THE SEARCH FOR ANCIENT HAIR:

A SCIENTIFIC APPROACH TO THE PROBABILITIES AND RECOVERY OF UNATTACHED HAIR IN ARCHAEOLOGICAL SITES

A Thesis

by

KATHERINE TURNER-PEARSON

Submitted to the Office of Graduate Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

MASTER OF ARTS

August 2007

Major Subject: Anthropology

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Approved by:

Chair of Committee,	Vaughn M. Bryant
Committee Members,	Michael R. Waters
	Charles T. Hallmark
Head of Department,	David Carlson

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ABSTRACT

The Search for Ancient Hair: A Scientific Approach to the Probabilities and Recovery of Unattached Hair in Archaeological Sites. (August 2007)

Katherine Turner-Pearson, B.A., Baylor University

Chair of Advisory Committee: Dr. Vaughn M. Bryant

A recent upsurge exists of archaeologists using ancient hair as a research tool, with new uses of this previously discarded archaeological material being introduced annually. Human hair deteriorates extremely slowly, and since the average modern human sheds approximately one hundred hairs per day, there should be copious amounts of hair debris left behind after humans leave a site; it is just a matter of how much of the hair survives in the archaeological environment.

Most loose hair recovered from archaeological sites, however, is found fortuitously and in many cases, because archaeologists were not actively searching for ancient hair, it is possible they tainted the hair they later tested in ways that compromised their data, or more importantly contaminated their samples with modern hair and did not test ancient hair at all. No standardized method has previously been established for searching for ancient hair in an archaeological site. This paper considers (a) a method of soil extraction in the field that avoids contamination with modern hair and elements that might hinder later test data; (b) the processing of samples in the laboratory while continuing sample integrity; (c) identification of the types of soils and

environments that are most favorable to hair preservation; and (d) an examination of the relevance of hair extraction from sites including the practicality and research potential.

This paper examines five archaeological sites, using three different methods of hair extraction, examining the pros and cons of each. This should enable future researchers to find a method that works best for their particular site. It also analyzes the soil chemistry of the sites in order to study the soil and hair survival relationship, so that scientists can better determine which soils hold the best potential for hair survival. Laboratory methods that avoid contamination of the samples are also outlined in order to help researchers keep sample integrity after leaving the archaeological site.

DEDICATION

This thesis is dedicated to my father, Donald R. Turner, who stopped at every historical maker we passed on the road, wandered through old cemeteries, and took me on my first archaeological "dig" when I was 13. He instilled in me a love for history and the mysteries of archaeology.

ACKNOWLEDGMENTS

I would like to thank the people who helped me through this process called graduate school. It is with sincere appreciation that I thank my committee, Michael R. Waters, Charles T. Hallmark, and especially Vaughn M. Bryant, who took over as chair after Robson Bonnichsen died. Their advice and expertise made me think twice about my methodology and conclusions, and I believe my research offers a much better contribution to archaeology because of it. I also wish to acknowledge my original chair, Robson Bonnichsen, posthumously for his dedication to his students and his encouragement and steadfast belief in my abilities.

This work could not have been accomplished without the help of Elton Prewitt, Jack and Wilma Skiles, Elizabeth Estes-Taylor and Garrett Cook, who allowed me into the sites I sampled.

To the friends I made at graduate school I owe a word of thanks. I do not know what I would have done without their friendship during the lonely times. To my friends back home, I offer a special word of gratitude for encouraging me and understanding when I was absent because of my work, particularly Kandace and Greg Menning, and Po and Stuart Madsen. I also wish to thank Al Redder for being such a great mentor for so many years.

And most importantly, I must thank my husband Warren Pearson, for listening to me through all the ups and downs of graduate school, but mainly being there during the "downs". It helped to have a soft place to fall.

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CHAPTER I

INTRODUCTION

This thesis examines the practicality of searching for unattached ancient hair in an archaeological site and offers a scientific method for searching for that hair without contamination by modern hair or elements that could skew future test data, in both the field and laboratory. Further, the research addresses the soil and environmental considerations associated with hair survival.

There are four major premises to this thesis: a method of soil extraction in the field that avoids contamination with modern hair and elements that might hinder later test data; the processing of the samples in the laboratory while continuing sample integrity; identification of the types of soils and environments that are most favorable to hair preservation; and an examination of the relevance of hair extraction from sites including the practicality and research potential.

This thesis follows the style of *American Antiquity*.

CHAPTER II

WHY SEARCH FOR ANCIENT HAIR?

Recently there has been an upsurge of archaeologists using ancient hair in a number of different research avenues, with new uses of this previously discarded archaeological material being introduced annually. Mitochondrial DNA is being extracted from degraded and even burnt ancient hair (Gilbert et al. 2004; Gough 1998; Wilson et al. 2001) and trace element analysis of hair has been used to determine both the diet of ancient people and to measure environmental degradation (Benfer et al. 1978; Gough 1998; Von Gisela Grupe and Dörner 1989; Hanson and Asmund 2002; Roy et al. 2005; Sandford and Kissling 1993 & 1994; Wilson et al. 2001). Using ancient hair for stable carbon and nitrogen isotopes is increasing as both are found more readily in hair than in ancient bone (McCullagh et al. 2005; O'Connell and Hedges 1999; Sealy 2001; Sponheimer et al. 2003; Wilson et al. 2001). Scientists are now using ancient hair to diagnose diseases in ancient people that are not identifiable in skeletal remains (Gough 1998; Lenihan 1988; Sandford and Kissling 1993), as well as determining issues such as weaning practices (Sandford and Kissling 1993), use of hallucinogens (Cartmell et al. 2002; Castro et al. 2002) and the overall health of ancient people (Roy et al. 2005; Klepinger 2001). In recent years researchers used hair to help determine that the Ice Man of the Oetztaler Alps was a strict vegetarian (Macko et al. 1999; *Science Daily* 1998), the geographic origin of a sacrificial mummy from Argentina (Fernández et al. 1999), and to conclude that both Arctic explorer Charles Francis Hall and Emperor

Napoleon Bonaparte died by arsenic poisoning (Lenihan 1988; Wilson et al. 2001; Zimmerman 2001). At Pendejo Cave in New Mexico, human hair was used as both a dating material and as proof of human occupation at the site over 12,000 years BP (Chrisman et al. 1996).

It takes only a small sample of ancient hair for most diagnoses, and since hair takes up little archival space and holds a wealth of biological and environmental information, it is increasing sought by archaeologists (Von Gisela Grupe and Dörner 1989; Hanson and Asmund 2002). Human hair deteriorates extremely slowly, and since the average modern human sheds approximately one hundred hairs per day, there should be copious amounts of hair debris left behind after humans leave a site; it is just a matter of how much of the hair survives in the archaeological environment (Bland 1984; Roy et al. 2005; Wilson et al. 2001).

Structure of Hair

Hair is a stable tissue, primarily made of keratin, a specific type of protein which contains high levels of sulfhydryl amino acid cystine. Sulfhydryl is a strong chelator which can bind heavy metals in an ionic state effectively in keratin (Bland 1984; Cone and Joseph 1996). Because of this unique composition, the levels of minerals in hair are much higher than the levels found in blood or urine (Bland 1984; Hanson and Asmund 2002; Obrusnil et al. 1973). Hair, unlike blood, is extremely sensitive to changes in the status of a particular element in the body, making it a much better "history book" of nutritional and environmental changes in the host than urine or blood, and can exhibit

elemental fluctuations along its shaft length (Brothwell and Grimes 2002; Gordus et al. 1975; Von Gisela Grupe and Dörner 1989; Obrusnil et al. 1973). Hair is also very biologically stable, which is important when looking for analysis in ancient people (Bland 1984).

Human hair is hormone dependant, with beard, mustache, pubic, and auxiliary hair the most dependant, and eyelash, eyebrow and head hair less dependant. The human scalp contains approximately 100,000 hairs, with slightly more for blondes and slightly less for redheads, and about ten percent (10,000) of the hairs are in a resting phase and not growing, at any one time (Bland 1984; Lenihan 1988). The resting stage (*telogen*), contributes the main shedding of hair, constituting the average shedding at 100 hairs per person per day. Active hair (*anagen*) grows at approximately 0.4 to 0.5 millimeters per day, or about one-half inch a month (Bland 1984; Harding and Rogers 1999; Ogle and Fox 1999; Robbins 2002; Valkovic 1977). Each hair follicle has an abundant amount of blood vessels which carry essential and potentially toxic trace elements to the hair. The elements are laid into the newly forming hair protein, based on the rate of growth of the hair and the hair's sulfhydryl content (Bland 1984). Hormonal and other chemical influences can affect the uptake of some elements, and because hair is primarily protein, any changes in the nutritive status of the host can change the composition of the hair, as well as its growth rate. These factors can influence the trace elements left in the hair, as well as the actual structure of the hair (Bland 1984).

Hair grows from large cavities in the dermis called follicles and is composed of epithelial cells arranged in three layers comprising the cuticle, cortex and medulla

(Bland 1984; Robbins 2002) (See figure 1.1). The cuticle consists of overlapping scales on the outer layer of the hair (Hicks 1977; Ogle and Fox 1999), while the cortex, basically, is a column of epithelial cells that form an inflexible homogenous mass, which in the newest growth of hair contains irregular shaped cells that carry tissue fluid. As the hair grows, the shaft dries and the cavities within the cortex lose their fluid transport properties (Bland 1984). The medulla is the center segment of the hair consisting of either distinct cells or an unstructured mass, that is sometimes shrunken and the intercellular spaces filled with air. In many cases the medulla does not extend the entire length of the hair shaft, and it is commonly absent in human hair (Moore et al. 1974; Harding and Rogers 1999; Hicks 1977). In some mammals, the spaces in the medulla are in regular patterns and can be used in the diagnosis of species (Harding and Rogers 1999).

Like all body tissues, hair is composed mainly of hydrogen, carbon, nitrogen, and oxygen, which makes up ninety-nine percent of its mass (Bland 1984; Lenihan 1988). The medulla contains the proteins *tricholyalin* and *arginine* and the amino acid *citrulline* (Harding and Rogers 1999). *Keratin* is the protein material of the cortex, which closely resembles the protein that constitutes fingernails and dental enamel. Hair gets its color from *eumelanin*, a brown pigment closely related to that of the skin pigment melanin (Harding and Rogers 1999; Ogle and Fox 1999). Creation of *eumelanin* requires the enzyme *tyrosinase* (Bland 1984). Redheads have a second iron-containing pigment called *phaeomelanin* (Ogle and Fox 1999), which is produced by a special enzyme that gives it its reddish tint, called *trichosiverin*; thus redheads usually have higher levels of

iron in their hair than blondes and brunettes, which must be taken into account when comparing analysis between different color types[1] (Bland 1984). Hair color is also affected by its surface transparency and reflectivity (Ogle and Fox 1999).

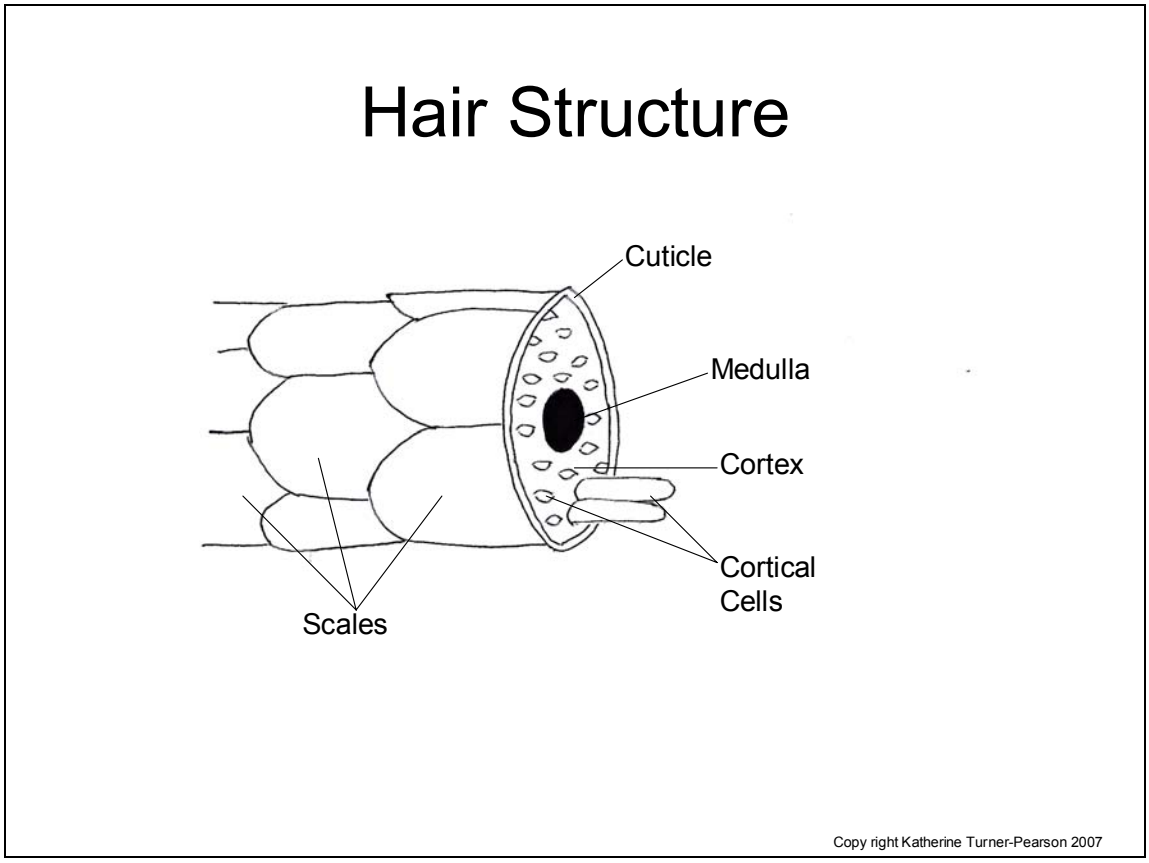

Figure 1.1 Structure of hair.

Currently about sixty elements have been identified in human hair, with concentrations ranging from 0.01 to 100 micrograms per gram (ppm) (Bland 1984; Lenihan 1988). Basically, hair serves as a "recording filament" that shows metabolic

[1] Blondes have higher copper levels and the lowest zinc levels, while black haired people have higher levels of chromium, lead and zinc (Frompovich 1982).

changes of elements over a long period of time, and provides an excellent record of past nutritional events (Bland 1984). Mineral analysis in hair measures the intracellular level of a particular element. High levels of an element may indicate a disproportionate deposition intracellularly of a mineral in a specific tissue, which in turn may cause a deficiency of that element in another tissue. Research has also shown that high levels of a specific trace element can be as important at indicating tissue imbalance as low levels (Bland 1984). One must use caution however, when interpreting the results of hair analysis among a group. The element levels in hair are not only related to nutritional status of that particular element, but also the absorption ability of the individual (Bland 1984). Trace elements usually found in the highest quantity are sodium, phosphorus, potassium, and sulfur, and are associated with physiological functions in the body (Goulding 1999)

There are two ways elements can arrive in hair; one is by ingestion or inhalation and the other is the result of absorption of the element from "fallout" onto the surface of the hair. With the ingestion-inhalation method, referred to as *endogenous*, the elements reach the hair by deposition through systemic processes, in that the element came into the body and arrived in the bloodstream before it was deposited in the hair. *Endogenous* element arrival can entail essential, trace, or toxic elements. With "fall-out," or *exogenous* sources, the elements literally fall onto the hair where they are absorbed into the looser, porous portions of the mass, and are usually toxic in nature (Bland 1984). The exogenous arrival is a concern for archaeologists, and the primary reason this author

advocates testing of the soil matrix from which ancient hair is recovered when doing trace element analysis.

How Minerals Get into Food Sources

The human body's composition is approximately fifty-five percent water, twenty percent protein, fifteen percent fat, *five percent minerals*, two percent carbohydrates and less than one percent vitamins, and what is most important from an archaeological view point is that all of these components are biodegradable *except* the minerals (Frompovich 1982).

The prophet Isaiah proclaimed that man was made from the clay of the earth, and he was right; the only source of trace elements naturally occurring in the human diet is through the soil. Minerals (rocks) are slowly (in geologic time) broken down by environmental processes into smaller and smaller particles which, when left exposed to the environment, form soil through a process called *pedogenesis* (Waters 1992). The soil is composed primarily of tiny grains of minerals, and plants that grow in the soil absorb nutrients released from the minerals as they take in water. Animals then eat the nutrient bearing plants, and absorb the nutrients into their own systems. A secondary way for animals to obtain minerals from plants is to eat another animal that has eaten mineral laden plants. Humans also ingest minerals from water sources that draw minerals from the rocks and soils in which it has come in contact. How much of a particular element a person consumes, is in direct proportion to the mineral content of the soil in which the plants grow (Lenihan 1988).

The functions of minerals in the human body vary, but are very specific, with the interaction of different minerals essential to the proper operation of the body. If one element is out of balance with the others, the body will not perform correctly, sometimes with devastating results. Some minerals are classified as *acid forming* (chlorine, iodine, phosphorus, and sulfur), or *alkaline base* minerals (calcium, iron, magnesium, potassium, and sodium) (Frompovich 1982). The *acid forming* minerals exist in the body as *negatively* charged ions, and the *alkaline forming* minerals constitute the *positively* charged ions. The two work in concert, with specific pairings of negatively and positively charge ions established, and if just one of the elements is out of balance, either by having too much of a particular element in the body, or too little, then the pairs will not match up in the manner they were intended. When this happens, the body ceases to perform properly (Frompovich 1982).

CHAPTER III

FIELD SAMPLING METHODS

The core premise of this thesis is finding a scientific, systematic method of soil extraction in order to search for ancient hair from an archaeological site that is both functional and practical in all types of soils and climates while avoiding contamination with modern hair.

Most hair recovered from archaeological sites not attached to mummified remains is found fortuitously, most often in the laboratory while processing samples of soil or artifacts. Investigators at Hind Cave in Texas found rodent hair embedded in stone tools while examining the tools for residue (Sobolik 1996), and in Peru, hairs later used in trace metal analysis fell out of a cranium under examination (Benfer et al. 1978). Tested loose hair from False Cougar Cave in Montana were first observed in the screen and later found during flotation of samples (Bonnichsen and Bolen 1985), and often hair is recovered during coprolite analysis (Holden 2001; Vaughn Bryant, personal communication 2006). In many cases, because archaeologists were not actively searching for ancient hair, it is possible that they tainted the hair they later tested in ways that compromised their data, or more importantly contaminated their samples with *modern* hair and did not test *ancient* hair at all. It is also possible that at some sites ancient hair that could be used in multiple research areas was discarded along with screened sediments and other non diagnostic items (Gough 1998). While many studies have been conducted on the cleaning methods of hair in the laboratory (Baumgartner and

Hill 1996; Bland 1984; Kidwell and Blank 1996; Passwater and Cranton 1983; Roy et al. 2005), no standardized method for searching for ancient hair in an archaeological site has been established (Gough 1998; Kidwell and Blank 1996; Obrusnil et al. 1973; Raghupathy et al. 1988). Gough (1998) conducted a pilot study of hair retrieval with laboratory analysis in 1998 with claimed success, but little work has been done in the field since.

For this thesis, five sites were tested: the Estes Ranch site in Lorena, Texas (state number pending); two Hanson Reservoir sites in King County, Washington (45KI280 and 45KI281); the Rainbow Lake Site (41ML262) in Woodway, Texas; and Eagle Cave (41VV167) in Langtry, Texas (Figure 2.1). The soils of the sites vary in chemistry along with their different climates. Two sites are in forested areas, one a grassland prairie, another on an active floodplain, and one is a dry rock shelter. The winters and summers vary widely from one another in their temperatures, as well as their annual rainfalls. These different environments provided the opportunity to test the sampling methods under different soil conditions in order to see if adjustments needed to be made for practicality's sake, and to help determine soil conditions that are more likely to have hair survival. An examination of soil chemical properties was also made where possible. The Hanson Reservoir sites were sampled by Robson Bonnichsen in 2004 using a method different from the one here proposed, and is used as a comparative method (Turner and Bonnichsen 2005). The samples from the Hanson sites are also used in the laboratory method portion of the thesis, and the results of their analysis included.

Figure 2.1 Locations of Sites in Study: 45KI280, 45KI281, 41ML262, 41VV167, and Estes Ranch Site.

Bonnichsen's Method and the Hanson Reservoir Sites (45KI280 and 45KI281)

The Hanson Reservoir sites are located on the Green-Duwamish River in King County in western Washington, on U.S. Army Corps of Engineers, Seattle District property near the Howard A. Hanson Dam (Figure 2.2). They are on the northern end

of the Southern Washington Cascades Physiographic Province in the *Tsuga heterophylla* vegetation zone, an area important for its timber production (Boreson 1999). Site 45KI280 is located just south of a low area thought to be a former swamp, and boasts a top soil layer of dark loam, with a sandy loam beneath. Artifacts from 1998 test excavations afforded evidence of possible occupations ranging from 9,835 B.P. to 150 B.P., and an "oxidized sediment" carbon date provided a date of 2,890 ± 110 B.P. (Boreson 1999). Based on preliminary investigations, site 45KI281 is believed to be a major campsite used for the manufacture of tools. It sits on a terrace traversed by two small creeks that is eroding the site significantly (Boreson 1999). According to investigators, the site sediment is a dark brown loam with charcoal streaks throughout until about 35 centimeters below the surface, where a massive sand horizon begins and continues to an unknown depth. Investigators have not yet published dates for this site, but believe it will mirror site 45KI280 (Boreson 1999).

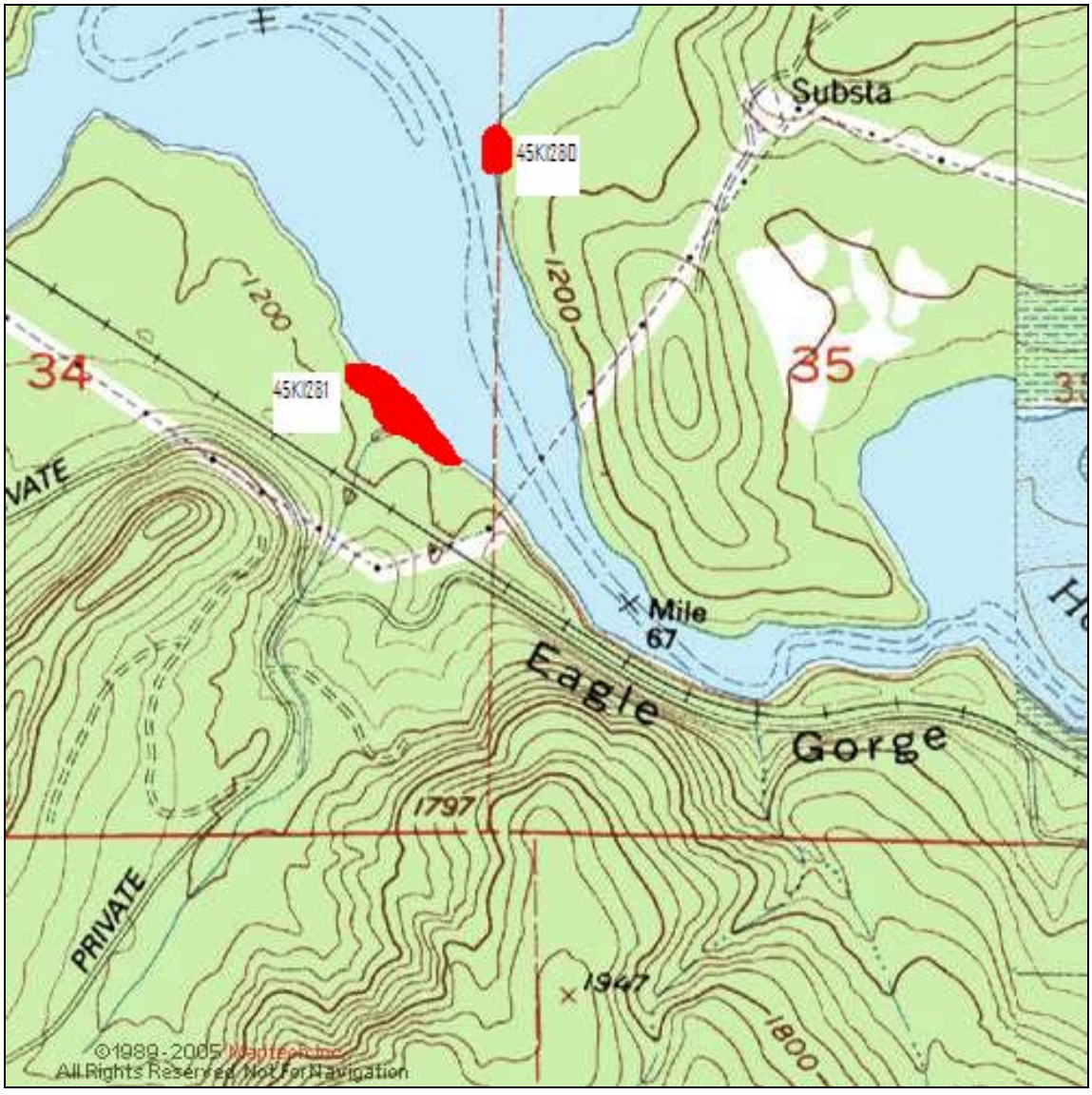

Figure 2.2 Howard Hanson Sites 45KI280 and 45KI281
(Maptech USGS Quadrangle 1:24,000 scale, 1989)

In March 2004, Robson Bonnichsen with the Center for the Study of First Americans at Texas A&M University traveled to the Hanson Reservoir sites in Washington in order to extract soil samples for possible ancient hair research. According to Bonnichsen's field notes, a 40 x 40 centimeter quad unit, 83N 100W, in

45KI280 was selected first for testing since it was relatively clear of debris and the stratigraphy of the occupation zone easily identifiable from the wall of the neighboring unit (Bonnichsen 2004). In his notes, Bonnichsen (2004) also observed the area had evidence of significant tree throw and forest fire modification. Bonnichsen and crew then moved to an area around a burned rock feature in unit 101N 111W for sampling. After completing their testing at Site 45KI280, the crew moved to Site 45KI281, and excavated 40 x 40 centimeter column of samples from the northwest corner of unit 498N 501W (Bonnichsen 2004; Turner-Pearson and Bonnichsen 2005).

The most important element of any hair sampling project is to avoid contaminating the samples with modern hair and pollutants that could skew any test results. Therefore, strict field collection methods were established by Bonnichsen and his crew. First, a framework made of 6.5 centimeter (2.5 inch) PVC pipe, covered with translucent plastic was placed over the units being sampled (Figure 2.3). All the tools were cleaned with Lysol sanitation wipes before and after the excavation of each level. To avoid contaminating the samples with their own hair, Bonnichsen and his crew covered their heads either with cotton head and facial protectors, or disposable surgical hair covers and masks. Head masks were tucked into new Tyvek coveralls, which were discarded and replaced after the completion of collections at each site (Figure 2.4). The crew also wore disposable surgical booties as well as new rubber gloves which were discarded and replaced before proceeding to a new column or unit (Bonnichsen 2004; Turner-Pearson and Bonnichsen 2005). To remove the samples, the crew used a sterilized 2 liter pitcher to measure each sample, taking a total of six liters from each

level. These were placed in 9.45 liter (2.5 gallon) plastic bags (Bonnichsen 2004; Turner and Bonnichsen 2005).

Figure 2.3 Crew Assembling Plastic Isolation Tent.

Figure 2.4 Robson Bonnichsen Prepares to Take Samples Under Isolation Tent.

At Site 45KI280, Bonnichsen and crew excavated a 40 x 40 centimeter column in the northwest quadrant of unit 83N 100W, using arbitrary ten centimeter levels. The levels started at the surface and sampling extended to 100 centimeters below datum. The bottom two levels, 100-120 centimeters below datum, consisted of water soaked sands and gravels and were not sampled (Bonnichsen 2004; Turner-Pearson and Bonnichsen 2005). Using the same methodology, Bonnichsen and crew excavated the lower fifteen centimeters of a burned rock feature in unit 101N 111W. This correlated with 20-35 centimeters below the datum (Bonnichsen 2004; Turner-Pearson and Bonnichsen 2005).

After Bonnichsen left Washington and returned to Texas, the crew moved to site 45KI281, and obtained a 40 x 40 centimeter column of samples from the northwest corner of unit 498N 501W, using the same methodology as used by Bonnichsen (Turner-Pearson and Bonnichsen 2005). The column started at the surface of the unit and extended to 80 centimeters below the datum (Bonnichsen 2004; Turner-Pearson and Bonnichsen 2005).

In order to further protect the samples from contamination, field processing was conducted under a specially erected tent. Under the tent, the crew, still dressed in protective gear, wrapped the samples in fine netting and washed them with tap water; the samples were never left exposed to the open air. After washing, the samples were left in their netting and placed in large plastic bags and shipped to Texas A&M University for analysis (Bonnichsen 2004; Turner-Pearson and Bonnichsen 2005).

Proposed Field Methods

While Bonnichsen was certainly careful and scientific in his field methodology of soil extraction in his search for ancient hair, it lacked the practicality necessary for widespread use among archaeologists, especially in the Southern States where summer temperatures often exceed 100°F. Therefore, the author sought a simpler method of sampling that would not involve hot clothing and plastic tents, yet minimize possible contamination. To test the practicality of the new method, three sites in Texas were chosen. Each had a different environment and soil type, and all three were sampled

during the summer months, in order to ascertain the method's practicality in the Texas heat.

The Estes Ranch Site

The Estes Ranch site is located on the second terrace on the north side of North Cow Bayou in McLennan County, Texas near present day Lorena (Figure 2.5). The 1,500 acre ranch lies on the Balcones Fault Zone, with the Grand Prairie to the west and the Blackland Prairie to the east. Both the South Bosque formation consisting of limestone and shale, and the Austin Chalk formation consisting of chalk and marl are represented on the ranch. The soil on the hill above the site is Heiden clay, Stephen-Eddy complex, while the terrace slope, where the site is located, is Lott silty clay (Miller and Greenwade 2001). The average winter low in McLennan County is 35 degrees Fahrenheit, and the average summer high is 95 degrees Fahrenheit, with an average annual rainfall of 33.4 inches (Miller and Greenwade 2001).

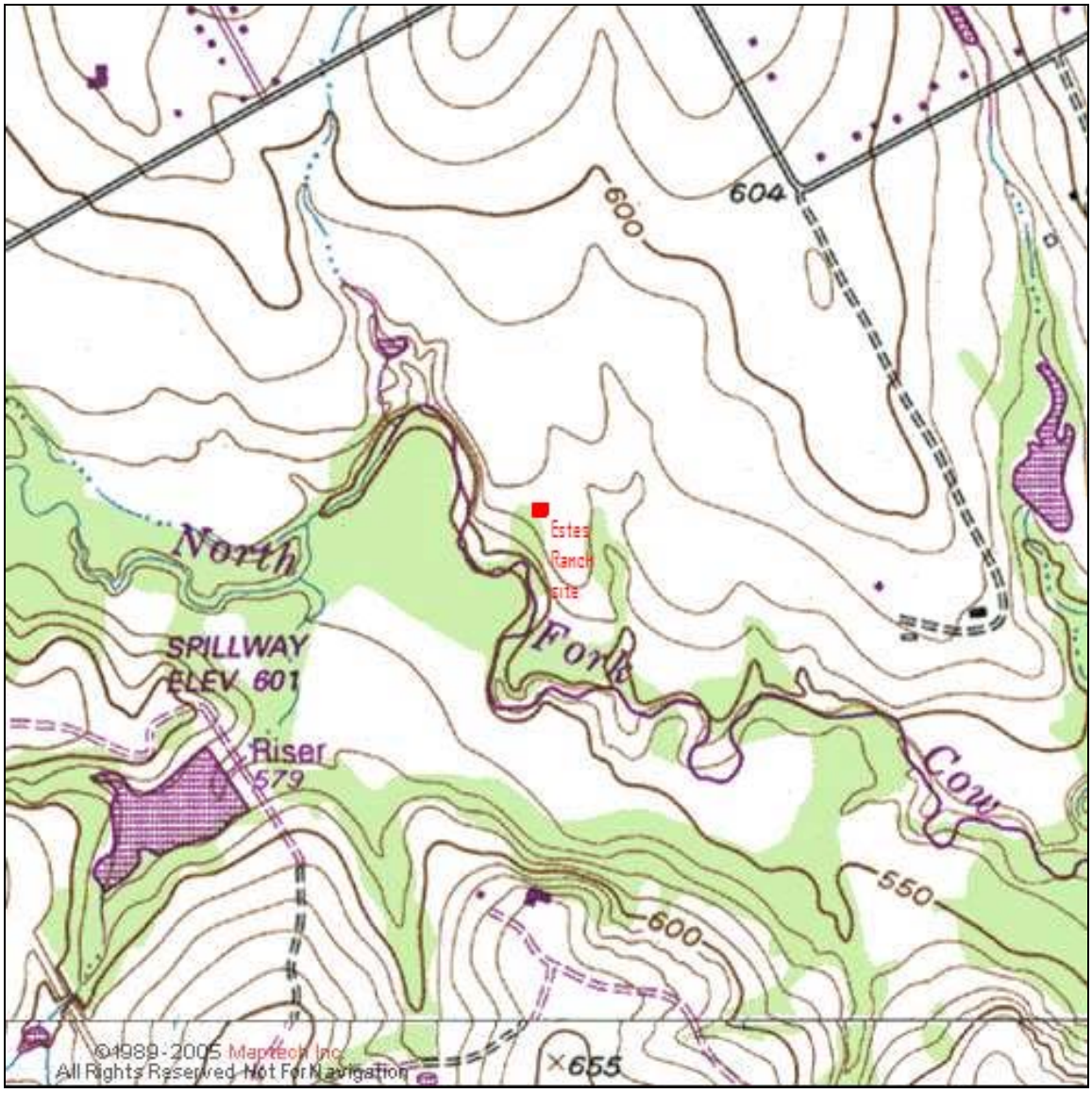

Figure 2.5 Estes Site Location.
(Maptech North Fork Cow Bayou USGS Quadrangle 1:24,000 scale, 1989)

Early evaluations of the site indicate a 9,000 to 6,000 B.P. Late Paleo/Early Archaic site with multiple burned rock features (Cook 2005; Hester 1997). Excavations at the site by Baylor University's Anthropology Department started in 2003 and are on-going. The samples were taken in May 2005, during Baylor's summer field excavations.

The soil at the site holds great shrinking and swelling capabilities, and at the time of the sampling, the soil was dry with deep cracks in its surface. The samples were taken adjacent to two burned rock features. The first group of samples was taken in unit E1 N37, Feature 7, and the second group was taken from unit W5 N38, Feature 9[2]. Both units were in an occupational zone approximately 21-25 centimeters below datum. The sample from Feature 7 shows a Munsell dry soil color of 10YR 6/2 light brownish gray, and the sample from Feature 9 exhibits a dry Munsell soil color of 10YR 5/2 grayish brown (GretagMacbeth 2000).

In anticipation of the sampling, several two centimeter diameter (3/4 inch) PVC pipes, approximately 20 centimeters long, with end caps of matching size were sterilized using 70 percent isopropyl alcohol[3] and air dried. The end caps were placed on the tubes after they dried. At the site, all tools were sterilized using disposable alcohol sanitizing wipes. The author donned a disposable surgical gown, surgical hair cover, and disposable gloves. All other crew members were asked to move away from the area. Standing in an open unit, the wall showing both the occupation zone and feature in the adjacent unit, was scraped using a sterilized trowel. After removing the cap, the open side of the PVC pipe was placed against the cleaned wall of the unit, and using a rubber mallet, the pipe was pounded into the wall until it reached into the surface to its entire

[2] Garrett Cook from Baylor University later informed the author that he discovered that Feature 9 had been excavated in a previous field school, and then backfilled. Therefore any hair found in that feature would be compromised. For purposes of this paper, the feature was included in the final report, since the purpose of the sampling was to test the practicality of the sampling method in different situations. However, if any hair was found in the samples, it would not have been tested, and the soil from the feature, while analyzed, was not used in any final analysis of the availability of hair in certain soil conditions.

[3] Alcohol kills cells by the denaturing of cell proteins, hindering cellular metabolism and destroying cell membranes. Proteins are not denatured as readily by alcohol in the absence of water, therefore a solution of 70 percent alcohol and 30 percent water is a better sanitizer than 100 percent alcohol (Berube and Oxborrow 1991; Larson and Morton 1991)

length. The pipe was then carefully removed and the end cap quickly put in place. The end caps were then secured with duct tape, and the pipe numbered, labeled, and placed in a canvas bag for transport (Figure 2.6). Three samples were taken in this manner at each feature. In retrospect of this sampling, the author realized the PVC pipe would have gone into the hard soil easier if the ends were beveled, creating a sharper edge. This oversight was corrected on all future testing.

Figure 2.6 Taking Samples at the Estes Ranch Site.

The Rainbow Lake Site (41ML262)

The Rainbow Lake Site (41ML262) is believed to be a Late Archaic (3,500 - 1,250 B.P.) (Hester 1997) seasonal camp site that rests on the floodplain of a small private lake in a wooded area in Woodway, Texas (Figure 2.7). The lake is part of a ravine and stream complex that drains to current Lake Waco. The private lake was formed in the ravine system in the 1920s (Donald Turner, personal communication 2005). Previous to the lake construction, the site was situated on a high terrace above the creek with a small seasonal spring running beside it and into the main stream system. The predominant feature of the site consists of multiple rock hearths and ovens. The site is situated in McLennan County with the Grand Prairie to the west and the Blackland Prairie to the east. The temperatures and rainfall for the site mirror the Estes Ranch site, with an average winter low of 35° F, and an average summer high of 95 degrees Fahrenheit. The average annual rainfall is 33.4 inches (Miller and Greenwade 2001). Soil analysis for the site indicates an Eddy-Urban soil complex, sandy clay loam (Miller and Greenwade 2001). This soil swells when wet, but cracks are seldom found in it when dry. Soil samples taken show a Munsell dry soil color of 7.5 YR 4/2 brown (GretagMacbeth 2000).

Figure 2.7 Rainbow Lake Site 41ML262 Location.
(Maptech, Rainbow Lake USGS Quadrangle 1:24,000 scale, 1989)

For sampling at the Rainbow Lake site, the same protocol was used as was at the Estes site. The tools and PVC pipe were sterilized, and disposable surgical gear and gloves were worn. However this time four centimeter (1.5 inch) PVC pipes of approximately twenty-two centimeters length were used, which had been beveled on one

end before sterilization. A larger diameter of pipe was used than at the Estes site, due to the substantial depth of occupation found at the Rainbow Lake site. This site has a very slow sediment accumulation and the occupation zone of the site begins at only five to ten centimeters below the surface. Therefore, it is very likely that any hair found in the site might be a modern intrusion that has worked down into the site from the surface. This fact might make the site an unsatisfactory locale for hair sampling, but since the primary purpose of the research was to develop a sampling technique in different soil environments, it served well. In July 2005, six samples were taken from unit S1 E23, which lays in the area of one of the fire hearths most recently unearthed in excavations. These samples were much easier to extract than at the Estes site, due in part to the beveling of the pipe end, but also due to the soil composition. The soil at the Rainbow Lake site contained significantly less clay that the Estes site, making the dry soil easier to penetrate. These samples were also sealed with caps, duct taped, labeled and taken to the laboratory for further processing.

Eagle Cave (41VV167)

Eagle Cave (41VV167) is a large Cretaceous limestone rockshelter located in Mile Canyon near the Amistad Reservoir one-fourth mile upland from the Rio Grande River at Langtry, Texas in the divide between the Stockton Plateau on the west and the

Edwards Plateau on the east (Ross 1965; Sobolik 1996) (Figure 2.8). It is positioned on the edge of the mesquite chaparral zone of the Tamaulipan biotic province to the south, the oak-cedar zone in the Balconian biotic province to the northwest, and the sortol-lechuguilla zone of the Chihuahuan province to the west (Sobolik 1996) Formations consist of the Comanche and Gulf series. The annual rainfall is only about 18 inches per year. The rockshelter is approximately 56.5 meters (185 feet) long and 26.5 meters (87 feet) deep, with an overhang of about 27.5 meters (90 feet) above the talus slope (Ross 1965). Partial excavations of the site in 1963 revealed nine stratigraphic occupation zones ranging from the Early Archaic (8,500 – 6,000 B.P.) to Late Archaic (3,500- 1,250 B.P.) (Hester 1997; Ross 1965). Since the shelter never floods, all horizons are loose, silt-sized loess, some mixed with fibre, and others with ash, and are considered sediment, not soil. Previous excavations showed a high level of organic material in the sediments with excellent preservation (Ross 1965; Elton Prewitt, personal communication 2005).

Figure 2.8 Eagle Cave Site 41VV167.
(Maptech, Mile Canyon USG Quadrangle 1:24,000 scale, 1989)

Figure 2.9 Looking from Eagle Cave into Mile Canyon. Note Remains of Wall from 1963 Excavations.

Mile Canyon is privately owned and access to it and Eagle Cave is highly restricted. However the landowners, Jack and Wilma Skiles, allowed samples to be taken under the watchful eye of Elton Prewitt in July 2005. No excavations have taken place since 1963, but a small portion of the exposed trench wall still remains (Figure 2.9). The rest of the wall has since been covered with loess and ceiling spall, and the majority of the site has not been excavated. The trench profile indicates nine distinct stratigraphic levels, each narrowly defined. Because of the shallow depth of each occupation zone, the diameter of the PVC pipe was decreased to 1.3 centimeters (1/2 inch). Each pipe was cut to approximately sixteen centimeters in length and beveled on

one end. All sterilization methods as in the other sampling were followed. Elton Prewitt, the landowner, and several other interested people accompanied the author to the site and were present during the sampling. The people who chose to watch the process closely, all agreed to wear the disposable gowns, hair caps, and masks as described above. They also gave hair samples (head and beard) in order to rule them out as possible donors should human hair be found in the samples. Nine samples were taken at the site, one from each occupation stratum. Since the strata were lying on top of each other with no sterile soil between them, and the sediments were dry and loose with little to no coherence to bind them together, the samples were taken in a zigzag pattern, so as to keep one level from collapsing into the other. The author would have preferred a larger sampling of each horizon, but was restricted to just the small area of the exposed wall (Figure 2.10). These samples were sealed, labeled and transported to the laboratory in the same manner as samples from the previous two Texas sites.

Figure 2.10 Taking Samples at Eagle Cave.

Nine stratigraphic horizons were sampled from top to bottom, with dry Munsell color readings as follows: sample 1: 2.5 YR 7/1 light reddish gray; sample 2: 2.5 YR 5/1 reddish gray; sample 3: 2.5 YR 7/1 light reddish gray; sample 4: 2.5 YR 5/1 reddish gray; sample 5: 2.5 YR 7/1 light reddish gray; sample 6: 2.5 YR 3/1 dark reddish gray; sample 7: 2.5 YR 4/2 weak red; sample 8: 2.5 YR 2.5/2 very dusky red; and sample 9: 2.5 YR 4/1 dark reddish gray (GretagMacbeth 2000).

Alternative Method

At the conclusion of the sample recovery at the three Texas sites, the author compared the amount of soil collected using the above method, to the amount from the Hanson Reservoir sites using Bonnichsen's method (Bonnichsen 2004) and realized there was a great difference between the total volume of soil recovered from the Texas sites and the Hanson Reservoir sites. Therefore, another method of collecting soil samples was entertained in an attempt to increase the total volume of soil collected for hair recovery that would still keep sample integrity intact

The author fashioned a small framework of welding rods into a one meter by 1.5 meter tent frame approximately twenty centimeters high, connecting the corners with metal wire. The frame was then covered with clear plastic sheeting, and after carefully scraping the overburden away, it was placed over half of Unit N2 E23 of the Rainbow Lake Site (41ML262). The low height was due to the shallow occupation horizon at the Rainbow Lake site, which starts approximately five to ten centimeters below the surface. The author donned gloves, and reaching under the tent, carefully removed ten centimeters of soil from half the unit, placing the soil into gallon sized zip-style bags (Figure 2.11). The bags were filled while under the tent to prevent contamination of the sample with modern hair. The process took very little time to complete, and the other half of the unit could have been excavated in the same manner by simply moving the tent over that portion of the unit. The bags were later transferred to the laboratory for processing.

Figure 2.11 Taking Samples at the Rainbow Lake Site Using the Alternative "Mini Tent" Made with Welding Rods.

CHAPTER IV

LABORATORY METHODS AND RESULTS

Laboratory Methods for the Hanson Reservoir Sites (45KI280 and 45KI281)

Special precautions to prevent contaminating the samples with modern hair continued in the laboratory at Texas A&M University. When handling the Hanson Reservoir samples in the open laboratory, personnel wore long sleeved disposable surgical gowns, surgical head covers, and rubber gloves. Samples were removed one-at-a-time and each net bundle containing a sample was placed into a specially designed net bag, which was folded over and stapled shut. The double netted bag was then placed in a disposable surgical hair-cover, which was wrapped around the sample bags and stapled shut. Each sample was then soaked individually in an aqueous solution of sodium metahexaphosphate[4] to dispense the sediments which had high clay contents (Figure 3.1). After twenty minutes, the samples were rinsed under running tap water and placed on drying racks, covered with another surgical hair-cover to avoid outside hair contamination, and allowed to dry. After drying, the netted and covered samples were placed in large plastic bags.

Once cleaned and dried, each sample was placed independently in a sterilized,

[4] Sodium metahexaphosphate $(NaPO_3)_6$ and sodium hexametaphosphate $(NaPO_3)_6$ are common names for sodium polymetaphosphate $(NaPO_3)_n$.

enclosed isolation box. This box had a Plexiglas top and side, long gloves attached to the Plexiglas side that allowed work inside the box, and a two-part pass tube with inside and outside covers. A rectangular glass plate was placed on the bottom of the box. The box and all tools were cleaned and sterilized with isopropyl alcohol. In processing, a sample was removed from its plastic bag and passed through the tube. Using the attached gloves, the net bag was cut open using sterilized scissors, and the contents placed on the glass plate. The sample was then sorted using a sterilized magnifying glass, knife, and tweezers. Sorting was accomplished by examining every tiny object and ped individually, then pushing it aside with the dull knife. Any fibers that looked like hair were placed in glass test tubes for later analysis under a microscope. After completing the sorting of a sample, the box and tools were again sterilized with isopropyl alcohol before proceeding to the next sample.

Figure 3.1 Net Bags of Samples from the Hanson Site Being Washed.

Samples from the column at Site 45KI281 (498N 501W, NWC, 0-80 cm. bd., samples 1 - 8), and sediments from two opposing quarters of the feature at Site 45KI280 (101N 111W, NWC, 20-35 cm. bd., samples 11 & 13) were more closely analyzed and divided into categories; charcoal, wood, seeds, chert flakes, and other artifacts, and bagged separately. Each category of material was weighed, with the chert flakes divided by size before weighing.

Hanson Results

Site 45KI281 – Unit 498N, 501W

The items found were charcoal, wood, seeds, and chert flakes. The majority of the objects were found in levels 1-4 (Table 1). No hair was recovered.

Site 45KI280 – Unit 101N, 111W

The items found in association with the burned rock feature were charcoal, wood, seeds, chert flakes, and one glass bead. The unit contained larger pieces of charcoal and wood than the other site, as well as more seeds (Table 2). The glass bead was charred and approximately 1mm in diameter (Figure 3.2). No hair was recovered.

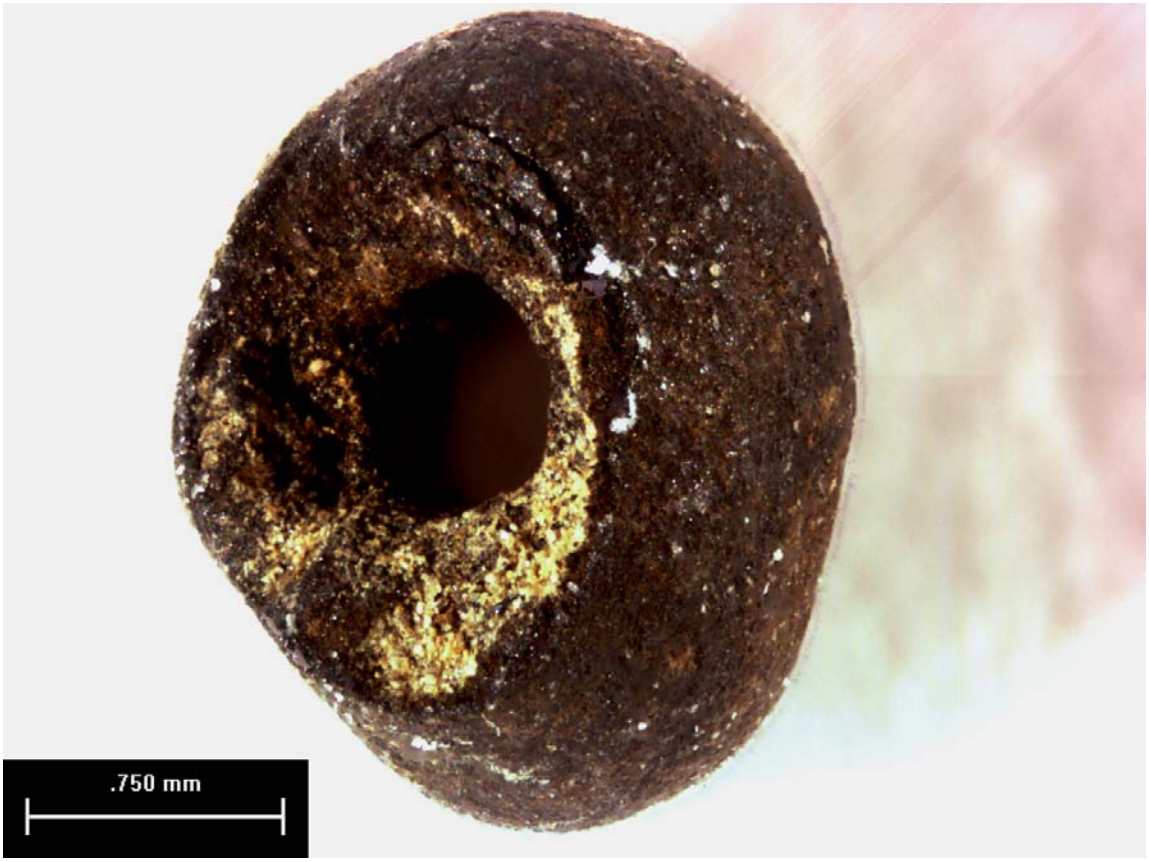

Figure 3.2 Charred Glass Bead from Hanson Site.

Table 1: Materials recovered from the column sample at Site 45KI281 (Unit 498N, 501W). Dates of each level are not yet determined.

LEVEL #	CHARCOAL (g)	WOOD (g)	SEEDS (g)	CHERT FLAKES (g)	Number of Chert Flakes (<1 cm)	Number of Chert Flakes (>1 cm)
Level 1	49.88	38.82	0.93	0.84	54	1
Level 2	65.08	6.73	1.29	0.11	22	
Level 3	26.28	0.78	0.18	1.43	11	1
Level 4	9.42	0.02	0.08	0.10	15	2
Level 5	4.21	-	-	0.02	3	-
Level 6	0.90	0.19	0.01	-	-	-
Level 7	0.71		0.01	0.02	1	-
Level 8	1.92	-	-	0.01	4	-
Total	158.40	46.54	2.50	2.53	110	4

Table 2: Materials recovered from the feature at Site 45KI280 (Unit 101N, 111W).

QUADRANT	CHARCOAL (g)	WOOD (g)	SEEDS (g)	CHERT FLAKES (g)	Number of Chert Flakes (<1 cm)	Number of Chert Flakes (>1 cm)	Number of Beads
NW Quad	64.75	7.96	0.38	1.49	40	3	
SE Quad	151.16	28.31	3.71	0.63	40	2	1
Total	215.91	36.27	4.09	2.12	80	5	1

Laboratory Methods for Samples from Estes Ranch, Rainbow Lake, and Eagle Cave

In the laboratory, the same isolation box was used as for the Hanson Reservoir samples. The box and all tools were sterilized with isopropyl alcohol between each sample processed. The closed PVC pipe containing the sample was placed into the pass tube, and the unit closed. The tube was opened on the interior side of the box, and the PVC pipe placed onto the glass plate. Since the samples from the Hanson site took an extremely long time to process, the author sought a faster method of sorting for the three Texas sites. In order to expedite the sorting process, the duct tape was removed from the sealed PVC pipes and the contents poured into the first of three sieves (diameters of 0.850 mm, 0.425 mm, and 0.212 mm). The sieves were then hand-shaken in order to move the samples through to the smaller screens below. The finest particles that passed through all the sieves landed on the sterilized glass plate. The contents from each sieve

was then placed in small plastic bags. This created four distinct groups for each original sample. The bags were then sealed and removed by way of the pass tube, and labeled upon removal from the chamber.

To examine the samples for hair under magnification, the bags were placed back into the chamber, and the contents transferred to a sterilized glass petri dish with a glass lid, then removed from the chamber by the pass tube. The petri dish was then placed under a microscope and the contents search for hair. For samples with a lot of fiber, it was necessary to use more than one dish, and to shake the dish from time to time in order to ascertain if any fiber or hair were lying beneath each other. When hair was discovered, the lid was lifted just enough to allow sterilized tweezers into the dish, and the hair was removed and immediately placed on a glass slide. Immediately a cover plate was taped over the hair. Great care was taken to keep hair from getting into the dish and the recovered hair was locked between the glass slide and cover as quickly and carefully as possible. The slide was labeled and the hair could then be studied in detail under the microscope.

Results from Estes Ranch, Rainbow Lake, and Eagle Cave Sites

There are subtle microscopic variations in the morphology of hair between species, and in many cases, between subspecies (Appleyard 1978; Teerink1991; Moore et al. 1974). These variations not only make a difference in the texture of the coats of animals, but in their strength and other properties that make some animal fibers more sought after in the textile industry than others (Appleyard 1978; Wildman 1954). The

identification of hair has forensic applications (Hicks 1977; Sachs 1996; Teerink 1991) as well as possible archaeological relevance (Bonnichsen and Bolen 1985; Holden 2001); however, making an absolute species classification is difficult, and relatively few fiber taxonomy books are available. In order to make a reliable identification, one must look at both fiber microscopy photographs and comparison samples from known species (Moore 1974; Teerink 1991; Wildman 1954). It is also necessary to examine the hair as a whole mount and observe the scale pattern as well as the medulla, and then to cross section the hair with a microtome for further analysis of the cuticle and medulla interior (Appleyard 1978; Teerink 1991; Wildman 1954). There are no short cuts to hair identification; there are no reliable measurement methods or chemical tests that can take the place of a systematic microscopic evaluation and sample comparison (Moore 1974). Therefore, it is recommended that hair recovered from archaeological sites be sent to an expert in the field of fiber microscopy to insure the samples are properly identified.

The author did not have comparison hair samples available or a microtome, and is certainly a novice at fiber microscopy. Limited funds prevented the author from sending the hair samples to a specialist for identification. Since the purpose of this research is to find a scientific method of hair recovery, absolute identification of the recovered hair was not deemed necessary. Therefore, the author made preliminary identification of recovered hair using microscopic observations and comparisons to descriptions and photographs in available hair and fiber identification books. In most cases, the identity was narrowed to an order and family, and all were based on the author's non-expert analysis. It is easier to "rule-out" a particular species, than to make

a positive identification, and many species were discarded as possible hair contributors, including humans. Human hair from all body regions is very distinguishable (Appleyard 1978; Moore 1974; Teerink 1991; Ogle and Fox 1999), and the author is certain that none of the hairs recovered are human.

Each of the recovered hairs was prepared for observation under the microscope by placing a small strip of double sided tape on a glass microscope slide, then placing the hair end on one side of the tape. The other end of the hair was then covered with a piece of double sided tape and a slide cover placed on top. Then the slide cover was secured more firmly to the slide by the addition of scotch tape on its ends. A couple of drops of distilled water were used as a viewing medium. Water was selected to prevent contamination of the hair with other chemicals that might skew any future testing conducted on the hair.

The pipe sampling method recovered a total of five hairs from two of the sites, one from Eagle Cave and four from Rainbow Lake. The Eagle Cave hair was recovered from Stratum IIa with a carbon 14 date of 1300-1620 B.C (Ross 1965). The hair is white and coarse with some of the root remaining, and was the most difficult hair to identify. In full mount observations, its scale pattern most closely resembles an *irregular-waved mosaic* pattern or a *regular petal* pattern, and its medulla as *unbroken vacuolated* or *unbroken with cortical intrusions* (Appleyard 1978; Moore 1974). The medulla is wide, occupying more than one-half the shaft width. The author's tentative identification put the hair's donor as a member of the Order Carnivora, Family Felidae, with the most likely candidate a mountain lion (*Felis concolor*) (Moore 1974). Special attention was

given in ruling out the common house cat (*Felis ocreata catus*) in order to make sure no contamination of the samples had occurred (Figure 3.3). The domesticated cat hair is distinguishable from the mountain lion hair in several areas, including the width of the medulla, scale pattern, and medulla pattern (Appleyard 1978; Moore 1974; Teerink 1991). The author also examined hairs from her own domestic cats in order to eliminate them as possible modern contaminates.

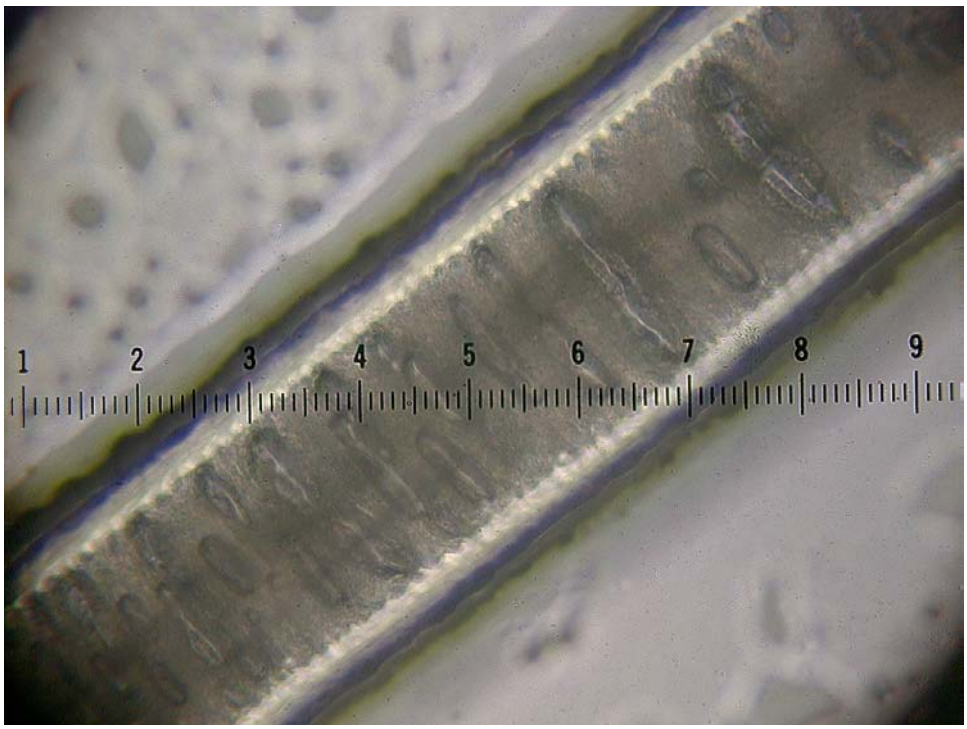

Figure 3.3. Hair from Eagle Cave Sample E.C.1 (400x).

Samples from the Rainbow Lake site produced four hairs, each distinctly different and representing three different species of animals. The first sample (RL.1) (Figure 3.4) presented an *irregular petal pattern* and its medulla resembled a *uniserial*

ladder[5] (Appleyard 1978; Moore 1974; Wildman 1954). Its identification most resembles the Order Rodentia, Family Cricetidae, Subfamily Cricetinae, and is most likely from a mouse (Genus-*Murinae*), though the author was unable to ascertain which species contributed the hair (Appleyard 1978; Moore 1974; Teerink 1991; Wildman 1954).

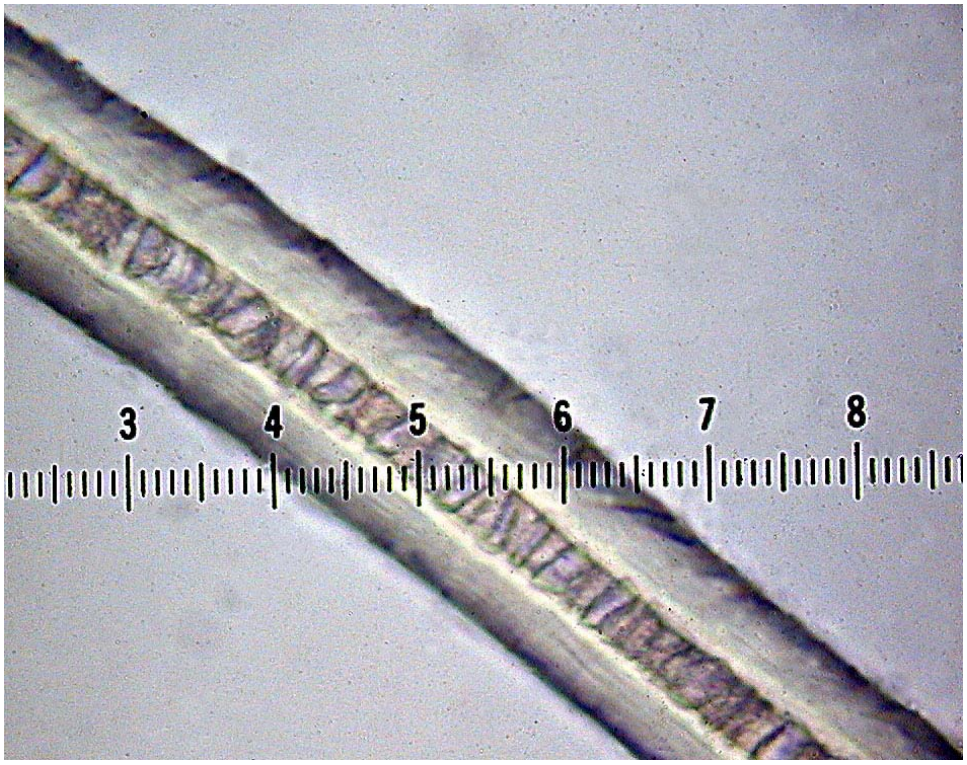

Figure 3.4. Hair from Rainbow Lake Sample R.L.1 (600x).

The second and third hairs from the Rainbow Lake Site (RL.2 and RL.3) (Figures 3.5 and 3.6) were from the same level and displayed a *double chevron* scale pattern and

[5] Appleyard (1991) refers to both uniserial ladder and multiserial ladder medullas as simply "ladder."

a *uniserial ladder* medulla, and are identified as rabbit hair (Order Lagomorpha, Family Leporidae) (Appleyard 1978; Moore 1974; Teerink 1991; Wildman 1954). Again, the species of rabbit is unknown, and it is uncertain whether the two hairs came from the same animal.

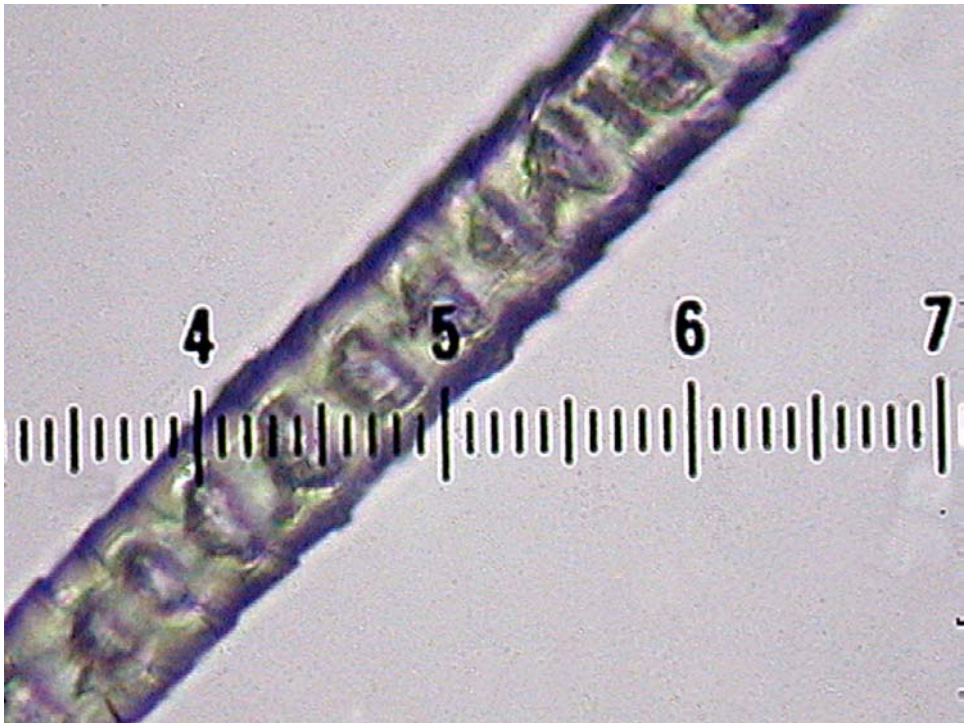

Figure 3.5. Hair from Rainbow Lake Sample R.L.2 (800x).

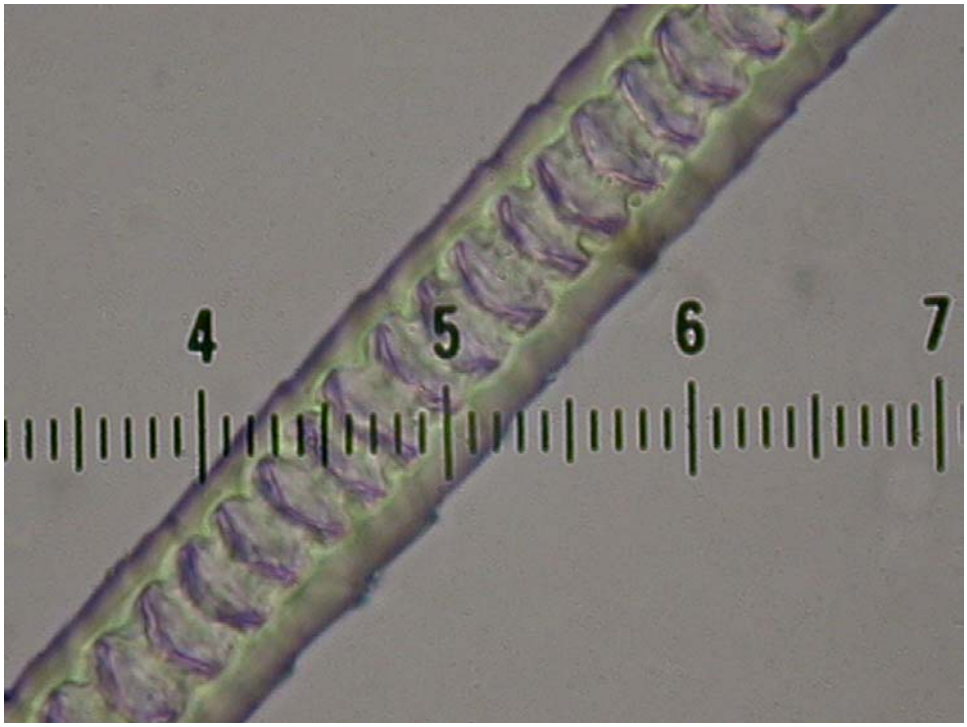

Figure 3.6. Hair from Rainbow Lake Sample R.L.3 (800x).

The fourth hair recovered from the Rainbow Lake Site (RL.4) was very difficult to identify partially due to its density (Figure 3.7). It was difficult to see the medulla or scale pattern using a whole mount observation. It appears to have a *mosaic* scale pattern and an *unbroken* medulla with *cortical intrusions* (Appleyard 1978; Moore 1974; Wildman 1954). There are several possibilities as to which animal to attribute the hair, as the general patterns are found in many animals. Unfortunately, discussions in the fiber identification books were conflicting in their descriptions of the animal hairs in question. However, the author found the hair to be most consistent with squirrel (Order Rodentia, Family Sciuridae) (Appleyard 1978; Moore 1974; Teerink 1991; Wildman 1954). It is not known which specific species of squirrel to attribute the recovered hair.

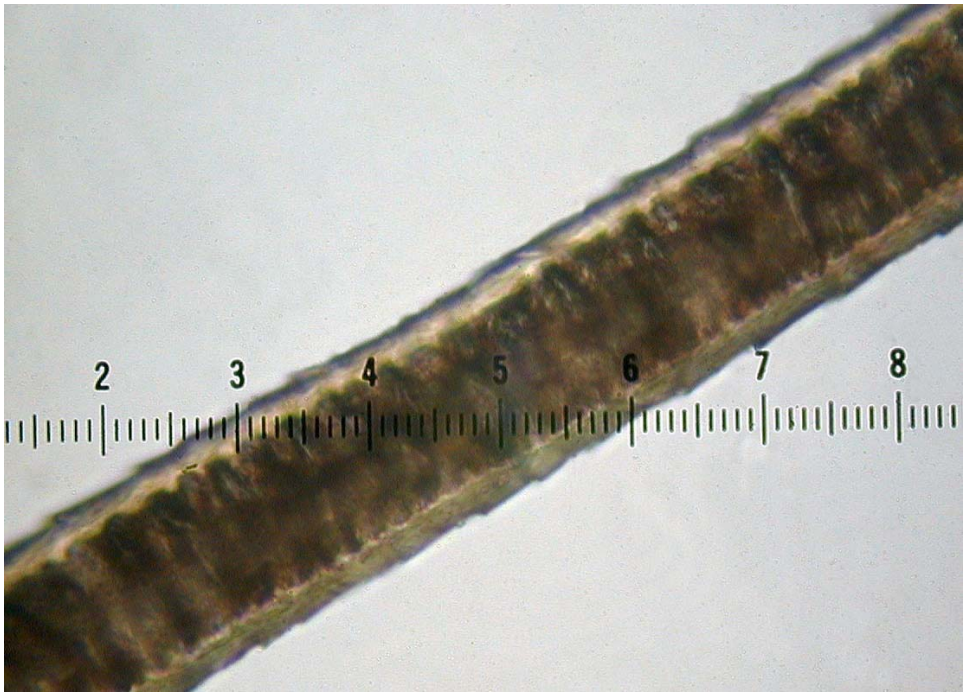

Figure 3.7. Hair from Rainbow Lake Sample R.L.4: (400x)

No hair was recovered from the Estes Ranch site. This site has approximately 432 cubic meters of soil in the known boundary of the occupation zone, and approximately 62.83 cubic centimeters of soil were recovered in sampling. This means only 0.0000872 percent of the site's soil was searched for hair. One could interpret the absence of hair in the samples as meaning that no hair survived at the site, or that the wrong locations were sampled and that hair still exists at the site, but the researchers failed to recover it. One could also argue that hair existed in the samples, but were not

found in the laboratory. There is no definitive way of knowing the answer without obtaining and processing more samples. However, since only a miniscule amount of the site was sampled, it is very much like the proverbial search for a "needle in a haystack," so that the lack of evidence of hair does not necessarily mean a lack of existence as it pertains to hair. It does mean that the soil chemical and physical properties should be taken into account when determining which sites to search in the future, as soil properties could be at least partially responsible for the lack of hair in the samples. Like so many cases in science, more testing is needed.

The samples from the alternative method of soil collection will be processed in the same manner as the above with the only difference being the amount of soil available.

CHAPTER V

SOIL ANALYSIS

Little has been reported about the effects of the burial environment on hair other than those associated with coffin metals leaching into hair (Brothwell and Grime 2002; Casallas et al. 2002; Radosevich 1993; Wilson et al. 2001). Archeologists have been remiss when it comes to studying the possible ion exchange that could occur in the soil that would affect not only the hair condition, but any testing for trace minerals in the surviving hair. High levels of elements such as calcium, iron, sodium, and lead in soils could greatly affect hair chemistry, as the hair could "absorb" those elements during ion exchanges that occur in the soil (Brady and Weil 2002; Wilson et al. 2001) and give unreliable data when tested, yet seldom is the soil matrix tested or these possibilities addressed (Brothwell and Grimes 2002; Casallas et al. 2002; Von Gisela Grupe and Dörner 1989; Radosevich 1993).

Recent studies indicate that the soil pH (Cronyn 2001) as well as the water content of the soil (Cronyn 2001; Sokol 2001; Wilson et al. 2001; Zaki et al. 2005) is a major factor in the survival of hair in the archaeological environment, with wet alkaline sites the least likely to have hair remaining (Cronyn 2001; Zaki et al. 2005). Therefore, after soil samples were processed and hair extracted, the soil pH was determined. The samples were also tested for calcium (Ca), phosphorus (P), magnesium (Mg), sulfur (S), sodium (Na), potassium (K), copper (Cu), iron (Fe), manganese (Mn), and zinc (Zn). While not the entire spectrum of the elements found in hair, these are major elements

commonly sought during trace-element analysis of hair (Bland 1984; Frompovich 1982; Mills 2004; Passwater and Cranton 1983), and could possibly be absorbed from the soil matrix into hair after burial, and skew future test data (Wilson et al. 2001).

Soil Analysis Protocol

Much of the soil from the Hanson Reservoir sites were washed out of the covered net bags before processing, and in the laboratory, they were exposed to chemicals used to disperse the sediments. Since any sediment remaining after processing was sent back to the investigators of the sites, no soil samples from the Hanson Reservoir remained for chemical analysis. However, the sediments from the other sites were analyzed.

Preparation of the samples took place at the Texas A&M University Soil and Crop Sciences Department, and all chemical analyses was conducted by their laboratory. Extractions and pH were conducted in the Soil Characterization Laboratory. Phosphorus, potassium, calcium, magnesium, sodium, and sulfur were extracted using Mehlich III extractant for five minutes (Mehlich 1978; 1984) and micronutrients copper, iron, manganese, and zinc were extracted using a 0.005 M DTPA, 0.01 M $CaCl_2$ and 0.10 M triethanolamine solution for two hours (Lindsay and Norvell 1978). Extracts were analyzed by ICP in the Texas Cooperative Extension's Soil Testing Laboratory. The samples that had been divided by grain size by sieves were recombined for the chemical analysis, but each soil horizon was kept separate. Since the samples from the Rainbow Lake site came from the same unit and the same horizon, they were combined for chemical analysis, as were the three samples from the Estes Ranch site Feature 7 and

the three samples from Feature 9. All samples were of two gram size except two samples from Eagle Cave. Due to an insufficient sample size remaining after removal of fibers, only 0.37 grams was used for Eagle Cave 6 and one gram for Eagle Cave 8. All results were expressed in milligrams per kilogram of soil (ppm on soil weight basis).

Soil Analysis Results

The Eagle Cave samples gave soil analysis results that are extraordinarily high in phosphorus (P), potassium (K), magnesium (Mg), sulfur (S), and sodium (Na) compared to the Estes Ranch and Rainbow Lake samples. These high numbers are attributed to the fact that Eagle Cave is a dry rock shelter with only loess and organic additions derived by human and animal activities in which to accumulate sediment, and it receives no rainfall or any other source of water in which to initiate pedogenesis (Brady and Weil 2002). Therefore, none of the chemicals from the human and animal activity can be leached from the sediments, and all of the material is still present in the shelter. This is supported by the pH values presented later. The extraordinarily high level of phosphorus (P) and potassium (K) probably indicates a large number of woody fires occurred in the shelter. This is especially true for phosphorus (P) in the lower stratigraphic levels, samples six through nine, where the phosphorus reached between 1,040 ppm and 2,000 ppm. The lower levels also contained a large amount of plant fibers, which could also contribute to the high concentration. The potassium (K) showed extremely high concentrations throughout the different stratigraphic levels, ranging from 21,600 ppm to 62,300 ppm. In comparison, the phosphorus at the Rainbow Lake site

which was taken along a burned rock feature, only reached 4.96 ppm, and the potassium was 184 ppm. Although extremely high levels of some of the elements were noted in Eagle Cave samples, these levels should not hinder the survival of hair in its archaeological environment, because the dry environment makes it inhospitable to fungi and bacteria that attack hair and chemical reactions that act as an agent of destruction to hair (Cronyn 2001; Wilson et al. 2002; Zaki et al. 2005). It also means that deterioration of organic materials is greatly hindered as demonstrated by the plant and fiber remains found in this, and similar shelters in the area (Dibble and Prewitt 1967; Sobolik 1996). This makes Eagle Cave a prime location for hair survival. Many perishable artifacts, such as woven sandals, knotted fibers, pointed sticks, and checkerweave matting were recovered during the 1963 excavations (Ross 1965). However, archaeologists need to be careful not to allow moisture into any of the soil samples while processing them, as the addition of H_20 could start chemical reactions that could affect any hair remaining in the sample.

The soil analysis from the Estes Ranch site was in the range the author expected. The soil from Feature 7 indicates a larger amount of phosphorus (P) and potassium (K), 8.37 ppm and 211 ppm respectively, then Feature 9 which had 4.54 ppm phosphorus (P) and 140 ppm potassium (K) levels. But the difference is to be expected, as it was later discovered that Feature 9 had been uncovered during a previous year's excavation and backfilled, and then uncovered a second time during the 2005 Baylor field school (Garrett Cook, personal communication 2006). The difference in chemistry between the two burned rock features is most likely caused by this error. The soil pH for Feature 7 is

8.1, and for Feature 9 is 8, indicating a slightly alkaline soil, which reportedly does not lend itself well to hair survival. However the moderate rainfall in the area could offset that disadvantage, and make some hair survival possible (Cronyn 2001; Zaki et al. 2005), as was also demonstrated at the Rainbow Lake site.

The Rainbow Lake Site (41ML262) has the highest calcium (Ca) level of all the samples with 36,900 ppm. It is a highly calcareous soil with a pH of 8. This is not a surprise, since the archaeological site is on a floodplain downhill from a solid limestone rock formation that is deflating, with little topsoil, and the site itself has very slow and shallow soil development. While the sample was taken adjacent to a burned rock feature, it only showed a potassium (K) level of 184 ppm. The site floods occasionally, which would help wash minerals through the soil, and add sediments and nutrients from the floodwaters of the nearby lake. Since hair was found at the site, one would suspect the seasonal flooding might have helped with the hair survival. However the age of any hair found has to be suspect due to the shallow depth of the archaeological occupation (see Table 3).

Table 3: Soil chemistry analysis on samples from Eagle Cave, Estes Ranch, and Rainbow Lake Sites. Units are milligrams per kilogram (ppm) on a soil weight basis.

Laboratory #	ID	P	K	Ca	Mg	S	Na	Mn	Fe	Cu	Zn	pH
R105876	Eagle Cave 1	14.5	21600.0	34600.0	703.0	6170.0	956.0	9.38	4.1	4.57	20.8	10.1
R105877	Eagle Cave 2	496.0	25800.0	20700.0	1950.0	2700.0	2120.0	20.3	19.2	6.67	59.5	7.4
R105878	Eagle Cave 3	84.9	34900.0	23300.0	603.0	5200.0	2460.0	7.6	3.8	3.46	23.1	11.0
R105879	Eagle Cave 4	686.0	62300.0	14900.0	1930.0	6910.0	2710.0	18.5	23.6	4.47	27.9	9.3
R105880	Eagle Cave 5	382.0	45300.0	20100.0	1450.0	6200.0	1150.0	14.8	35.5	8.70	43.5	10.7
R105881	Eagle Cave 6	1130.0	33500.0	14100.0	3600.0	2940.0	2170.0	31.9	65.9	5.20	30.0	6.8
R105882	Eagle Cave 7	1040.0	47600.0	14700.0	4080.0	5060.0	1640.0	28.5	13.9	3.29	19.7	7.3
R105883	Eagle Cave 8	1986.0	39200.0	27000.0	4440.0	4520.0	282.0	30.8	31.4	2.54	22.0	7.3
R105884	Eagle Cave 9	2000.0	38100.0	15900.0	4310.0	4050.0	1130,0	28.5	28.6	1.85	19.0	7.0
R105885	Estes Ranch F7	8.37	211.0	16300.0	94.4	19.3	42.1	88.0	21.2	7.73	32.8	8.1
R105886	Estes Ranch F9	4.54	140.0	17300.0	90.6	12.7	32.9	62.2	16.4	4.95	18.6	8.0
R105887	Rainbow Lake	4.96	184.0	36900.0	196.0	14.4	32.8	36.8	19.6	3.29	5.91	8.1

CHAPTER VI

CONCLUSIONS

Hair survival in the archaeological record is dependant on a variety of factors including, how long the hair is exposed to the elements before it is buried, amount of rainfall, temperature, and the soil properties of the site (Cronyn 2001; Sokol 2001). Fungi and other organisms that assist in decomposition also play a factor in the condition of any ancient hair recovered (Wilson et al. 2002). Yet very few researchers seem to take into consideration the importance of these factors when trying to understand the viability of hair remaining at a site and the impact they may play in test results. Recently Wilson and colleagues (2002) conducted field and laboratory experiments in England, modeling hair degradation in an archaeological site, with some interesting findings. They noted that "survival" of hair does not necessarily mean it is structurally intact, even if it appears intact under a microscope. Although hair is more resistant to decomposition than other biomaterials, and while micro-organisms are responsible for the majority of decay in an archaeological site, only a few specialized organisms can decompose hair (Wilson et al. 2002). When fungi attack the hair in a site, it usually does so by tracking in from the ends of the hair fibre or by tunneling through the outer cuticle, leaving the hair morphology intact upon cursory inspection (Wilson et al. 2002).

Considering the vast amount of information scientists can gleam from a single hair, it may still be worth the effort to look for hair even with the possibility of hair decay in archaeological sites. Although much can be learned from the recovery of

animal hair, including diet and environmental conditions, people often equate success in hair sampling as finding human hair, and that finding animal hair constitutes failure. Consideration of soil properties, particularly the soil pH, and the archaeological environment should provide a logical framework to conclude if hair remains in an archaeological site. If archaeologists choose to search for ancient hair, they need to conduct their investigation in a manner that protects the sample from contamination with modern hair or additions that could skew future test results. These were the areas considered by the author during this project, and in retrospect the areas addressed for future researchers.

Where to Search for Hair

There is no definitive evidence as to soil properties and environments in which ancient hair best survives, and more research needs to be conducted in this area. This thesis examines three sites, but, it is not by any means a broad cross sectional study of the soil and hair survival relationship. There are many factors that can improve the likelihood of finding ancient hair. The first factor is the age of the archaeological site. Logic dictates that the more recent the site, the better the opportunity of hair survival. Also important is the soil pH and water content (Cronyn 2001; Sokol 2001; Wilson et al. 2001; Zaki et al. 2005). Water facilitates the microbial deterioration of materials (Cronyn 2001; Zaki et al. 2005) so sites with low amounts of rainfall, or sites located in dry rock shelters such as Eagle Cave, have much better chances of hair survival than sites in areas of high rainfall or wet caves.

Cronyn (2001) recognizes soil pH is a major factor in hair survival, with alkaline soils the least favorable. Besides Cronyn, there is little research in this area. All of the sites tested in Texas were alkaline, with Eagle Cave yielding the highest pH (11.0). Yet hair survived, and the author suspects more could be found in Eagle Cave if a larger sample size were allowed. All of the sites tested in Texas had low to moderate amounts of rainfall, with Eagle Cave the extreme, with no precipitation entering the shelter, and exhibiting extremely low humidity. The idea that acid soils have better chances of ancient hair survival may come from the fact that while fungi live equally well in both acid and alkaline soils, bacteria and actinomycetes do not (McCourt 1994). This may provide fewer agents of destruction to hair in acid soils than alkaline soils. But hair survives best in xeric environments than mesic environments, and acid soils tend to be found in humid regions, while alkaline soils tend to be found in more xeric regions (McCourt 1994). Obviously, like so many areas of science, the evidence contradicts itself, making a definitive answer difficult, if not impossible. However, based on the results of the sites tested in this project, hair can survive in moderately alkaline soils if rainfall is not excessive.

Although soil conditions are a major factor in, not only hair survival, but in the survival of all archaeological remains, they are seldom discussed in archaeological journals and reports. Soil is not a stagnant entity, but is continually changing. Even while archaeologists are working at a site, removing layer upon layer of soil and sediment, the soil itself is changing beneath them. Ion exchange quietly transforms the soils in the archaeological environment, and is dependant on many factors including

parent material, rainfall, and additions to the soil such as animal waste and plant decay (McCourt 1994; Miller and Greenwade 2001). Human activities have a major impact on soil development and its chemical changes. For instance, fires bring potassium into an archaeological site, which in turn encourages root growth (Miller and Greenwade 2001), and root growth can disturb the buried occupational horizon, moving and breaking fragile and biological artifacts. Human excrement, animal remains, and even pottery and tools, all change the soil composition as the components decompose and weather and their products enter the soil. Metal artifacts bring iron, lead, copper, and other elements into the site that might not have been present in large quantities before, and can alter soil chemistry in an area and in retrospect, the rate of deterioration on artifacts, including hair (Miller and Greenwade 2001).

It seems logical that ion exchanges in the soil could also occur between the soil and the buried ancient hair. If the soil has a high level of iron for instance, it seems reasonable to assume that hair buried in iron-rich soil might "absorb" iron ions, and have higher iron content upon testing than it would have had immediately after shedding from its host. It is also possible that exchanges could cause hair to lose elements as well. Researchers need to be mindful of such ion exchanges when conducting trace element analysis of ancient hair. While the hair recovered in this project was not tested for trace elements, it is recommended that the soil from which hair is recovered be tested when performing trace element analysis on the hair.

Sampling Methods

When examining the method of field sampling at the Hanson Reservoir site (Bonnichsen 2004), one soon discovers that the method was too convoluted and cumbersome to execute in the field on a regular basis. This is especially true in the Southern States where summers reach soaring temperatures and the idea of working beneath a tent of plastic sheeting while wearing Tyvek coveralls over one's regular clothing sounds not only miserable but actually dangerous. For archaeologists to make hair research routine, they must have a simple protocol that is both easy to follow in the field, and inexpensive. The author's method of sampling for hair is inexpensive and simple to execute; the equipment needed in the field is lightweight and easy to carry.

When comparing the PVC pipe method of sampling to the alternative welding rod "mini tent" method, the author prefers using the PVC pipe method. While a large amount of soil can be collected quickly using the "mini tent," the author found it more difficult to maintain the integrity of the sampling process, and was keenly aware of ways the samples could be contaminated with modern hair, even while being diligent. When reaching under the tent, the plastic sheeting has to drape across the moving arms of the researcher while taking the samples, which allows the sheeting to rise up around the arm area. One then has to be very careful not to let outside sediments, leaves and other debris enter the tent either by wind or by catching on the sleeve of the researcher, as one can assume that if these items make it into the tent, so can modern hair contaminates. It is hard to see through the plastic sheeting, even when every effort is made to find the clearest plastic available, making it almost impossible to excavate the unit using normal

archaeological field techniques. If an artifact is found that needs to be measured for provenience, it very likely will be missed and placed it into the soil sample bag; therefore, the tent method does not help in that regard.

If researchers want a larger sample size using the PVC pipe method, they only need to take as many samples as possible along the unit wall, then cut the remaining portions of the wall back, creating a new wall, then take more samples along that wall, and then cut it back again. This could continue until the occupation horizon in a unit was completely excavated. While this might destroy an entire unit's occupation horizon as far as its ability to excavate keeping artifacts in situ, any artifacts would still be recovered from a known level and unit, and the samples could be processed for other micro items besides hair. This might outweigh the disadvantage of the loss of provenience. The volume of the sample would only be limited to the size and number of pipes used. The PVC pipe method was quick and easy to use, and the author felt more confident in the sample integrity than with the "mini tent" method.

The following PVC pipe sampling method is recommended. Equipment needed in the field: PVC pipe of the appropriate diameter; PVC end caps of the same diameter; isopropyl alcohol[6]; a rubber mallet; disposable surgical head covers, face covers, and long sleeve disposable surgical gowns; disposable gloves; duct tape; Sharpie; and a sturdy bag for transport.

[6] Alcohol kills cells by denaturing proteins, hindering cellular metabolism and destroying cell membranes. Proteins are not denatured as readily by alcohol in the absence of water, therefore a solution of 70 percent alcohol and 30 percent water is a better sanitizer than 100 percent alcohol (Berube and Oxborrow 1991; Larson and Morton 1991).

Archaeologists need to first and foremost ensure that there is no cross contamination with modern hair so all crew in the sampling area should wear disposable surgical hair coverings. These are available from many different manufacturers and can be purchased by the box or the case, and they come in several different styles to accommodate various hair lengths. These are lightweight and breathable, but do not allow hair to pass through them. All personnel in the area should also wear long sleeve disposable surgical gowns over their clothing, and surgical face and beard covers if they have a beard or mustache. Protective eye gear could also be worn to protect from modern eyebrow and eyelash contaminates. Everyone should be wearing long pants and closed-toe shoes as well, since hair is also found on the foot and leg. All surgical garments should be disposed of after taking the samples, and not reused. These precautions may seem excessive, but it is better to be overly cautious when it comes to any form of scientific research, and the surgical gear is lightweight and only takes a moment to don.

A recognizance of the archaeological site should be made prior to sampling to ascertain not only the best sampling location, but to determine what size PVC pipe should be used. The diameter of pipe should be in direct proportion to the depth of the occupation horizon. Two end caps should be obtained for each length of pipe used in the sampling. After the diameter of the pipe is established, it should be cut to the appropriate length, and then one end beveled prior to sterilization. The author beveled the pipe edges using an electrically turned stone wheel. After sharpening, all the pipes and end caps should then be sterilized with isopropyl alcohol. The author accomplished

this by placing the pipe segments in a glass dish with the alcohol and rolling the segments in the solution to make sure they were completely exposed to the sterilization agent. The end caps were soaked in the solution. The pipe fragments and end caps should be air-dried in a place where they have little chance of being contaminated with hair. The author placed the pipe fragments on a sterilized stainless steel dish rack and covered the pipes with a new disposable surgical gown while they dried. After the pipes are dried, the caps should be placed on both ends, and the fragments stored in a clean bag until use at the archaeological site.

In the field, after donning the disposable surgical gear, the investigator should scrape the surface of the wall planned for sampling with a sterile trowel. The cap should be removed from the sharpened edge of the pipe, and the beveled end placed against the surface of the wall, then the pipe driven into the soil by hammering on the opposite end with a rubber mallet. After the pipe has reached its entire length into the surface, it should be carefully extracted so as not to spill its contents, and caped. The pipes usually come out easily by pulling on the capped end of the pipe and twisting slightly. The end caps should be secured with duct tape and the pipe labeled appropriately. The pipes should be placed into a secure bag for transport.

One potential problem with this core method is the possibility of striking rocks with the pipe, which either block the progress of the pipe into the unit being sampled, or lodge in the pipe, keeping soils from entering the pipe. However this was not a problem for the author at any of the sites sampled, and the author feels that the benefit of having samples completely contained in the field during recovery and during transport

outweighs this potential difficulty. To offset the likelihood of having a sample pipe blocked by coarse fragments, as well as to increase the possibility of successfully recovering hair, one should take as many samples as possible at each site. Another possible problem is sampling an occupational horizon that is not level, and the core including soil from more then one time period. One way to minimize this possibility is to sample a unit that has the units around it already excavated so that all four, or at least two, of the walls are exposed, thus revealing the contour of the strata. If this is not possible or practical, one could use short pipes, then clear the remaining sediments back to the depth of the pipes, check the horizon, then sample with short pipes again

If choosing the "mini tent" method, it is recommended that the welding wire frame not be made over half a meter in depth so that the person taking the samples can easily reach across the entire tent. The height of the tent should be appropriate to the depth of the occupation horizon being sampled, so that a person does not have to stoop or lay down to work under the tent. The plastic sheeting should be new, and not removed from its packaging until immediately before applying it to the "tent" frame, in order to avoid modern hair contaminates that might adhere to its surface. The same is called for with the use of the plastic or Teflon baggies used to store the samples, as they too could collect modern hair on an outer surface and bring it into the "tent". The plastic sheeting should be draped on the ground surface around the unit and weighted down to prevent it from blowing up in strong breezes. The person taking the samples should wear either long gloves that have been cleaned of any possible hair attached to them, or preferably, new disposable gloves and a new disposable surgical gown (Table 4).

Table 4: Sampling methods conclusions.

Sampling Methods Conclusions
• Hanson sites method – most expensive method – impractical – cumbersome – dangerous to use in the South in summer • Pipe method of sampling – inexpensive – easy to execute in the field – works well in hot weather – best for sample integrity – not a large sample size with each pipe – possibility of rocks blocking pipes • "mini-tent" method – inexpensive – easy to execute in the field – Works well in hot weather – quickly obtain large sample size – not as good as pipe method for sample integrity – difficult to see through plastic to see

Sample Size and Location

Obviously, the larger the soil sample size the greater the chances of recovering hair, but in the case of the Hanson Reservoir sites, the samples were larger than necessary. This made the laboratory analysis cumbersome and expensive, with over 460 man hours used to process the samples. Sampling huge units in their entirety is not a practical approach to hair recovery due to its cost. Therefore, collection location is critical. In reviewing the sample collection method used for the Hanson sites, the author recognizes that a more strategic approach to the collection location would have created a smaller, yet more targeted sample. The samples should come from the occupation horizon, but the exact location should be based on knowledge of the site being sampled.

At the Rainbow Lake and Estes sites, the sampling locations were near burned rock features where people may have gathered to cook or keep warm. In previous work at the Rainbow Lake site, the units closest to the burned rock features had contained micro flakes from tool manufacture, indicating that people were working around the area of the fires. Therefore, the samples for this project were taken from a unit adjacent to a partially exposed rock feature, and indeed, micro flakes were recovered as well as hair. At Eagle Cave sampling was limited to the only portion of the excavation wall that remained exposed, so planning a logical location for sampling of the site was not possible; also the occupational horizons were very thin so small PVC pipes had to be used that limited the sample size. Despite these restrictions, one hair was recovered from the small sample.

To search for hair at an archaeological site one may feel like they are looking for the proverbial "needle in a haystack." But the fact that hair was recovered from very small sample sizes can be encouraging. At Eagle Cave, nine 1.5 centimeter diameter PVC pipes sixteen centimeters in length were used for sampling, containing a total *sample* volume of about 0.00026 cubic meters of soil.[7] The *site* was estimated to have approximately 3,100 cubic meters of soil[8] so only 0.000008 percent of the site was sampled; yet one hair was recovered. At Rainbow Lake 0.00217 percent of the site was sampled by using six, four-centimeter PVC pipes twenty-two centimeters in length, to

[7] 1.5 cm diameter x 16 cm length: Pi x R^2 x 16 = 28.274 cm^3 x 9 samples = 254.466cm^3 = 0.00025466 m^3 vol. (rounded)
[8] 56.39m L x 26.51m W x 2.13m D = 3,184.13m^3 vol. (rounded)

take a total soil *sample* volume of 0.00166 cubic meters[9] from an estimated *site* volume of 76.5 cubic meters[10]. While no hair was recovered from the Estes site, only an estimated 0.00009 percent of the site was sampled by using six, two-centimeter diameter PVC pipes, twenty centimeters in length. The total *sample* volume of the site was only 0.00038 cubic meters[11], while the *site* soil volume was estimated at 432 cubic meters[12].

Laboratory Methods

The laboratory method used for processing the Hanson Reservoir samples, while thorough, was extremely slow and labor intensive, making it impractical for many archaeological projects where funding is a factor. By streamlining the process with simple sieves, the sorting process progressed at a more rapid pace without sacrificing any of the controls on the samples, and is highly recommended. The Hanson samples were also washed using a dispersing agent, which removed most of the soil peds but would have affected subsequent soil analysis on the dispersal material and is not recommended. If the clay content is so great that the samples must be rinsed, perhaps the site is not the best location for hair collection. If researchers need to sample a site with high concentrations of clay and decide to rinse the soil samples, a portion of the soil should be set aside for chemical analysis.

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[9] 4cm diameter x 22 cm length: Pi x R^2 x 22cm = 276.46cm^3 = 276.46m^3 x 6 samples = 1,658.76021cm^3 = 0.00165876 m^3 vol. (rounded)
[10] 34m L x 15m W x 0.15m D = 76.5m^3 vol. (rounded)
[11] 2cm diameter x 20cm length: Pi x R^2 x 20cm = 62.83185307 cm^3 = 0.6283m^3 x 6 samples = 376.991184cm^3 = 0.000376991 m^3 vol. (rounded)
[12] 40mL x 40mW x 0.27mD = 432 m^3 vol. (rounded)

The following laboratory techniques are recommended. Equipment includes a Plexiglas isolation box with a pass tube and long gloves attached for work inside the box or a "clean bench", a glass plate, three sizes of small soil sieves (relative to the size of the soil peds, with the smallest sieve screen suggested at no larger than 0.425 millimeters), tweezers, a magnifying glass, isopropyl alcohol and wipes, glass Petri dishes and covers, glass microscope slides and covers, scotch tape, Teflon storage bags, and a microscope.

The isolation chamber, tweezers, magnifying glass, and sieves should be cleaned with the isopropyl alcohol, and then the tools and sieves placed inside the chamber. An individual sealed pipe with a soil sample should be placed through the pass tube into the isolation chamber and the pass tube closed. Using the attached gloves to access the chamber, remove the end caps and empty the contents of the pipe onto the stacked sieves. Gently shake the sieves to allow the soil sediments to pass to the finest screen. While still in the isolation chamber, carefully pour the contents of each sieve into either a Teflon bag or a glass Petri dish and cover for further analysis. After completion of each sample, clean the isolation chamber and tools with the isopropyl alcohol. An alternative method to the isolation box would be the use of a "clean bench," which would keep hair from any laboratory worker from falling into the samples under processing. If the clean box is used, long sleeves and gloves should be used to avoid contamination by hand and arm hair.

Another possible method to separate sediments from hair is the use of a heavy density separation medium such as those used in flotation flora recovery. But one

should be cognizant of possible problems with soil chemical analysis due to the elements in the solution. Therefore, a portion of the soil sample should be kept aside, sorted by a method other than heavy density separation, and used for the chemical analysis of the soil.

The Petri dishes should be examined under a microscope and fibers that look like hair should be carefully removed with tweezers and placed on a glass microscope slide and a cover immediately placed over it. The specimen can then be examined under a microscope to determine if it is indeed hair, and if so to what species? If the sifted soil samples are in bags, they should be returned to the isolation chamber for transference to Petri dishes as a precautionary measure.

After the divided soil samples have been thoroughly investigated for hair, the separated units of each sample should be recombined for chemical analysis. The method and elements selected for soil analysis is dependant on the testing planned for the hair. If trace element analysis is planned for the hair samples, then it is recommended that the soil be tested in the same manner as the hair and for the same elements. If the hair is being tested for DNA, Isotopes, or just species, then any laboratory method will suffice, as long as it is consistent among the samples in the research project.

Final Thoughts

The search for ancient hair can seem a bit daunting when trying to keep sample integrity both in the field and laboratory, especially when it is not commonly sought in archaeological sites. It would be easy to simply dismiss the very idea of using ancient

hair as a diagnostic tool since it is not part of the regular protocol of site excavation and keeping the sample integrity requires a bit more work on the part of the researcher. But when one considers the vast amount of information scientists can ascertain from a single hair, it seems archaeologists should at least try and embrace the idea of a new research tool. But the author does not claim that hair sampling should be conducted at each and every archaeological site, but should be performed after careful consideration of the climate and soil chemistry, and the exact location within the site carefully scrutinized. When searching for ancient hair, researchers need to make sure they conduct their investigation in a manner that protects the hair from contamination with modern hair or elements that could skew test data.

The author does not claim that the sampling method here described is perfect and that no other method should ever be used or that it could not be improved upon. In fact the author hopes that it is merely a beginning of a more scientific approach to ancient hair research and that it will start a dialogue with other scientists as to the possibilities of ancient hair investigations. She believes that as the premises concerning loose hair in an archaeological site are understood, the data can be synthesized into a standardized scientific method of hair retrieval from sites, and that this is the beginning of that standardized method. This research can also contribute to a better understanding of the probability of hair survival and the pitfalls of ancient hair analysis. As this is a relatively new field of archaeological investigation, both the positive and negative findings should enhance the understanding of ancient hair research. Hopefully this project is but a beginning of that understanding.

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