (thus also called 'muscle shrinkage lines'). A less common manifestation of curved transverse fractures may also form as 'concentric rings.' Concentric rings typically occur in fossae or areas of concentrated tissues, such as the popliteal region of the femur. They are a consequence of bone cortical thickness, shape, articulation, and soft tissue obstruction, but are not necessarily the byproduct of elastic muscle fibers shrinking. The curved transverse fracture also commonly results in 'coning,' where the fractured diaphysis appears arched at the fracture margin.</td>
</tr>
</tbody>
</table>

Table 2.2. Types and Descriptions of Heat Induced Fractures (from Symes et al. 2008: 42-43)
Figure 2.2. Longitudinal Fracture. The red arrow points to the longitudinal fracture. Refer to Table 2.2 for a text description of this type of fracture. Illustrated by David Reimer from a photo taken during this thesis.

Figure 2.3. Step Fracture. The red arrow points to the direction of the fracture. As seen from the text description in Table 2.2, a step fracture intersects two longitudinal fractures. Illustrated by David Reimer from a photo taken during this thesis.
Figure 2.4. Patina Fracture. The red arrow indicates the region of the bone having a patina fracture. Refer to Table 2.2 for a text description of this fracture type. Illustrated by David Reimer from a photo taken during this thesis.
Figure 2.5. Delamination fracture: The red arrows point out the two separate layers of cranial bone that peeled apart as a result of heat exposure. For a text description of this type of fracture refer to Table 2.2. Illustrated by David Reimer from a photo taken during this thesis.
Figure 2.6. Burn Line Fracture: For a text description of this type of fracture refer to Table 2.2. Due to the lack of an example of this type of fracture in this study, this picture was taken from Symes et al. (2008:36, plate 4).
Figure 2.7. Curved Transverse Fracture: This red arrow points to the curved transverse fracture. This type of fracture is formed when the body is burned in flesh causing muscle contractions which cause this fracture pattern. For a text description of this fracture type refer to Table 2.2. Illustrated by David Reimer from a photo taken during this thesis.
Even with this protection, high temperature can disrupt the enamel and cause it to crack away from the dentine. According to a study done by Harsányi (1976), tooth enamel will begin to change in color around 200°C, begin to break apart around 700°C, and by 900°C the tooth enamel will break in smaller pieces and continue to crack into small fragments (Fairgrieve 2008:147). A study conducted by Beach et al. (2008) experimented on heated teeth in order to document the changes at various temperatures of both the enamel and dentin on teeth in intervals of thirty minutes and an hour. Their research found that the dentin seems to be less susceptible to heat than enamel, and even teeth exposed to extreme temperatures were often still seen to have an intact root structure (Beach et al. 2008:142). Furthermore, enamel begins to break apart as early as half an hour into heating (204°C) making color change difficult to detect. Therefore, based on their research results (included here as Table 2.3-2.4), Beach et al. (2008:142) concluded that the tooth root is much more stable and tends to only exhibit one color change at a time, making the root the most reliable area of the tooth to collect data.

This information is important because, as mentioned previously, preservation of the tooth root may allow for extraction of DNA to help identify individuals. Williams et al. (2004) first pioneered the extraction of DNA from burned teeth to determine the sex of individuals (Fairgrieve 2008:178). They found that DNA could still be extracted and profiled from deciduous teeth subjected to temperatures up to 400°C. Duffy et al. (1991) also conducted research on pig heads and found that teeth burned in fleshted jaws at temperatures of 300°C for over an hour still had intact cellular nuclei which would allow for DNA extraction. (Fairgrieve 2008:178).
<table>
<thead>
<tr>
<th>Temperature, °C (°F)</th>
<th>Enamel</th>
<th>Dentin</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Munsell value</td>
<td>Feature</td>
</tr>
<tr>
<td>200 (400)</td>
<td>No change</td>
<td>CEJ flaking</td>
</tr>
<tr>
<td>260 (500)</td>
<td>10 yr 8/2</td>
<td>CEJ flaking</td>
</tr>
<tr>
<td>316 (600)</td>
<td>10 yr 8/2</td>
<td>CEJ flaking</td>
</tr>
<tr>
<td>371 (700)</td>
<td>10 yr 3/2</td>
<td>Enamel gloss Patina</td>
</tr>
<tr>
<td>427 (800)</td>
<td>10 yr 3/2</td>
<td>Separation of crown Extreme CEJ flaking Patina</td>
</tr>
<tr>
<td>482 (900)</td>
<td>10 yr 3/2</td>
<td>Crown Separation Extreme CEJ flaking Patina</td>
</tr>
<tr>
<td>538 (1000)</td>
<td>Multiple colors</td>
<td>Enamel Disintegration</td>
</tr>
<tr>
<td>593 (1100)</td>
<td>Multiple colors</td>
<td>Enamel Disintegration</td>
</tr>
</tbody>
</table>

Table 2.3: Enamel Dentin Color and Features at 30 min (from Beach et al. 2008:142). The heading Feature refers to the heat alterations and CEJ refers to the cementoenamel junction.

<table>
<thead>
<tr>
<th>Temperature, °C (°F)</th>
<th>Enamel</th>
<th>Dentin</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Munsell value</td>
<td>Feature</td>
</tr>
<tr>
<td>204 (400)</td>
<td>No change</td>
<td>CEJ flaking</td>
</tr>
<tr>
<td>260 (500)</td>
<td>10 yr 8/2</td>
<td>CEJ flaking</td>
</tr>
<tr>
<td>316 (600)</td>
<td>10 yr 8/2</td>
<td>CEJ flaking</td>
</tr>
<tr>
<td>371 (700)</td>
<td>10 yr 3/2</td>
<td>Enamel gloss Patina</td>
</tr>
<tr>
<td>427 (800)</td>
<td>10 yr 3/2</td>
<td>Separation of crown Patina</td>
</tr>
<tr>
<td>482 (900)</td>
<td>5 y 7/1</td>
<td>Extreme enamel degradation</td>
</tr>
<tr>
<td>538 (1000)</td>
<td>Multiple colors</td>
<td>Enamel disintegration</td>
</tr>
<tr>
<td>593 (1100)</td>
<td>Multiple colors</td>
<td>Enamel disintegration</td>
</tr>
</tbody>
</table>

Table 2.4: Enamel Dentin Color and Features at 60 min (from Beach et al. 2008:143). The heading Feature refers to the heat alterations and CEJ refers to the cementoenamel junction.
Byers’s (2002) text for forensic anthropologists provides a detailed description of how to
discern trauma in cremated remains. Byers (2002:274) defines trauma as “an injury caused to
living tissue by an outside force.” Different types of inflicted trauma that can be detected on
cremated skeletal remains include blunt force trauma, sharp force trauma, and projectile trauma.
Each of these inflicted traumas has its own characteristic features.

Trauma either occurs prior to death (antemortem), at death (perimortem), or after death
(postmortem). Antemortem trauma can be identified by the presence of bone healing with
evidence of bony calluses and rounded edges of the bone at the trauma site due to the remodeling
of the tissue during bone repair. Perimortem trauma, like postmortem trauma, can be identified
by the lack of healing characteristics that are seen in antemortem trauma (Byers 2002:290).

Perimortem trauma can be distinguished from antemortem and postmortem trauma by
several characteristics according to Byers (2002). A sharp v-shaped edge at the trauma site with
no rounding at the wound’s edge on the bone is indicative of perimortem trauma. The fact that no
rounding occurs at the edge of the depression is important because rounded edges are
characteristic of a natural depression supporting a blood vessel, rather than a traumatic cut mark.
“Hinging” is another characteristic of perimortem trauma. The term “hinging” refers to a bone
that is not completely broken into two pieces, but rather having one portion still connected to the
remaining bone such that they could bend back and forth like a hinge (Byers 2002:290-291). In
addition, fracture lines also indicate perimortem trauma. Trauma that takes place postmortem
usually does not exhibit fracture lines. A postmortem break usually snaps the bone into two or
more pieces, instead of the “hinging” as seen in a perimortem break. The broken end of the bone
in a postmortem break is flat and not jagged as in the case of perimortem break (Byers 2002:291).

Trauma

Blunt force trauma varies depending on the weapon used and the specific bone which is struck (Tomczak and Buikstra 1999). Berryman and Symes (1998:340) reference Mortiz (1954:344) in identifying four distinguishing characteristics of blunt force trauma on the skull, including “inbending of the skull with a fracture advancing from the inner table to outer table, a crushing of the outer table and diploe with no inner table fracture, an inbending of the outer table, and a shattering of the inner table and diploe.” Long bones struck by blunt force trauma usually exhibit simple fractures with no radiating fracture lines. The long bones are usually broken into two separate pieces because of the type of force applied to the bone by the blunt trauma (Byers 2002).

Sharp force trauma can be caused by weapons such as knives, axes, and hatchets. Byers (2002) defines the three different categories of sharp force trauma that can occur on bone: punctures, incisions, and clefts. Punctures are seen on bones that have been hit vertically by the weapon and produce a cone shaped wound. A slashing motion of a weapon that has a long sharp blade usually causes incisions which are identifiable because of their “V” shaped appearance. Pressing putty into the incision will create a mold of the defined “V” shape which aids in the positive identification of such traumas. Finally, a weapon that also has a long sharp blade and is forced upon the bone in a vertical motion causes clefts (Byers 2002). The presence of striations on the bone and “wasteage” of the bone are two features that are usually unique to sharp force trauma (Byers 2002). Striations associated with sharp force trauma appear as a series of lines on the bones and occur when a weapon is used that has a dull or serrated edge (Tucker et al. 2001).
Wasteage is defined as pieces of the bone that are separated from the primary bone after sharp force trauma has occurred (Byers 2002:339).

Mayne (1990) and McKinley (1993) both argue that “knife wounds retain their characteristic, “V” shaped, appearance when exposed to fire” (de Gruchy and Rogers 2002:933). Using these studies as a foundation, de Gruchy and Rogers (2002) experimented with the effects of heat on chopped bone. The experiment was conducted using pig forelimbs and beef ribs which were hacked with a cleaver. Both the cleaver’s edge and the tip were used to impact the bone. After burning the bone, evidence of chop marks were still seen on the pig forelimbs. The beef ribs for the most part burned in the fire, and yielded no results. From this study, it was concluded that bone knife wounds and chop marks do retain their characteristics on cremated remains (de Gruchy and Rogers 2002).

Pope and Smith (2004) conducted research in order to determine if traumatic head injuries could be detected on the skulls of cremated individuals. They applied ballistic, blunt force, and sharp force trauma to donated human crania, and then burned them under conditions simulating forensic fire (Pope and Smith 2004:432). From this experiment, Pope and Smith (2004:439) reported that heads do not explode when heated and that distinct characteristics of ballistic, blunt, and sharp force trauma do survive the effects of fire making them recognizable to the analyst. Subsequent information compiled by Pope and Smith (2004) informs us about the changes to bone induced by the heat, and the signature of trauma exhibited on bone upon completion of burning (Table 2.5). Recognition of these distinct trauma types often requires reconstruction of the cranium. Therefore, Pope and Smith (2004:439) found, despite the survivability of trauma evidence on burned bone, that the degree of the fire, the extinguishing of
<table>
<thead>
<tr>
<th>Number</th>
<th>Treatment</th>
<th>Heat-related Changes During Burning</th>
<th>Signature of Trauma Type in Burned Cranial Bone</th>
</tr>
</thead>
<tbody>
<tr>
<td>16</td>
<td>Ballistic</td>
<td>Wounds retract and shrink focally to expose bone. Exposed injuries undergo advanced thermal destruction. Open injuries accelerate color changes to bone.</td>
<td>Internal or external beveling from penetration. Secondary radiating or concentric fracture from impact. Organic carbonized venting of wounds or linear fractures. Juxtaposition of color in adjacent fragments. Radiating fracture into green bone. Extremely deformed, ragged, or eroded fracture margins. Lead wipe or pellets embedded in bone upon X-ray.</td>
</tr>
<tr>
<td>6</td>
<td>Sharp</td>
<td>Heat causes margins of soft tissue injury to bulge; this is different than heat-related skin splitting. Incisions retract and shrink focally to expose bone. Exposed injuries can undergo advanced thermal destruction. Open injuries accelerate color changes to bone.</td>
<td>Linear incisions, depressions, cuts, chops, tool marks, partial saw marks, complete saw marks, punctures, stabs, hacks, and drill marks, etc. Features of perimortem tool marks cannot be replication in or mistaken for stay postmortem marks in dry calcined bone.</td>
</tr>
<tr>
<td>10</td>
<td>Control</td>
<td>Heat creates color changes, blistering, and skin splintering. Elastic skin exposes bone earliest in thinnest areas. Skin, fat, and muscle burn according to thickness. Bone changes colors according to exposure to heat.</td>
<td>Heat creates delamination, well-defined heat fractures, fragmentation, embrittlement, and color changes. &quot;Exploded appearance&quot; is created by heat fragmentation, fallen debris, extinguishment, movement, and recovery.</td>
</tr>
</tbody>
</table>

Table 2.5: Summary of Differential Heat Effects for Cadaver Heads With, and Without, Traumatic Injuries (from Pope and Smith 2004:437; reprinted by Fairgrieve 2008:123). The heading Number refers to the sample size tested for each variable.
the fire, the collapse of debris, and the incomplete recovery of the remains greatly diminishes the chances of locating trauma on burned bone.

Pathology

Methods for describing pathologies on cremated remains are necessary in order better understand the health of the cremated individuals, which further may suggest a reason why a culture sometimes used cremation as a burial practice. This importance can best be captured in the words of English paleopathologist Calvin Wells (1980) cited in Holck (1997:186):

“It cannot be too often or too strongly emphasized that the pathology of a group of people is never randomly produced. It reflects, sometimes very closely, the environment in which they live, the geographical and climatic influences which bear on them, the behavior in the environment, their patterns of dress, houses, tools, weapons, and much else. This being so, the study of the accidents and diseases which afflict a people can reveal more about their living circumstances than any evidence except the most detailed written description based on direct observation. It is this intimate relationship between pathology and patterns of living which makes that study of ancient disease both imperative and rewarding.”

Holck’s (1997) work on cremations at the Museum of Antiquities at the University of Oslo provided much evidence that pathological conditions can be found in cremated remains (Table 2.6). Due to the variation in burn patterns, specific locations that diseases attack bone, and the improved preservation of cremated remains (due to lack of the decaying process), pathologies can be seen on burned bone. To explain, bone density and the location of each bone in the body play a vital role in the probability of each bone’s survival during a fire. Thinner, flatter, and more delicate bones such as ribs and facial bones are often destroyed. However, those dense bones such as vertebrae (with the exception of cervical), limb joints, and bones of the cranial vault do survive longer when burned. Therefore, pathologies and traumas that are found in these areas should be able to be observed. Cremated remains do survive decay better than green or fleshed bones, because the organic components have been burned away, protecting them from animals and bacteria that thrive on organic remains.
<table>
<thead>
<tr>
<th>Observed Changes on Bone Surface</th>
<th>Potential Causes</th>
</tr>
</thead>
</table>
| Inflammation and infectious changes | Unspecific osteitis and periostitis  
|                                 | Osteomyelitis  
|                                 | Tuberculosis  
|                                 | Leprosy  
|                                 | Echinococcosis |
| Changes in joints and vertebral column | Degenerative arthritis  
|                                     | Rheumatoid arthritis  
|                                     | Gouty arthritis  
|                                     | Scheuermann's disease |
| Metabolic disorders | Osteoporosis  
|                      | Rickets, osteomalacia |
| Dysplasias | Hip dislocations  
|           | Spina bifida  
|           | Sacral lumbar vertebrae  
|           | Cleft palate  
|           | Abnormal sutures  
|           | Chondrodystrophia  
|           | Dysostosis cleidocranialis |
| Malformations | Scoliosis  
|               | Posttraumatic deformities |
| Changes associated with blood disorders | Cribria Orbitalia  
|                                      | Cribra cranii  
|                                      | Myelomatous destructions |
| Endocrine disturbances | Hyperpituitarism (Acromegaly, Gigantism)  
|                           | Hypopituitarism (Nanism)  
|                           | Cretinism |
| Tumors | Primary tumors (benign, malignant)  
|        | Secondary tumors |
| Diseases of teeth and jaws | Caries  
|                           | Periodontal disease  
|                           | Cysts, abscesses  
|                           | Dental anomalies |
| Other changes | Vascular impressions  
|                | Costal grooves  
|                | Paget's disease  
|                | Other forms of hyperostosis |
| Traumatic changes | Fractures  
|                  | Piere or cut injuries  
|                  | Crush injuries  
|                  | Others |

Table 2.6: Observable Diseases on Cremated Bone (from Holck 1997:187-188)
Linear enamel hypoplasias in teeth, as well as Harris lines in long bones are known indicators of health in unburned remains. Both of these occurrences result from metabolic insult at one or more points during childhood and/or adolescence and can be the result of weaning or nutritional deficiency. Both conditions are evident when using radiology techniques (Holck 1997:202). Linear enamel hypoplasia’s (LEHs) are indicative of complete growth discontinuities, but are evident only in tooth enamel both macroscopically and microscopically. However, the intense heat of the cremation process often causes the enamel to pop off the tooth, resulting in the loss of linear enamel hypoplasia data making LEH’s a rare find in cremated remains (Holck 1997).

Harris lines are striations or “disc shaped densities in spongy bone tissue that are found in transverse sections of bone” (Holck 1997:202). Holck’s study (1997) found that Harris lines are not destroyed by fire as readily as LEH’s. By taking X-rays of both unburned and burned bones, Holck (1997) was able to show that Harris lines can be seen not only in unburned skeletal remains, but in cremated remains as well.

In summary, there are a variety of different methods that can be employed to analyze cremated bone. It is true that at one time literature was lacking concerning the description and techniques needed to carry out such analysis. Recent literature has provided new methods of analysis and information concerning cremated remains. However, a good deal of this information is being ignored and not used. Therefore, it is proposed that trauma and pathologies have been overlooked on cremated prehistoric skeletal remains from the archaeological record.
CHAPTER 3

METHODOLOGY

Sample Selection

All skeletal remains that were examined in this study are housed in the Laboratory for Human Osteology at the University of Alabama. Lab notes from Charles Snow’s inventory from the late 1930s and early 1940s and analysts’ notes from the Tennessee Valley Authority skeletal material housed at the University of Alabama were examined to locate previously identified cremated remains. In addition, cremations analyzed during Native American Graves Protection Repatriation Act (NAGPRA) inventories and mentioned in other researchers’ notes also were examined for this study. The sample size (N=46) includes all cremations that could be located in the osteological collection of the University of Alabama. While there may be more cremations housed in this collection, the ones selected for this study are the ones that are known about at this time. These burials are compiled from nine different sites, including Little Bear Creek (1Ct8), Mulberry Creek (1Ct27), Perry Site (1Lu25), Bluff Creek (1Lu59), Long Branch (1Lu67), Whitesburg Bridge (1Ma10), Flint River (1Ma48), McKee Island (1Ms32), and Hunter Station (1Mt99). The quantities of cremated remains vary across the nine archaeological sites. For a listing of each burial number analyzed and excavation and cultural information present on the original burial forms see Appendix B.

Documentation

The data for this study were gathered on two different types of forms, a data collection form and a pictorial skeletal form. The data form is the Alabama Museum of Natural History
Skeletal Inventory, and was used to gather all written data collected about each cremated individual. More specifically, this form includes an inventory of the bones present, the estimated age, sex, and stature (if possible) and any traumas or pathologies noted on the remains. Any burial photographs or drawings that were present were noted on the data form. All analysis of the skeletal remains was in accordance with the NAGPRA guidelines established by the museum. There were no invasive examinations where bone and teeth were destroyed. The skeletal form consists of a single sheet containing a picture of a complete skeleton taken from Buikstra and Ubelaker (1994: Chapter 2 attachment 3a). In order to detect patterns of localized burning due to accident or ritual activity, the pieces of bone found in this study were colored in on the pictoral skeleton. Colored pencils, ranging from light grey, to black, to white, were used in order to demonstrate the severity of the burns on each bone. If burn patterns exist within a group of people from a site, a comparison of the illustrations made these patterns more evident.

Skeletal Examination

Each cremated individual was examined to determine their age and sex. After reviewing the accuracy associated with the methods used in previous studies, several means of analysis were utilized. In addition to determining age and sex, each skeleton was inspected for the presence of pathological conditions and traumatic injury. Lastly, each skeleton was inspected to determine if the bones are green (fleshed) or dry (without flesh) when burned. In order to properly understand the data gathered from each skeleton, bone color and body position (when possible) was recorded.

To determine the age of adults several methods were utilized. These included dental wear (Lovejoy 1985), dental eruption (Ubelaker 1978: Fig 4-21; Bass 2005:301-302) fusion of the long bone epiphyses (Buikstra and Ubelaker 1994; after Krogman and İşcan 1986; McKern and

For this study, individuals were divided into four age groups (when possible): child (birth-11 years), juvenile (12-20 years), young adult (21-35 years), and old adults (36 +years) (after Buikstra and Ubelaker 1994). For statistical purposes this category was regrouped into adolescent (birth-20 years) and adults (20+ years), because bone size and epiphyseal fusion can distinguish between an adult and adolescent individual, but when burned, they sometimes are not complete enough to determine a numerical age.

Sexing techniques were only attempted on adult skeletal remains due to the inaccuracies involved with sexing prepubescent individuals. Due to the fragmentary nature of cremated remains, the skull (nuchal area, mastoid process, supraorbital ridge, and supraorbital margin) (Buikstra and Ubelaker 1994; Meindl and Lovejoy 1985) and head of the humerus, femur, and scapula were utilized to determine sex (Bass 2005).

Evidence of pathology and trauma was determined by visual examination only. No invasive or destructive techniques or radiographic images were taken. Descriptions of these
pathological conditions and evidence of trauma were recorded on the data form, but for the purpose of this study these variables were noted as either “1” present or “2” absent. Experimentation by Mayne (1990), McKinley (1993), Holck (1997), Pope and Smith (2004), and de Gruchy and Rogers (2002:933) proves that visual examination is an accurate method to detect trauma and pathology on cremated human remains.

Bone color was noted for each cremated individual for three main reasons: to determine the amount of bone shrinkage that may have occurred, to estimate the temperature of the fire, and to understand the burn pattern. The criteria used to document this data were the temperature that a bone burns and bone shrinkage. The temperature at which the bone burned was categorized as (1) 130-240°C, (2) 240-340°C, (3) 440°C or (4) 600°C (after McCutcheon 1992). The bone shrinkage was extrapolated based on the bone color. All bones that are not calcined were exposed to temperature less than 600°C, so (1) 1-2 percent shrinkage has occurred; likewise all calcined bones reached temperature of 600°C and were categorized as (2) 10-25 percent shrinkage (van Vark 1970, Ubelaker 1989a, Maples and Browning 1994, Byers 2002). In actuality, Byers (2002) found that bones heated to 800°C shrink up to 10-15 percent, but calcination occurs at 600°C because there is no visual difference between bone heated to 600°C and 800°C these bones were placed in the same category because extensive shrinkage may have occurred. The position the body was buried was noted in order to compare with the burn pattern. The burial position was categorized as (1) fully flexed or (2) not documented. As mentioned previously, body position and tissue shielding determines the manner in which a body is destroyed by fire (Symes et al. 2008).

To test the hypothesis that if bone color correlates to bone temperature, then bones burned at lower temperatures will show signs of trauma and pathology more frequently than
those burned at higher temperatures, a comparison of three variables were performed. The bone shrinkage variable divides the bones into two categories: (1) 1-2 percent bone shrinkage rates, which includes bones burned at lower temperatures (non-calcined); and (2) 10-25 percent bone shrinkage rates which includes only bones that are calcined. Each category was compared to the trauma and pathology variables to determine how many cases of trauma and pathology are noted for both calcined and non-calcined remains.

Lastly, certain additional aspects of each burial were recorded in order to provide descriptive information for intrasite patterns and patterns among cremations from all sites. These specific categories were added to the study to better understand the cremation as a burial custom as well as the way in which the custom was carried out. Each of these categories are all listed as present, coded as “1,” or absent, coded as “2”. These categories were broken down into two groups that make up a total of nine variables. The first group of variables concerns the treatment of the individual’s body and includes: only the cranium burned, only the cranium present, fire hottest on face, right side of body burned more severely, left side of body burned more severely, localized burning on body excluding the cranium, burned in flesh, and burial position. These mortuary variables are designed to help indicate customs involved with mortuary ritual surrounding cremations, such as fire placement and orientation of the body in the grave. The last category, burned in flesh, denotes the individuals that were burned in flesh as opposed to those skeletons that were burned without flesh or dry. The last variable is concerned with other items that were found in the graves of the cremated individuals: (1) burial artifacts. The burial forms that were originally filled out in the late 1930s and 1940s were reviewed for each skeleton and the presence or absence of burial artifacts will be recorded based on the reports of the original excavators.
For the site comparisons, the data from each of the categories were compared between four of the nine sites that were analyzed. Because five of the sites contain only one or two cremations, only four of the nine sites are used for the site comparison. The small sample numbers of cremated individuals from the five unused sites would provide skewed data concerning burial customs and practices at those sites. The four sites whose site cremation data will be analyzed and reported include: Little Bear Creek (n=11), Mulberry Creek (n=9), the Perry Site (n=12), and Bluff Creek (n=6).

**Statistical Analysis**

All data were entered into the software program Statistical Package for the Social Sciences 17.0 (SPSS). Each skeleton was assigned a unique identifying number and entered with its site number, skeletal number, age, and sex. In addition, each of the categories created to detect patterns, as well as pathology and trauma information were recorded for each individual.

Since the data encompassed individuals from a range of nine sites, a Microsoft Excel spreadsheet was also employed to conduct the calculations for each specific site. The total number of burials housed by the University of Alabama’s Museum of Natural History’s Laboratory of Human Osteology for each site was compared to the number of cremations recovered from that site. In addition, SPSS was used to calculate the demographic and descriptive data for the entire sample. After examining the data for the entire sample; the variable data was entered into Excel to calculate the data for each specific site. The letter “N” (uppercase) will be used when referring to the entire population from this sample (N=46), and “n” (lowercase) will be used when describing a sample of the population (n=2).
CHAPTER 4

RESULTS

The entire cremation data set for this study consisted of (N=46) individuals (see Appendix B). These cremated human remains were excavated from nine sites, including Little Bear Creek (1Ct8), Mulberry Creek (1Ct27), Perry Site (1Lu25), Bluff Creek (1Lu59), Long Branch (1Lu67), Whitesburg Bridge (1Ma10), Flint River (1Ma48), McKee Island (1Ms32), and Hunter Station (1Mt99). Based on site reports, most if not all of the Tennessee Valley shell burials are Middle to Late Archaic. In contrast, the Hunter’s Station burials are from the Late Woodland period (Knight: personal communication). Furthermore, McKee Island shows evidence of both prehistoric and post contact occupation. According to Padgett (2006:77), “the earliest horizon at McKee Island with burials was Gunterlands IV.” The analysis of artifacts such as pottery and stone tools yielded dates for the different occupations uncovered at these sites. For many of these sites the cremated remains were associated with the shell midden.

The original findings from Little Bear Creek (1Ct8) reported that fourteen cremated individuals were recovered from the Little Bear Creek site (1Ct8), but only eleven were found for this study’s analysis. These remains were associated with the shell midden complex even though they sometimes occurred near the surface (Webb and DeJarnette 1948a:34). Individuals from Little Bear Creek (1Ct8) were primarily buried in round graves and the fire was place on top of the body (Webb and DeJarnette 1948a:34). The Pickwick Basin Report (Webb and DeJarnette 1942) includes a discussion of the following sites: Mulberry Creek (1Ct27), Perry Site (1Lu25), Bluff Creek (1Lu59) and Long Branch (1Lu67). According to this report, nine
cremations were recovered from the Mulberry Creek site (1Ct27), and all nine were analyzed for this study. Webb and DeJarnette (1942:243) suggested that these cremated remains were most numerous after the shop site was established. Ten cremations were said to have been recovered from the Perry Site (1Lu25), but twelve were found within the collection and analyzed for this study. Nine cremated individuals were found at the Bluff Creek site (1Lu59), but this study only located six within the collection. Webb and DeJarnette (1942:112) found that seven of these burials were secondarily deposited and two were cremated in situ. It was further reported that the cremations were recovered from Archaic period deposits, suggesting that this method was “rule and dominant” (Webb and DeJarnette 1942:113). Lastly, while only one cremation could be located for examination from the Long Branch site (1Lu67), four were reportedly found during the original excavation (Webb and DeJarnette 1942:185). Webb and DeJarnette (1942:185) state that none of these cremations took place in situ, so all must have been re-deposited, having been burned at another location. The Whitesburg Bridge report (Webb and DeJarnette 1948b: 18-22) lists the finds for the Whitesburg Bridge site (1Ma10), but no cremations were listed in the report as being recovered; however, two were located in this collection and examined for this analysis. Lastly, the Flint River (1Ma48) report (Webb and DeJarnette 1948c:37) does state that two cremations were recovered during the original excavation and both of these individuals were analyzed in this study. There is some discrepancy with this site report, the report lists that burial 45 is a cremation; however, when looking in the collection it was found that burial 57 and 100 are cremated individuals (Webb and DeJarnette 1948c:40). Both individuals were likely found in layers that suggested they were from the Archaic period. Not all the site reports gave a clear time period for which the cremated individual might have lived. However, based on the severity of
wear on all of the teeth, the cremated individuals appear to have lived during the Middle to Late Archaic period.

**Demographic Information**

An analysis of the cremated remains yielded the following age at the time of death: child (n=3), juvenile (n=2), young adult (n=6), or older adult (n=10) at the time of death. Using this variable only 21 of the 46 individuals could be aged. Distinguishing the age of a young adult from an older adult was difficult in some instances. However, distinguishing an adult from an adolescent individual was much easier due to markers such as fusion of the epiphyses, tooth eruption, overall size of the bones, and characteristics such as arthritic vertebral lipping which is seen primarily in adults. Therefore, the ages were regrouped into adolescent (n=5) and adult (n=38). Eighty-three percent of the cremated individuals were adults, while only 11 percent were children. This method appeared to be more useful for this study because very few (n=3) remains could not be distinguished as adult or adolescent.

While sexing the remains of cremated individuals is difficult due to the fragmentary conditions of the remains; the sex was determined for 35 percent (n=16) of the sample. Of the sexed remains 63 percent were male (n=10), while 37 percent were female (n=6). The five adolescent individuals were not sexed because of the inaccuracies involved in sexing prepubescent remains. Taking this into account, (n=25) individuals of the total sample (N=46) were not able to be sexed due to the fragmentary nature of the remains.

An analysis of all individuals (N=46) revealed that very little trauma was present on the cremated remains. While trauma was in fact present, it was only evident on seven percent (n=3) of the sample. More specifically, four percent (n=2) of non-calcined bones possessed trauma, while only two percent (n=1) of the calcined remains possessed trauma. The types of trauma seen
in this sample include a broken mandible, clavicle, and fibula. However, various pathological markers were more frequent in the entire sample (N=46). Twenty six percent (n=12) of the cremated remains possess some type of pathological condition. Of these, half (n=6) of the non-calcined bones possessed pathology; while the remaining (n=6) pathologies were located on calcined bones. The majority of the pathologies recorded for this sample consisted of arthritis found in the vertebrae, but arthritic characteristics were also seen in the joints, hands, and ankles. In one instance evidence of porotic hyperostosis was present on the cranium.

**Bone Shrinkage**

Sixty-seven percent of the burials (n=31) were found to have been exposed to the highest temperature of fire (600°C and up) based on the calcined condition of the remains. Oddly, 28 percent (n=13) of the remains were only heated to temperatures ranging from 240-340°C, while four percent (n=2) of the remains reached a temperature of approximately 440°C. From these data it was inferred that 33 percent (n=15) of the individual’s remains exhibited a low shrinkage rate of one-two percent (McCutcheon 1992). In turn, 67 percent (n=31) of the remains could exhibit shrinkage rates ranging from 10-25 percent (van Vark 1970, Ubelaker 1978, Maples and Browning 1994, Byers 2002).

Originally this study assumed that all cremations were intentional. However, while examining the remains it seemed that some individuals may have been accidentally, or unintentionally, burned. These individuals had localized burns that were caused by a low temperature fire and took place after the bone became dry or fleshless. In order to determine if an individual was accidentally cremated, the bone temperature was compared to four of the categories designed to record the treatment of the individual’s body. First, it is likely that any individual that was unintentionally exposed to heat was exposed to lower temperatures of fire.
Therefore, a list was made of all individuals that were burned at temperatures which produced 1-2 percent shrinkage rates. In addition, lists were made of all individuals whose crania were the only bone burned, those who were burned only on the right side, those who were burned only on the left side, and those who had signs of localized fire trauma on areas of the body that were not the cranium. The individuals who were on one of these four lists and on the list of individuals who were exposed to low heat, were considered to have been accidentally burned. It was typical for only one portion of a body to be burned, but it was not typical for the direct burn to be produced by lower temperatures. Therefore, it is suggested that the remains of individuals exhibiting evidence of exposure to a low temperature and some type of localized burn pattern were not intentionally cremated.

Therefore, it is probable that 17 percent (n=8) of these cremations may have been accidentally burned. As described above, this percentage is solely based on the number of individuals that were burned at lower temperatures, exhibiting the lowest amount of shrinkage, and had localized burning in one area.

**Descriptive Information**

As mentioned previously, the first seven descriptive variables were created to understand the treatment of the cremated individual’s body. The first of these categories is cranial burning which refers to individuals whose cranium was the only burned area of the body. Cranial burning was found in 26 percent of the cremated individuals (n=12). Furthermore, in 13 percent of the burials only the cranium (n=6) was present. For 37 percent (n=17) of the individuals, the fire reached its hottest temperature on the cranium, and the bones became less affected by the heat toward the lower extremities. In only one instance was the body burned on the right side; however, in nine percent (n=4) of the burials, the body was burned on the left side. Also,
localized fire damage was found on other parts of the body except for the cranium in nine percent (n=4) of the cremations. In each instance, none of the burned bones showed signs of curved transverse cracking or warping, meaning that the bone appears to have been heated after the bones were dry and not burned in the flesh. Conversely, the majority, 72 percent (n=33), of the individuals appear to have been burned in flesh, based on the presence of curved transverse fractures, patina, delamination, and warping. Lastly, while the burial position of the body in the burial context plays an important role in understanding heat induced trauma patterns, burial position was only documented in the original field records for a small sample of the cremated individuals (n=4). In all four of these cases the individuals were fully flexed.

The last variable provides information concerning the other items that were associated with the grave. Only nine percent (n=4) of the cremations were listed in the site reports and burial forms as having burial artifacts associated with the burial (see Appendix B).

Conducting this study revealed an interesting pattern that led to the creation of an additional variable for this study: buried with the bones of an unburned adolescent child. This category refers to cremations that were associated with the skeleton of an unburned adolescent child, approximately ages 7-14, a pattern that was noticed during the examination. This variable was developed because in no instance were there bones of an unburned adult associated with a cremated burial. By noting these findings, the interesting fact was discovered that 17 percent (n=8) of the cremated individuals in this sample N=46 were associated with the bones of unburned adolescent children.

Such low proportions of cremations for each of the site comparisons are to be expected. Of the 2,047 burials from all nine sites only 46 of these individuals were cremated, accounting for two percent of all burials (Table 4.1).
<table>
<thead>
<tr>
<th>Site Number</th>
<th>Site Name</th>
<th>Total Remains</th>
<th>Cremated Remains</th>
<th>Percentage of Cremated Remains</th>
</tr>
</thead>
<tbody>
<tr>
<td>1Ct8</td>
<td>Little Bear Creek</td>
<td>163</td>
<td>11</td>
<td>7%</td>
</tr>
<tr>
<td>1Ct27</td>
<td>Mulberry Creek</td>
<td>149</td>
<td>9</td>
<td>6%</td>
</tr>
<tr>
<td>1Lu25</td>
<td>Perry Site</td>
<td>1031</td>
<td>12</td>
<td>1%</td>
</tr>
<tr>
<td>1Lu59</td>
<td>Bluff Creek</td>
<td>208</td>
<td>6</td>
<td>3%</td>
</tr>
<tr>
<td>1Lu67</td>
<td>Long Branch</td>
<td>92</td>
<td>1</td>
<td>1%</td>
</tr>
<tr>
<td>1Ma10</td>
<td>Whitesburg Bridge</td>
<td>114</td>
<td>2</td>
<td>2%</td>
</tr>
<tr>
<td>1Ma48</td>
<td>Flint River</td>
<td>211</td>
<td>2</td>
<td>1%</td>
</tr>
<tr>
<td>1Ms32</td>
<td>McKee Island</td>
<td>68</td>
<td>1</td>
<td>1%</td>
</tr>
<tr>
<td>1Mt99</td>
<td>Hunter Station</td>
<td>11</td>
<td>2</td>
<td>18%</td>
</tr>
<tr>
<td>Totals:</td>
<td></td>
<td>2047</td>
<td>46</td>
<td>2%</td>
</tr>
</tbody>
</table>

Table 4.1. Total Burial Summary

**Site Comparisons**

For the site comparisons any statistic that was not reported for the ten descriptive variables was not present for that site (Table 4.2). All other variables where data were present at the archaeological sites are reported here and discussed. The site reports for each of these four sites associate these cremated individuals with the Middle to Late Archaic period. In addition, an analysis these individual’s teeth found severe wear which is typical of an individual living during the Archaic period.

**Little Bear Creek (1Ct8)**

Of the cremated individuals (n=11) recovered from the Little Bear Creek site, 91 percent (n=10) of them were adults. The age of one individual is unknown. Of the individuals whose sex could be determined (n=4), 27 percent (n=3) were male and 9 percent (n=1) were female. Trauma was only evident on one individual, but pathology could be documented for 55 percent (n=6) of the individuals. The individual with the trauma had a broken mandible, clavicle, and fibula. All of the breaks had healed. Interestingly, the fibula had not healed into a single bone,
<table>
<thead>
<tr>
<th>Site Comparison Variables</th>
<th>Little Bear Creek (1CT8)</th>
<th>Mulberry Creek (1CT27)</th>
<th>Perry Site (1LU25)</th>
<th>Bluff Creek Site (1LU59)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total 11</td>
<td>Percent</td>
<td>Total 9</td>
<td>Percent</td>
</tr>
<tr>
<td>Number of Cremations</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adolescent</td>
<td>0 0%</td>
<td>2 22%</td>
<td>3 25%</td>
<td>0 0%</td>
</tr>
<tr>
<td>Adult</td>
<td>10 91%</td>
<td>7 78%</td>
<td>8 67%</td>
<td>5 83%</td>
</tr>
<tr>
<td>Unknown Age</td>
<td>1 9%</td>
<td>0 0%</td>
<td>1 8%</td>
<td>1 17%</td>
</tr>
<tr>
<td>Male</td>
<td>3 27%</td>
<td>2 22%</td>
<td>2 17%</td>
<td>3 50%</td>
</tr>
<tr>
<td>Female</td>
<td>1 9%</td>
<td>3 33%</td>
<td>0 0%</td>
<td>0 0%</td>
</tr>
<tr>
<td>Unknown Sex</td>
<td>7 64%</td>
<td>4 44%</td>
<td>10 83%</td>
<td>3 50%</td>
</tr>
<tr>
<td>Only Cranium Burned</td>
<td>7 64%</td>
<td>0 0%</td>
<td>2 17%</td>
<td>0 0%</td>
</tr>
<tr>
<td>Only Right Side of Body Burned</td>
<td>0 0%</td>
<td>1 11%</td>
<td>0 0%</td>
<td>0 0%</td>
</tr>
<tr>
<td>Only Left Side of Body Burned</td>
<td>1 9%</td>
<td>0 0%</td>
<td>2 17%</td>
<td>0 0%</td>
</tr>
<tr>
<td>Localized fire not on Cranium</td>
<td>1 9%</td>
<td>1 11%</td>
<td>1 8%</td>
<td>1 17%</td>
</tr>
<tr>
<td>Burned Entirely</td>
<td>2 18%</td>
<td>7 78%</td>
<td>7 58%</td>
<td>5 83%</td>
</tr>
<tr>
<td>Only Cranium Present</td>
<td>4 36%</td>
<td>0 0%</td>
<td>0 0%</td>
<td>0 0%</td>
</tr>
<tr>
<td>Parts of Entire Body Present</td>
<td>7 64%</td>
<td>9 100%</td>
<td>12 100%</td>
<td>6 100%</td>
</tr>
<tr>
<td>Fire Hottest on Face</td>
<td>6 55%</td>
<td>2 22%</td>
<td>6 50%</td>
<td>0 0%</td>
</tr>
<tr>
<td>Fire Not Hottest on Face</td>
<td>5 45%</td>
<td>7 78%</td>
<td>6 50%</td>
<td>6 100%</td>
</tr>
<tr>
<td>Burial Artifacts</td>
<td>0 0%</td>
<td>2 22%</td>
<td>0 0%</td>
<td>0 0%</td>
</tr>
<tr>
<td>No Burial Artifacts</td>
<td>11 100%</td>
<td>7 78%</td>
<td>12 100%</td>
<td>6 100%</td>
</tr>
<tr>
<td>Trauma</td>
<td>1 9%</td>
<td>0 0%</td>
<td>2 17%</td>
<td>0 0%</td>
</tr>
<tr>
<td>No Trauma</td>
<td>10 91%</td>
<td>9 100%</td>
<td>10 83%</td>
<td>6 100%</td>
</tr>
<tr>
<td>Pathology</td>
<td>6 55%</td>
<td>0 0%</td>
<td>2 17%</td>
<td>2 33%</td>
</tr>
<tr>
<td>No Pathology</td>
<td>5 45%</td>
<td>9 100%</td>
<td>10 83%</td>
<td>4 67%</td>
</tr>
<tr>
<td>Burning in Flesh</td>
<td>8 73%</td>
<td>7 78%</td>
<td>9 75%</td>
<td>3 50%</td>
</tr>
<tr>
<td>Burned Dry</td>
<td>3 27%</td>
<td>2 22%</td>
<td>3 25%</td>
<td>3 50%</td>
</tr>
<tr>
<td>Buried with Unburned Adolescent</td>
<td>0 0%</td>
<td>0 0%</td>
<td>3 25%</td>
<td>2 33%</td>
</tr>
</tbody>
</table>

Table 4.2. Site Comparison Data Summary of the Little Bear Creek (1Ct8), Mulberry Creek (1Ct27), the Perry Site (1LU25), and Bluff Creek (1LU59) sites.
but had formed a pseudojoint which allowed proximal and distal portions of the bone shaft to move independently. Only the cranium was burned on seven (64 percent) of the individuals. In four instances, the cranium was the only part of the body present in the cremation burial. The fire appeared to be the hottest on the cranium in 55 percent of the burials. Of the eleven individuals, 73 percent (n=8) appear to have been burned in flesh.

A total of 163 were recovered during the excavation of Little Bear Creek (1Ct8) based on the number of individual burials housed by the University of Alabama’s Laboratory of Human Osteology. Of this total, only 7 percent of the burials from this site are cremations. Though this is a low percentage, this site, Little Bear Creek (1Ct8), contained the highest percentage of cremations in relation to the number of burials recovered.

**Mulberry Creek (1Ct27)**

In all, 149 were excavated from Mulberry Creek (1Ct27) based on the burials housed at the University of Alabama. Nine individuals or six percent recovered from the Mulberry Creek (1Ct27) were cremated. Of the cremated individuals, 22 percent were adolescents (n=2) and 78 percent (n=7) were adults. Of the adults that could be sexed, two were male and three were female. The majority (78 percent) of these cremated remains appear to be completely cremated (n=7), meaning the remains of these individuals had no unburned portions of bone. Only 22 percent (n=2) of the individuals appear to have been exposed to the highest temperature fire near the cranium. No individuals from the Mulberry Creek site (1Ct27) had any identifiable trauma or pathology. Mulberry Creek (1Ct27) is the only site of the four selected for comparison to contain cremations that were found to have been associated with burial artifacts. Though this is an interesting find, the number is low only 22 percent (n=2) were found to have been buried with
artifacts (see Appendix B). Of these cremations, 78 percent (n=7) of the individuals were found to have been burned in flesh.

*Perry Site (1Lu25)*

The Perry Site (1Lu25) contained more cremated individuals (n=12) than any other site, but this number is not significant because approximately 1,031 burials from this site are curated by the University of Alabama, meaning that only one percent of those were cremations. Of those few cremations, 67 percent (n=8) of them were adult, while 25 percent (n=3) were adolescent individuals. The age of the other individual could not be determined. Of the adults, only two individuals were able to be distinguished as males, and no females were identified. Half of the individuals (n=6) were exposed to hotter temperatures around the cranium and 17 percent (n=2) were burned only on the left side of the body. Of the cremated individuals, 17 percent (n=2) had signs of either trauma or pathologies. The individuals with traumatic injury showed signs of healed bone fractures, while those with pathologies exhibited signs of arthritis in the vertebral column. Three of the individuals (25 percent) were found during the analysis for this study to have been recovered with the remains of an unburned adolescent child. In 75 percent (n=9) of the cases, the remains were found to have been burned in flesh.

*Bluff Creek (1Lu59)*

Of some 208 burials which were recovered from the Bluff Creek site (1Lu59) only six were cremated remains accounting for only three percent of the burials from this site. Of these, 83 percent (n=5) are adult, and fifty percent (n=3) are male. The age of one individual and the sex of three individuals could not be determined. Thirty three percent (n=2) show signs of pathology and no trauma was present on the remains. Fifty percent (n=3) of the cremated remains were found to have been burned in flesh and 50 percent were burned dry. Two
individuals (33 percent) were associated with the remains of an unburned adolescent child. The total number of burials housed at the University of Alabama is 208 for the Bluff Creek site (1Lu59). Therefore, cremated individuals account for three percent of the remains recovered for this site.
CHAPTER 5

CONCLUSIONS

The primary focus of this study was to combine methods of analysis from physical anthropology and forensic science to increase understanding of the age, sex, health, and cause of death of cremated individuals. More specifically, it was hypothesized that if bone color correlates with bone temperature, then bones burned at lower temperatures will show signs of trauma and pathology more frequently that those burned at higher temperatures. In addition, if there is localized intraburial burning, then the cremation was due to mortuary ritual or accidental fire.

Once the analysis began for this study, it was apparent that the information being collected would progress beyond the two original hypotheses. As a result, a secondary focus involved developing an extensive literature review of what studies have been conducted in both the fields of archaeology and forensic science to provide a good foundation for the methodology used in this study. Because literature was found to be lacking concerning cremated prehistoric remains, this study can serve as a foundation for future studies or as a basis for more experimentation to improve the methodology for analyzing cremated remains.

Sample

Before the discussion of the results, it is important to consider the sample size of this study (N=46). The sample size is extremely small to try and report mortuary trends of those who practiced cremation as a burial custom. Despite the small nature of this cremation sample, it does represent those present from over 2,000 remains from the skeletal collections from nine
prehistoric sites. Therefore, it is proposed that this information itself is important. Of these totals only 2 percent (N=46) were cremated individuals. This fact suggests that there may have been a specific reason for cremations, such as a ceremonial burial custom, a means to dispose of diseased individuals, or a way to destroy enemies. Likewise, the small number of cremations could be due to the fragmented nature of cremations, which may render them difficult to detect, or they may have been unconsciously overlooked by the excavators.

To understand the data for this study most accurately, the research design involved the analysis of data as a whole, which includes the data from all nine sites, and the analysis of the data from the four specified sites to detect unique intrasite cremation practices. This distinction is made in order to look for cross-cultural patterns between sites as well as individual site customs.

**Comprehensive Cremation Study**

**Demographic Information**

This study revealed that 83 percent (n=38) of the total cremated individuals (N=46) from the sites were adults and eleven percent (n=5) were adolescent individuals. The approximate age of the remaining six percent (n=3) could not be determined. Of the total number of cremated individuals that could be sexed (N=46), 22 percent (n=10) of those were male and 13 percent were female (n=6). Therefore, there is no definite significance in the sex of individuals that is cremated. In addition, trauma was not a major similarity between the burials analyzed for this study (N=46). In the six percent of individuals who had trauma, the trauma had healed. In no instance was a specific trauma determined to be the cause of death. As mentioned previously, the trauma found in this study included a broken mandible, clavicle, and fibula. In addition, evidence of healing traumatic injury was identified in the phalanges, metacarpals, and metatarsals. While pathological conditions were seen in 26 percent (n=12) of the total population, the majority of
these markers were the effects of aging and lifestyle rather than disease. These markers included degenerative arthritis and osteoarthritis in the bone joints and vertebral column, and one instance of porotic hyperostosis. Therefore, these data do not support the idea that populations burned diseased individuals. However, considering that 24 percent \((n=11)\) of the individuals with pathology from this population exhibited degenerative arthritis and osteoarthritis which is usually associated with old age, it is plausible to suggest that they had a tendency to burned older individuals.

An analysis of trauma and pathology revealed that the degree of the burn does affect the markers that can be found on the bone. From this study, of the six percent \((n=3)\) of the bones found to have traumatic injury, four percent \((n=2)\) of the markers had trauma on non-calcined bones, while the other two percent \((n=1)\) could still be identified on calcined remains. In addition, evidence of pathology was noted on 26 percent \((n=12)\) of the sample. Interestingly, half of this pathology was noted on non-calcined remains and the other half was identified on calcined remains. Therefore, the hypothesis that if bone color correlates to bone temperature, then bones burned at lower temperatures will show signs of trauma and pathology more frequently than those burned at higher temperatures, is rejected because both trauma and pathology can be identified on either calcined or non-calcined remains. This agrees with previous findings (Mayne 1990; McKinley 1993; Holck 1997; de Gruchy and Rogers 2002; Pope and Smith 2004).

**Descriptive Information**

The additional descriptive variables were created to detect patterns concerning the treatment of the individual body and artifacts associated with the graves. The first seven variables were created to learn more about the treatment of the body during cremation process.
The analysis revealed that 26 percent (n=12) of the individuals had burned crania. In these individuals the cranium was the only bone burned in the body. Along the same lines, in 13 percent (n=6) of the burials only the cranium was present in the burial pit and the only body part cremated. This type of find could suggest that the head was removed from the body in the flesh and then cremated, or conversely the head could have been the only body part recovered in excavation. Four of the six remains that make up this statistic came from the same site, 1Ct8. So, for some reason, possibly mortuary ritual, heads were burnt in the flesh at 1Ct8 and then buried in a pit or cut off and placed in a pit then burned. A more detailed discussion will follow in the site comparison analysis discussion.

The second hypothesis suggested that if there is localized intraburial burning, then the cremation was due to mortuary ritual or accidental fire. This analysis finds support for this hypothesis. In addition, data from this study showed that one can even differentiate between the ritual and the accidental fire.

The mortuary ritual associated with cremation is synonymous with intentional cremation of an individual by fire. It is proposed here that bodies exposed to intentional fire will likely have been exposed to a higher-temperature fire. Therefore, if localized burning of a skeletal element(s) was at high temperature, indicated by calcination of the bone, then a specific mortuary ritual could be involved. For example, in 37 percent (n=17) of the sample (N=46) the fire reached its hottest temperature at the cranium and lessened in heat-altered severity as the fire spread away from the face toward other parts of the body. From this, it is suggested that here the fire was deliberately placed at or near the head. This would explain the trend of the distal portions of the body not being as affected, if at all, by the fire.
Accidental burning was determined in the cremated remains using a threefold comparison of the bone color, bone temperature, and localized burning categories. The categories were chosen because localized burning caused by low-temperature fires, indicated by color, most likely was accidental fire. These fires were not attended or their temperatures would have been higher. By using the method described it was found that eight individuals (17 percent) of the entire sample (N=46) may have been accidentally burned. Because the majority of these burials were associated with a shell midden, they may have been too close to a neighboring fire, such as a cooking fire.

Based on the color of the bone and the presence of curved transverse fractures, patina, delamination, and heat induced warping of the bones, 72 percent (n=33) of the individuals appear to have been burned in the flesh. Considering, that another 17 percent (n=8) of the sample are thought to have been accidentally burned, only 11 percent (n=5) of the sample appears to have been intentionally burned dry, or without flesh. Based on such a large percentage of in-flesh cremated burials, it seems that cremation was normally a practice that took place immediately following death. In addition, 67 percent (n=31) of the total number of cremations remains are found to have been associated with the highest temperature based on their calcined nature. Considering that calcination of bone occurs at 600°C or 1112°F, these fires are clearly intentional because they would need to be tended to reach such a high temperature. Therefore, the cremation of these individuals appears to be intentional across all nine sites.

The last descriptive variable, burial artifact was created to discuss grave goods associated with the burials. In nine percent (n=4) of the population grave goods were associated with the individuals (see Appendix B). While this is not a large number of individuals with grave goods, it does indicate that when the body was buried it was with an artifact placed in the grave. Burial
artifacts inclusions are associated with individuals who are a member of the group, not an enemy. Those individuals were respected.

As mentioned previously, findings throughout the study revealed that remains of some individuals were associated with the bones of unburned adolescent children, who were approximately seven to fourteen years old. This study finds that 17 percent (n=8) of the cremated individuals (N=46) were found in analysis to be bagged with the bones of an unburned adolescent child. The original burial forms have no written indication that two individuals were bagged together. In no instance was the entire unburned skeleton present, but in each instance parts of the child’s entire body was present. It is an archaeological field and lab standard to bag and record each burial separately. Therefore, it appears that these children were associated with the cremated individual. However, it must be said that due to the smaller nature of the bones of children, it is possible that the bones were not seen when the cremations were deposited. Cremation pits may also have been reused with a set of child remains placed in them at some time. Or the unburned child remains could have been a sacrifice or ritual dedication. Or the bones were not noticed by the original excavators. Notes from the original excavations do not mention the association of these cremations with the bones of children. Despite there being numerous potential explanations for this phenomenon, it is worth being noted.

Site Comparisons

Little Bear Creek (1Ct8)

The majority of individuals recovered from the Little Bear Creek (1Ct8) site were adults. The age for one of the individuals is not known, but the individual was definitely not a young child. A comparison of the total number of burials found at this site, 163 burials, to the number of cremations (n=11) revealed 7 percent of the population was cremated. This statistic is the
highest of all the sites used in this study. The different groups of people who lived at this site over time appear to have only cremated adults. Of these, 27 percent (n=3) were found to be male and 9 percent (n=1) were female, whereas the sex of the additional 64 percent (n=7) is unknown. This presence of both sexes does not indicate any pattern, but analysis of the age may indicate that cremations at this site consisted of older individuals. Some type of pathology, such as degenerative arthritis and osteoarthritis, was noted on 55 percent (n=6) of this population. These individual were older adults, and these pathologies, were associated with age as opposed to disease. This finding supports the idea that the mortuary practice at this site involved the cremation of older individuals. The traumatic injuries (broken mandible, clavicle, and fibula) that were visible in one individual were healed. Therefore, injury and infectious disease do not seem to be plausible reasons these individuals were cremated.

Furthermore, at site the Little Bear Creek site (1Ct8), only the cranium was burned in 64 percent (n=7) of the skeletal remains. This statistic for this group was higher than any other site. A mortuary pattern is suggested here is a fire was placed on or near the face when an individual from this site was cremated. In support if this idea, it also was found that 55 percent (n=6) of the individuals were exposed to the hottest fire temperature on the cranium. In four instances (36 percent) only the cranium was present in the burial. Of the nine sites with cremated remains this mortuary cremation behavior is unique to the Little Bear Creek site (1Ct8). Once again this statistic is unique to this site. This is not to say this happened at this site, but excavation procedures could be the cause for only the cranium being present at time of analysis, or these individuals’ heads may have been buried separately from the body. In another study on cremation cemeteries in Eastern Massachusetts it is reported that blackened deposits were found containing pockets of bone and “all three collectors stressed the fact that they had picked up the
largest pieces they saw” (Dincauze 1968:40). The reason for the high number of burned crania in this thesis may be unknown but it is definitely worthy of note. Cremation does appear to have been a ritual that was performed at this site soon after death in that 73 percent (n=8) of the individuals were burned in flesh.

*Mulberry Creek (1Ct27)*

Six percent (n=9) of the total number of individuals excavated from the Mulberry Creek site (1Ct27) were cremated. Again, the majority (n=7 or 78 percent) of these cremations were adult individuals, and 22 percent (n=2) of the cremated remains belonged to adolescent individuals. Sexing these adult individuals revealed that two were male and three were female, which once again proves that sex was not a factor in determining who was cremated. Unlike the Little Bear Creek site (1Ct8), only 22 percent (n=2) of these individuals were exposed to the hottest temperature on their cranium. Instead, 78 percent (n=7) of these remains were completely cremated. All seven of the individuals who were completely cremated were burned in the flesh. This site was the only site selected for site comparison that had cremated remains associated with grave artifacts (n=2). The presence of burial artifacts with remains may indicate that these cremations were of individuals that were probably not enemies.

*Perry Site (1Lu25)*

Although the Perry Site (1Lu25) had more cremated individuals (n=12) than any other group, the cremations only account for 1 percent of the total burials (n=1031) excavated from the site. Again, like at other sites there were more adult cremations (n=8) than children (n=3). However, children did account for one quarter of the sample. Only two of the cremated remains could be sexed, and both were males. The Perry Site (1Lu25) is the only site where only males were found to be cremated, but considering that only two of the 12 individuals in this sample
could be sexed, this is not significant. Half of the cremated individuals from the site experienced the hottest fire in close proximity to the face, which is similar to what was found at the Little Bear Creek site (1Ct8). Furthermore, two of the individuals were only burned on the left side of the body, which is also another burn pattern that was present at the Little Bear Creek site (1Ct8). Skeletal analysis did reveal that there was evidence of trauma on two individuals, which consisted of broken phalanges on both the hand and foot. Once again the Little Bear Creek site (1Ct8) was the only other site with an individual having traumatic injury. Though the Perry Site (1Lu25) does have some parallel findings with the Little Bear Creek site (1Ct8), it differs in that 25 percent of the cremated individuals were found to have been buried with the bones of an unburned adolescent child. These should not be the result of bagging two separate burials in the same bag in the field because during these excavations the burials should have all been given separate bags. Until this study these remains had not been examined since the 1940s. Considering this, the unburned juvenile remains were presumably excavated together with the cremated remains, making them associated with the burial. Though it appears that a child was buried with these cremated individuals, other explanations are plausible. For example, the small nature of the juvenile bones may have been overlooked by the people who buried the cremated individual or by the individuals who carried out the excavation. Therefore, the occurrence of unburned adolescent, meaning individuals aged from 7-14 years old, remains with the cremations may be accidental. However, in no instance are there unburned adult bones found bagged with a cremated individuals. In addition, this occurrence is not only found at the Perry Site (1Lu25), but also at the Bluff Creek site (1Lu59) which is the last site to be discussed below. As in the other four sites used for this comparison study, the majority (n=9) of the individuals from the Perry Site (1Lu25) were burned in flesh.
Bluff Creek (1Lu59)

The Bluff Creek site (1Lu59) contained the smallest number of cremations of the sites used for the site comparison. Once again the majority (83 percent) of the cremated individuals were adults (n=5) and the age of the remaining individual is unknown. Furthermore, half (n=3) of the cremated individuals were male, but the sex of the remaining three individuals could not be determined. These demographics are very similar to the pattern that was seen at the Perry Site (1Lu25). Another similarity to the Perry site (1Lu25) is that 33 percent (n=2) of the individuals were buried with the bones of an unburned adolescent child. As discussed previously, this is not well understood, but it should again be noted. All but three of the individuals at this site were burned in flesh. This indicates that the burning of the body was likely intentional because it was done shortly after death.

Summary

An investigation of archaeological literature indicates that detailed analyses of cremated human remains are few, and the study of these types of remains has been long ignored. Evidence from this study proves that the methodologies developed by previous studies can be combined to carry out a meaningful and valuable analysis of prehistoric cremated individuals. Cremation is a mortuary practice that is often rare in an osteological collection. As was found in this study, out of 2,047 individuals from the nine sites used in this study, only 46 are cremated individuals, some two percent of the burials excavated from these sites. Even though cremations are rare, they are important sets of human remains to analyze. This study stresses this importance of analyzing both the remains of cremated prehistoric individuals and modern sets of human remains that are evidence in forensic cases.
Limitations were in effect for this study because this sample included burials which are governed by procedures that were a result of the Native American Graves Protection Repatriation Act (NAGPRA). This researcher did not use any invasive techniques that would have destroyed some of the remains. Therefore, this study only used macroscopic examination of the remains to produce the results here. However, in some other collection another analyst may be able to use more invasive techniques which would provide even more data on cremations. For example, DNA can be extracted from burned human remains, therefore a DNA profile for some individuals could be constructed (Fairgrieve 2008). Another issue encountered in this study is the small sample size which can produce skewed data, or data difficult to examine for statistical significance. But considering that every cremated individual was analyzed from this collection, the data that were collected are sound. Therefore, a study encompassing a larger sample of cremations could provide more detailed and more accurate results in the future concerning both methodology in cremation analysis and revelations about prehistoric mortuary cremation behavior.

This study hypothesized that if bone color correlates with bone temperature, then bones burned at lower temperatures will show signs of trauma and pathology more frequently that those burned at higher temperatures. In this study only a slightly higher percentage of trauma was found in non-calcined bone, but the same percentage of pathology was identified in both non-calcined and calcined bone. Therefore, the hypothesis was rejected. As found in the research of Mayne (1990), McKinley (1993), Holck (1997), de Gruchy and Rogers (2002), and Pope and Smith (2004), trauma and pathology markers are identifiable on burned bone despite the degree of severity of burning. In a larger study it may be found that traumatic and pathological markers in bones burned at lower temperatures may be identified more frequently, but this study shows
that despite the degree of burning, indicators of trauma and pathology are present and recognizable. This is important because bioanthropologists and forensic analysts can get vital information from cremated remains.

In addition, this study hypothesized that if there is localized intraburial burning, then the cremation was due to mortuary ritual or accidental fire. Based on comparisons of certain burn patterns and the temperature at which the bone burned, this hypothesis was not rejected. Not only did this study provide a criterion for determining if bones were burned in localized areas, but it also suggested a criterion for distinguishing between mortuary cremation ritual behavior and cremation by accidental fire. The study of both prehistoric and modern forensic case cremations can extend far beyond just determining sex and age of a cremated individual. By examining the burn patterns on bone, one can understand more about the mortuary behavior, which can give the researcher a clearer understanding of a prehistoric culture or the perimortem specifics about the death of an individual in a modern forensics case.

A secondary purpose of this study was to conduct an extensive literature review in order to create a methodology for the analysis of prehistoric cremated remains housed at the University of Alabama’s Laboratory for Human Osteology. The cremated remains in this skeletal collection have largely been ignored since their excavation in the late 1930s and early 1940s. This study provided a detailed description of the demographics of the individuals within the collection. In addition the descriptive information gathered informs us about prehistoric mortuary behavior including burial customs, body placement, fire placement, and associated burial artifacts. New research conducted in the last decade has helped build a stronger methodological foundation for collecting data or evidence when examining prehistoric and modern cremated remains. Therefore, this study found that using methods, many borrowed from forensic science, to analyze
prehistoric remains is worthwhile because these methods are effective and the results they provide give us an understanding of a mortuary behavior that has been largely ignored in prehistoric studies.
REFERENCES


Browne T. 1658. Hydriotaphia, Urn-burial; or, a Discourse of the Sepulchral Urns Lately Found in Norfolk.


Appendix A. “This diagrams of an anterior skeleton in pugilistic posture highlighting the initial, secondary, and final areas to express burning on bone. The figure also includes dorsal and palmar views of the pattern of burning on the hand. The green lines indicate common areas of fracture” Symes et al. 2008:32). Illustration from (Symes et al. 2008: Plate 2).
Appendix A continued. “This is a posterior view of the skeleton diagram in pugilistic posture highlighting the initial, secondary, and final areas to burn on bone. This figure also includes a magnified view of the burn patterns on the frontal and lateral skull” (Symes et al. 2008: 33). Illustration from (Symes et al. 2008: Plate 3).
### Appendix B

<table>
<thead>
<tr>
<th>Site</th>
<th>Burial ID</th>
<th>Depth</th>
<th>Grave Type</th>
<th>Original Photo or Sketch</th>
<th>Degree of Cremation</th>
<th>Reburial</th>
<th>Artifacts</th>
<th>Burial Position</th>
<th>Notes from TVA Burial Form</th>
</tr>
</thead>
<tbody>
<tr>
<td>Little Bear Creek</td>
<td>8</td>
<td>7 ft. below 140-0</td>
<td>pit</td>
<td>yes</td>
<td>partial</td>
<td>no</td>
<td>ground anculosae</td>
<td>fully flexed face down</td>
<td>Shallow pit lined with sandstone boulders, fire was built on top of body. 1-10-1938</td>
</tr>
<tr>
<td>(1C8)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>beads</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Little Bear Creek</td>
<td>9</td>
<td>3.4 ft. below 110-0</td>
<td>information not given</td>
<td>yes</td>
<td>partial/accidental</td>
<td>no</td>
<td>None</td>
<td>fully flexed</td>
<td>Appeared accidental</td>
</tr>
<tr>
<td>(1C8)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Little Bear Creek</td>
<td>70</td>
<td>8.4 ft. below 135R2</td>
<td>pit</td>
<td>yes</td>
<td>total cremation</td>
<td>no</td>
<td>None</td>
<td>fully flexed</td>
<td>Intentional cremation. Body placed in pit and then fire was built on top.</td>
</tr>
<tr>
<td>(1C8)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Little Bear Creek</td>
<td>87</td>
<td>8.5 ft. below 150L1</td>
<td>information not given</td>
<td>no</td>
<td>total cremation</td>
<td>information not given</td>
<td>None</td>
<td>disturbed burial</td>
<td></td>
</tr>
<tr>
<td>(1C8)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Little Bear Creek</td>
<td>105</td>
<td>4.75 ft. below 140L7</td>
<td>information not given</td>
<td>no</td>
<td>total cremation</td>
<td>information not given</td>
<td>None</td>
<td>information not given</td>
<td></td>
</tr>
<tr>
<td>(1C8)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Little Bear Creek</td>
<td>125</td>
<td>7.1 ft. below 130L1</td>
<td>partial</td>
<td>yes</td>
<td>partial cremation</td>
<td>no</td>
<td>anculosae shell beads</td>
<td>information not given</td>
<td>Adult burial was in what had formerly been used for a fire pit. Sandstone slabs and water worn boulders lined pit. Lots of material at bottom indicate fire pit</td>
</tr>
<tr>
<td>(1C8)</td>
<td></td>
<td></td>
<td>stone cist</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Little Bear Creek</td>
<td>126</td>
<td>7.1 ft. below 130L3</td>
<td>information not given</td>
<td>yes but poor</td>
<td>total cremation</td>
<td>information not given</td>
<td>None</td>
<td>partly flexed</td>
<td></td>
</tr>
<tr>
<td>(1C8)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Little Bear Creek</td>
<td>147</td>
<td>2.5 ft. below 110R4</td>
<td>information not given</td>
<td>yes</td>
<td>total cremation</td>
<td>information not given</td>
<td>Piece of hematite at base of burial</td>
<td>information not given</td>
<td>Cremated adult not sketched or photographed</td>
</tr>
<tr>
<td>(1C8)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Little Bear Creek</td>
<td>149</td>
<td>2.5 ft. below 110R5</td>
<td>information not given</td>
<td>no</td>
<td>partial cremation</td>
<td>information not given</td>
<td>Burial bead</td>
<td>information not given</td>
<td></td>
</tr>
<tr>
<td>(1C8)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Little Bear Creek</td>
<td>151</td>
<td>2.0 ft. below 110R1</td>
<td>information not given</td>
<td>no</td>
<td>total cremation</td>
<td>information not given</td>
<td>None</td>
<td>information not given</td>
<td></td>
</tr>
<tr>
<td>(1C8)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Little Bear Creek</td>
<td>154</td>
<td>2.6 ft. below 110R3</td>
<td>no pit or stone cist</td>
<td>no</td>
<td>total cremation</td>
<td>no</td>
<td>None</td>
<td>information not given</td>
<td>Cremated adult</td>
</tr>
<tr>
<td>(1C8)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

APPENDIX B. Summary of original burial form data for each individual analyzed in this study.
<table>
<thead>
<tr>
<th>Mulberry Creek (1Ct27)</th>
<th>32</th>
<th>5L4 at 6.6 ft. below 10L4</th>
<th>information not given</th>
<th>no</th>
<th>total cremation</th>
<th>information not given</th>
<th>None</th>
<th>information not given</th>
<th>Hand full of bones found. Could not distinguish between accidental burning or cremation.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mulberry Creek (1Ct27)</td>
<td>46</td>
<td>10L8 at 4.1 ft.</td>
<td>information not given</td>
<td>no</td>
<td>total cremation</td>
<td>information not given</td>
<td>None</td>
<td>information not given</td>
<td>Small pile of charred human remains. Were not burned in situ.</td>
</tr>
<tr>
<td>Mulberry Creek (1Ct27)</td>
<td>79</td>
<td>12.5 ft. below 30L20</td>
<td>no pit or stone cist</td>
<td>no</td>
<td>total cremation</td>
<td>information not given</td>
<td>None</td>
<td>information not given</td>
<td>Small pile of charred human remains surrounded by charcoal and ashes. Determined to be a cremation</td>
</tr>
<tr>
<td>Mulberry Creek (1Ct27)</td>
<td>115</td>
<td>30' 6.45</td>
<td>information not given</td>
<td>yes</td>
<td>partial cremation</td>
<td>information not given</td>
<td>Bag contains 5 pieces of chertdebitage without a cortex</td>
<td>information not given</td>
<td>Cremation was not in situ. Skeleton was in anatomical order and the skull was the only thing charred.</td>
</tr>
<tr>
<td>Mulberry Creek (1Ct27)</td>
<td>121</td>
<td>8 ft. below 85L15</td>
<td>no pit or stone cist</td>
<td>yes</td>
<td>total cremation</td>
<td>no</td>
<td>Bag contains one piece of shell and two bone artifacts. Both burned with body...calcined white.</td>
<td>information not given</td>
<td>On sheet for sk#125. Associated with Sk#125. Sk# 121,122,123,124,and 125 were found together.</td>
</tr>
<tr>
<td>Mulberry Creek (1Ct27)</td>
<td>122</td>
<td>8 ft. below 85L15</td>
<td>no pit or stone cist</td>
<td>yes</td>
<td>total cremation</td>
<td>no</td>
<td>None</td>
<td>information not given</td>
<td>On sheet for sk#125. Associated with Sk#125 ) Sk# 121,122,123,124,and 125 were found together.</td>
</tr>
<tr>
<td>Mulberry Creek (1Ct27)</td>
<td>123</td>
<td>8 ft. below 85L15</td>
<td>no pit or stone cist</td>
<td>yes</td>
<td>total cremation</td>
<td>no</td>
<td>None</td>
<td>information not given</td>
<td>On sheet for sk#125. Associated with Sk#125 Sk# 121,122,123,124,and 125 were found together.</td>
</tr>
<tr>
<td>Mulberry Creek (1Ct27)</td>
<td>129</td>
<td>8ft. Below 65L15</td>
<td>information not given</td>
<td>yes</td>
<td>total cremation</td>
<td>no</td>
<td>None</td>
<td>information not given</td>
<td>On sheet for sk#128. Associated with Sk#128) Sk# 128,129,130, and 131 were found together.</td>
</tr>
<tr>
<td>Mulberry Creek (1Ct27)</td>
<td>134</td>
<td>9 ft. below 65L16</td>
<td>no pit or stone cist</td>
<td>yes</td>
<td>total cremation</td>
<td>no</td>
<td>None</td>
<td>information not given</td>
<td>Sk# 132 and #133 were apparently buried together and larges stones were thrown in on the bodies. Sk#134 was a cremation and association with Sk#132 and sk#133 is doubtful.</td>
</tr>
</tbody>
</table>

APPENDIX B continued.
<table>
<thead>
<tr>
<th>Perry Site (1Lu25)</th>
<th>Depth</th>
<th>Feature Location</th>
<th>Pit/Stone Cist</th>
<th>Excavation</th>
<th>Cremation</th>
<th>Criteria</th>
<th>Remains</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>63</td>
<td>2 ft. below</td>
<td>120L6</td>
<td>no pit or stone cist</td>
<td>yes</td>
<td>total cremation</td>
<td>yes</td>
<td>None</td>
<td>information not given</td>
</tr>
<tr>
<td>85</td>
<td>4 ft. below</td>
<td>85L2</td>
<td>no pit or stone cist</td>
<td>yes</td>
<td>total cremation</td>
<td>yes</td>
<td>Flint Chips</td>
<td>information not given</td>
</tr>
<tr>
<td>528</td>
<td>4.0 ft. below</td>
<td>125L25</td>
<td>pit</td>
<td>yes</td>
<td>total cremation</td>
<td>information not given</td>
<td>None</td>
<td>information not given</td>
</tr>
<tr>
<td>633</td>
<td>0.375 ft. from datum 30R2</td>
<td>no pit or stone cist</td>
<td>yes</td>
<td>highly fragmented</td>
<td>information not given</td>
<td>None</td>
<td>Extended laying face up</td>
<td></td>
</tr>
<tr>
<td>676</td>
<td>2.30 ft. from datum 125R2</td>
<td>pit</td>
<td>no</td>
<td>total cremation</td>
<td>information not given</td>
<td>None</td>
<td>information not given</td>
<td>Associated burials Sk#673-674. Grave contained charcoal and burned rocks. Could be in situ making this the older burial.</td>
</tr>
<tr>
<td>678</td>
<td>3.425 ft. from datum 145R8</td>
<td>information not given</td>
<td>yes but poor</td>
<td>partial cremation</td>
<td>information not given</td>
<td>None</td>
<td>information not given</td>
<td>Remains of parted- intentional burial enclosed in regular normal material with no signs of any crematory.</td>
</tr>
<tr>
<td>695</td>
<td>4.85 ft. from datum 110R3</td>
<td>pit</td>
<td>no</td>
<td>total cremation</td>
<td>information not given</td>
<td>None</td>
<td>information not given</td>
<td>Cremated remains deposited in pit which evidently served as crematory which was intruded from lower part of zone E and extended into silt cave.</td>
</tr>
<tr>
<td>801</td>
<td>2.10 ft. from datum 170L19</td>
<td>pit</td>
<td>yes but poor</td>
<td>partial cremation</td>
<td>information not given</td>
<td>see description</td>
<td>information not given</td>
<td>Cremated remains contained in shallow pit in which was charred shell and a heavy deposit of charcoal.</td>
</tr>
<tr>
<td>813</td>
<td>3.65 ft. from datum 110R9</td>
<td>no pit or stone cist</td>
<td>yes but poor</td>
<td>highly fragmented</td>
<td>information not given</td>
<td>Incomplete and fragmentary incised shell pendant, pierced deer ulna and shell beads.</td>
<td>information not given</td>
<td>Bones almost entirely consumed by fire- area occupied is small no apparent ??? To remains surrounding earth is charcoal stained.</td>
</tr>
<tr>
<td>845</td>
<td>0.30 ft. from datum 150R20</td>
<td>no pit or stone cist</td>
<td>yes</td>
<td>highly fragmented</td>
<td>information not given</td>
<td>Wood specimen #9</td>
<td>information not given</td>
<td></td>
</tr>
</tbody>
</table>

APPENDIX B continued.
<table>
<thead>
<tr>
<th>Location</th>
<th>No.</th>
<th>Distance from Datum</th>
<th>Pit or Stone Cist</th>
<th>Partial Cremation</th>
<th>Total Cremation</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perry Site (1Lu25)</td>
<td>949</td>
<td>1.65 ft. from Datum 125L8</td>
<td>No pit or stone cist</td>
<td>Yes</td>
<td>No</td>
<td>None information given. Burial dismembered prior to interment in this spot. Dismemberment may have been due to accidental burning on body may have been disarticulated - then partially burnt and then buried here. Note portion of body is still articulated. Associated with SK#948.</td>
</tr>
<tr>
<td>Perry Site (1Lu25)</td>
<td>952</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Original burial record could not be located.</td>
</tr>
<tr>
<td>Bluff Creek (1Lu59)</td>
<td>135</td>
<td>2 ft. from Datum st. 125R3</td>
<td>Information not given</td>
<td>Yes but poor partial cremation</td>
<td>Information not given</td>
<td>None information given. Possibly fully flexed, but unsure because it was a reburial.</td>
</tr>
<tr>
<td>Bluff Creek (1Lu59)</td>
<td>162</td>
<td>Zone B</td>
<td>Pit</td>
<td>Yes but poor partial cremation</td>
<td>Information not given</td>
<td>None information given. The human character of the bones was discovered only after the workman had intermingled them with various animal bones. Sketch shows where workman thought he found them.</td>
</tr>
<tr>
<td>Bluff Creek (1Lu59)</td>
<td>166</td>
<td>11 ft. below Datum 135L2. Zone G</td>
<td>Information not given</td>
<td>Yes but poor partial cremation</td>
<td>Information not given</td>
<td>None information given. Either burned fully flexed and then reburied or accidentally burned layin on side.</td>
</tr>
<tr>
<td>Bluff Creek (1Lu59)</td>
<td>169</td>
<td>10 ft. below Datum 130R3 stake. Zone E</td>
<td>Information not given</td>
<td>Yes but poor total cremation</td>
<td>Information not given</td>
<td>None information given. Associated with burials 188-187-185. Darkened earth indicative of burning in situ.</td>
</tr>
<tr>
<td>Bluff Creek (1Lu59)</td>
<td>174</td>
<td>115 ft. from Datum Stake 155R2. Zone G</td>
<td>Information not given</td>
<td>Yes but poor partial cremation</td>
<td>Likely a reburial</td>
<td>None information given. Information unclear (see TVA notes)</td>
</tr>
<tr>
<td>Bluff Creek (1Lu59)</td>
<td>186</td>
<td>7.5 ft. from Datum Stake 140. Zone B</td>
<td>Yes</td>
<td>Yes but poor total cremation</td>
<td>No</td>
<td>None information given. Associated with burials 188-187-185. Darkened earth indicative of burning in situ.</td>
</tr>
<tr>
<td>Long Branch (1Lu67)</td>
<td>39</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>No burial record.</td>
</tr>
<tr>
<td>Whitesburg Bridge (1Ma10)</td>
<td>87</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Original burial record could not be located.</td>
</tr>
<tr>
<td>Whitesburg Bridge (1Ma10)</td>
<td>89</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Original burial record could not be located.</td>
</tr>
</tbody>
</table>

**APPENDIX B continued.**
<table>
<thead>
<tr>
<th>Location</th>
<th>Number</th>
<th>Status</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flint River (1Ma48)</td>
<td>57</td>
<td>lost records</td>
<td></td>
</tr>
<tr>
<td>Flint River (1Ma48)</td>
<td>100</td>
<td>lost records</td>
<td></td>
</tr>
<tr>
<td>McKee Island (1Ms32)</td>
<td>14</td>
<td>not recorded</td>
<td>Not burned in situ and no artifacts</td>
</tr>
<tr>
<td>Hunters Station (1Mt99)</td>
<td>3</td>
<td>could not find original record</td>
<td>1 Big Sandy point Early archaic 7500 BC and 2 Early Woodland pottery sherds red painted/stripped</td>
</tr>
<tr>
<td>Hunters Station (1Mt99)</td>
<td>9</td>
<td>could not find original record</td>
<td></td>
</tr>
</tbody>
</table>

APPENDIX B continued.