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Analysis of the Skeletal Remains from the Knobloch Site, 20AE633, Allegan County, Michigan

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ANALYSIS OF THE SKELETAL REMAINS FROM THE KNOBLOCH SITE, 20AE633, ALLEGAN COUNTY, MICHIGAN

by

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ANALYSIS OF THE SKELETAL MATERIAL FROM THE KNOBLOCH SITE, 20AE633, ALLEGAN COUNTY, MICHIGAN

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The skeletal remains of at least thirty individuals were recovered from the Knobloch site, 20AE633, Allegan County, Michigan. The site is from the Late Woodland period, a time which saw a variety of strategies for food procurement, including hunting, gathering, fishing, and agriculture. It is not known to what extent these strategies were practiced. The results of trace element analysis of skeletal samples from the Knobloch site assemblage indicate a diet reliant on hunting and gathering.

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CHAPTER I

INTRODUCTION

The Knobloch site (20AE633) is located in the NW 1/4, of the NE 1/4, of Section 22, Hopkins Township, T3N, R12W, Allegan County, Michigan. The site is located three-quarters of a mile south of the Rabbit River, a tributary of the Kalamazoo River. The site was discovered in the fall of 1975 in a farmer's potato field, when a concentration of fragmentary burnt and unburnt human bone overlying an articulated burial was unearthed. The site was excavated over the next few years by crews of students under the direction of the late Dr. Richard E. Flanders from GVSU (then Grand Valley State Colleges). The crews from GVSU uncovered a series of four storage pits, nine hearths, two structures, and three burial areas. With the exception of human skeletal material, all excavated material has been curated in the Anthropology Laboratory at Grand Valley State University (the human skeletal remains were repatriated in the spring of 1996). Archaeological investigations were last conducted at the site in 1979, with site boundaries never having been delineated.

Three research questions regarding the population at the Knobloch site will be addressed. In this study a discussion of the skeletal material and trace element levels is presented, followed by an investigation of three questions related to the trace element levels determined for certain skeletal samples from the assemblage and their relation to the Knobloch site. The first question examines the results of trace element analysis on cremated and non-cremated skeletal material. Incineration of skeletal remains is a step in conducting trace element analysis, therefore, there should be no difference in trace element levels between cremated and non-cremated skeletal samples. Samples from the Knobloch site assemblage of both cremated and non-cremated human remains were analyzed for this determination. The second question examines the subsistence strategies of Knobloch populations based on trace element analysis to determine diet. Subsistence strategies of Late Woodland peoples in southwest Michigan were diverse and analysis of trace element level ratios and comparison to other sites with known food procurement strategies should predict whether the Knobloch site population was relying on hunting and gathering or agriculture. Finally, intersite differences in trace element levels provides some evidence, however slight, regarding the social organization of the population sampled. In the case of a stratified society, different trace element analysis results should indicate differential access to food resources. For an egalitarian society, trace element comparisons should reveal similar ratios, reflecting, more or less, equal access to food resources consumed by the group.

Site History and Cultural Affiliations

The area surrounding the Knobloch site has been farmed since the end of the 19th century (DePuydt, 1978:2). Plowing that has taken place over the years has disrupted the stratigraphic levels, complicating excavation and analysis of cultural and skeletal material (DePuydt 1978:2). Most artifacts from the site were uncovered in the plow zone, while very little human skeletal material was recovered from the same area. Two radio-carbon dates were obtained from two separate features and indicate two distinct components. The first, Feature 15, puts the date of the site at A.D. 1140 +/- 50 (Beta - 10961) and has been determined to be a seasonal maple-sugaring encampment (DePuydt, 1978). The second, Feature 2, is from A.D. 1440 +/- 90 (Beta - 8593) and marks the burial component (DePuydt, 1978).

The radio-carbon dates place the Knobloch site in the Late Woodland time period. According to Brashler and Mead (1996:202), this period began around A.D. 500 and lasted until European contact. Archaeological evidence that supports the Late Woodland dates for the site include triangular projectile points (Brashler & Mead, 1996:203; Fitting, 1968:3; Kingsley & Garland, 1980:25; Quimby, 1966:2), an elbow pipe fragment (Buikstra & Goldstein, 1973:8; Fitting, 1970:143; Quimby, 1960:84), and collared rims on cord-marked pottery fragments (Brantsner, 1989:31; Brashler & Mead, 1996:203; Fitting, 1968:24; McPherron, 1967:277). Other indications that the assemblage is Late Woodland include notions that Late Woodland burials tend to be multiple (Fitting, 1965:130) and that Late Woodland sites in the Great Lakes region are noted to have an absence of artifacts in direct relation to burials (Buikstra & Goldstein, 1973; Cauble, 1971; Churcher & Kenyon, 1960; Greenman, 1937; Prahl, 1991).

Subsistence strategies of populations from this period in the Great Lakes region are generally diverse. The Late Woodland period saw a variety of strategies, including hunting and gathering, incipient agriculture, and fishing. For many groups, it is not known to what extent any of these strategies were implemented, although inferences can be made in accordance with artifactual evidence recovered from a site.

According to Parker (1996; see also Parachini, 1981), horticultural practices in the Upper Mississippian period for the Kalamazoo River Valley were minimal, since environmental factors in this area were not particularly conducive to agriculture (Kingsley, 1977:148). Walz (1991:62) states that subsistence behavior during the Berrien phase (A.D. 1400 to 1600) was "one in which seasonally scheduled logistical moves are undertaken, perhaps from a semi-permanent agricultural settlement, to take advantage of discrete, short-term aggregations of resources." With this model, it would be likely that wild food resources and agricultural endeavors would both account for subsistence for a population in this area. According to Walz (1991:65), there would be "intensive harvesting of seasonally available resources from aquatic and riparian habitats during the warm season from logistically oriented limited activity sites, followed by an autumn harvest of agricultural fields and winter hunting of game mammals." If this model is correct for the Knobloch site population, the subsistence strategies would be varied according to season, thus allowing for a diet not completely dependent on one main type of food resource.

A number of archaeological sites are located in the Kalamazoo River Valley, many of which are from the same period and with attributes reminiscent of the Knobloch site. Although the Knobloch site is the only known Late Woodland and possible Upper Mississippian site with a mortuary complex from the area, other sites in Allegan County have material remains that share many characteristics with the Knobloch site.

These include Allegan Dam (20AE56) (Martin, 1976), DeBoer (20AE62) (Kingsley & Garland, 1980), and Hacklander (20AE78) (Kingsley, 1977). The Allegan Dam and Hacklander sites have comparable types of lithic and ceramic assemblages, while the DeBoer site shares the distinction as a maple-sugaring site. All are from the Late Allegan phase of the Late Woodland time period.

Analysis of Trace Elements and the Knobloch Site Population

The Knobloch site is unique to the Kalamazoo River Valley and its tributaries since it is the only excavated site in the area with abundant human skeletal remains. Due to the general lack of skeletal material from this time period in this area, the Knobloch site skeletal assemblage is important in that it may give general clues to the lifestyles of the people of the Kalamazoo River Valley, and in particular, to possible subsistence strategies. Data gathered from the analysis of human skeletal remains from the site will be important since there has been little chance to research the biological aspect of past populations from this area. Information regarding subsistence strategies of peoples from the Late Woodland period in southwestern Michigan has been derived primarily from analysis of material remains such as lithics, ceramics, and the flora and fauna from various archaeological sites, and the analysis of these remains allows for the determination of food type availability. A drawback to analyzing only lithic, ceramic, floral and faunal remains from a site is that the amounts of certain foods consumed cannot be determined. A site may contain large quantities of floral and faunal remains, but this does not mean all recovered foods were consumed by the entire population, nor does it show how much of each type of food was consumed. A site may contain large quantities of faunal remains, but inferences made from only this type of material may not be accurate since many types of floral remains that have been consumed did not preserve through time or, as is the case for many sites excavated prior to the mid-1970's, were not collected for archaeobotanical analysis (Parker, 1996:308), thus leaving a skewed perspective on the past population's diet.

Analysis of human skeletal remains allows for a closer and more accurate look at the dietary habits of a population. Dietary analyses can be concerned with various aspects of skeletal remains, including, for example, dental pathology as an indicator of maize consumption, nutritional deficiencies manifest in certain bones, and Harris lines as indicators of arrested growth. Trace element analyses are available which consider the chemical composition of skeletal remains to determine relative proportions of vegetable matter and animal matter in the diet.

Trace element analysis is used to evaluate the behavior of past populations and to reconstruct their dietary habits, often with an emphasis on the testing of hypotheses regarding social organization and status (Gilbert, 1977:85; Nelson & Sauer 1984:141; Schoeninger, 1979:295) with this type of inquiry showing the dominant components of a past diet (Gilbert, 1977:86). Numerous dietary applications of trace element analysis are devoted to determining the importance of plant matter in prehistoric diets and to determine the relative importance of terrestrial mammals and/ or marine mammals in certain archaeological samples (Connor & Slaughter, 1984:123). Trace element analysis has been used to reconstruct past diets and in the analysis of prehistoric ecological situations and residence patterns (Aufderheide, 1989:237; Kozlovskaya, 1993:135), and in the determination of societal differences resulting from status, gender, or shift in subsistence strategy (Gilbert, 1977:85; Sillen & Kavanagh, 1982:61). Each evaluation is based on the knowledge that food items contain different trace element levels, and that the levels of these elements in human skeletal remains reflect dietary intake of the elements prior to death.

Trace element analysis of human skeletal material allows for the determination of information concerning a past population's subsistence strategies, and investigation of certain skeletal components through trace element analysis will allow for determination of the Knobloch site population's subsistence strategies.

CHAPTER II

LITERATURE REVIEW

Although excavations at the Knobloch site lasted from 1975 until 1979, very little has been written over the years concerning the site. In 1978, an undergraduate student from GVSU performed a short analysis of the skeletal remains from the site and wrote a general report regarding his findings (DePuydt, 1978). One other report was written, although author and date were not included, which gave a summary of the site as a whole and included information concerning the lithic and ceramics assemblages and site features (report on file at GVSU's Anthropology Laboratory). The two reports, along with field notes and square sheets, were the only sources of information available regarding the site in particular. Nothing has ever been published concerning the Knobloch site.

An abundance of articles and books are available dealing with lifestyles of Late Woodland period indigenous populations in the Great Lakes region, most notably Fitting (1965, 1975) and Quimby (1960). Locally, many articles and reports have been published which are focused on Late Woodland sites in Allegan County, Michigan and include authors such as Brantsner (1989) regarding the Upper Buff Creek site; Kingsley (1977) concerning the Hacklander site; Kingsley and Garland (1980) regarding the DeBoer site; Parachini (1981) about the paleoethnobotany of the Elam site;

and Walz (1991) concerning the paleoethnobotany of the Schwerdt site.

Articles and books used in the analysis of the skeletal remains for general estimation of age and sex for adults and sub-adults include Bass (1987) and Buikstra and Ubelaker (1994). Articles more specific to certain aspects of skeletal analysis include Lovejoy et al. (1985) who discuss age estimation from the auricular surface of the ilium; Meindl et al. (1985) concerning age estimation from the os pubis; Stewart (1979) about general sex estimation; Ubelaker (1989) regarding age estimation by tooth eruption patterns; and White (1991) for sex determination by cranial and pelvic attributes.

Analysis of cremated remains was conducted in accordance with Baby (1954) and Buikstra and Goldstein (1973). Baby's article dealt with Hopewell cremation practices in Ohio and was the first relatively large-scale examination of cremated human skeletal material. Baby (1954) determined how to differentiate bone burned with flesh present from bone burned dry. Buikstra and Goldstein's (1973) account concerned the Perrin's Ledge crematory in Illinois and described how to determine minimum number of individuals from quantities of cremated skeletal remains.

Numerous articles and reports dealing with trace element analysis were consulted for the current research. Some articles, such as those by Aufderheide (1989) and Sandford (1992), give in depth descriptions of trace elements and the techniques and instrumentation for trace element analysis. Others give general ideas of what types of inquiries can be made regarding biological and social characteristics of past populations when trace element analyses are involved. Included are Beck (1985) regarding intrasite studies; Blakely (1989) and his work with pregnancy and lactation; Gilbert (1977) concerning status differences and the separation of sex, age, and social classes; Klepinger (1984) regarding dietary reconstruction and assessment of nutrition from trace element levels; and Sillen and Kavanagh (1982) concerning bodily metabolism of trace elements.

Other reports concern trace element analyses that have been conducted and offer observations on subsistence strategies of the populations under study. Some examples include Byrne and Parris (1987) and their work with the skeletal population from a Middle Woodland site in New Jersey; Connor and Slaughter (1984) dealing with Inuit Indian populations; Ezzo et al. (1995) regarding skeletal samples from the southeast Atlantic coast; Price (1985), Price and Kavanagh (1982), and Price et al. (1985) and extensive analyses of Late Archaic populations in the Midwest; and Schoeninger (1979) and her work with human skeletal remains from Chalcatzingo in Mexico.

CHAPTER III

TRACE ELEMENT ANALYSIS

Chemical analysis of human skeletal material is conducted to ascertain the dietary patterns and nutritional fitness of past populations (Sandford, 1992:89). Two assumptions are made in the implementation of trace element analysis of skeletal material for dietary reconstruction-- first, the measured level of an element is equal to the level of the element at the time of death and second, the relation between the elements in bone and those in the diet are understood (Lambert & Weydert-Homeyer, 1993:217). The trace elements strontium, barium, and zinc have been determined to be the only elements that fit the criteria (Wolfsperger, 1992:280).

History

Due to its prevalence in the environment and its chemical stability once absorbed into skeletal material, strontium was one of the first trace elements to be used for dietary reconstruction by chemical analysis (Byrne & Parris, 1987:373). Toots and Voorhies' (1965) were the first researchers to conduct analyses of strontium in bone. This early work was performed to determine if certain Pliocene creatures were either herbivores or carnivores by the amount of strontium contained in the skeletal material. Toots and Voorhies' analysis was done on skeletal material from a single fossil quarry, to ensure that possible diagenetic factors were uniform in their effects (Elias, 1980:1). Strontium analysis of human bone was first conducted in the early 1970's by Brown (Schoeninger, 1979:296), who was the first to notice that the dietary intake of meat could be correlated with social status in a group of Mexican Indians. In another early study, Gilbert (1977) was able to show, through trace element analysis, the probability of a shift from hunting and gathering to maize agriculture.

Trace Elements

Trace elements comprise approximately 2% of the average human body, with a trace element being defined as one that constitutes less than 0.01% of the entire body mass (Armelagos et al., 1989:240; Gilbert, 1977:86; Sandford, 1992:83). To be considered for use in anthropological research, a trace element must accumulate in bone and the amount in the bone must reflect the concentration attained at time of death of the individual (Aufderheide, 1989:241).

Three trace elements are unaffected post-mortem by diagenesis, or the chemical alteration of original composition following deposition in soil through leaching, decomposition, or ground water exposure (Price et al., 1992:420)--strontium, barium, and zinc (Wolfsperger, 1992:280). As long as the mineral portion of a bone is intact, the levels of the three trace elements should reflect levels at death (Price et al., 1992:429).

Strontium

Strontium has been described by Connor and Slaughter (1984) and Sillen and Kavanagh (1982) as an alkaline earth metal which is unevenly distributed throughout the lithosphere. Strontium has no discernible function nutritionally or biochemically in the human body (Aufderheide, 1989:243; Price et al., 1992:513). According to Gilbert (1977:93), strontium may aid calcification, precipitate apatite formation, and may enhance resistant qualities of tooth dentin and enamel. Of ingested strontium, only 20% to 40% is absorbed into the human body (Sillen & Kavanagh, 1982:69), 99% of which is stored in bone mineral (Burton & Wright, 1995:274; Wolfsperger, 1992:280). The other 1% is stored in soft tissue, excreted renally, or, in certain circumstances, transferred to the placenta or mammary glands (Blakely, 1989:193; Byrne & Parris, 1987:374; Schoeninger, 1979:297).

Plants generally contain the highest amount of strontium of any living organism (Connor & Slaughter, 1984:125). Since strontium is an alkaline earth metal, plants absorb vast amounts of the element from soil and their water source (Connor & Slaughter, 1984:126). Unlike terrestrial vertebrates, plants do not discriminate between calcium and strontium when absorption occurs, and tend to have strontium levels similar to that of their water source (Connor & Slaughter, 1987:126). Schoeninger (1979:297) refers to plants as closed systems that do not excrete trace elements (every element that is absorbed is stored by the plant). Strontium is absorbed into the roots of the plant, is drawn into the stem, and is continually deposited into the leaves (Schoeninger, 1979:297).

The amount of strontium deposited in the body parts of mammals depends on the amount of the element available in the diet (Connor & Slaughter, 1984:126). Herbivores, omnivores, and carnivores have varying levels of skeletal strontium, and since herbivores eat only plant matter, these animals get strontium from a fairly direct source, thus ingesting a very large amount of this element, resulting in comparatively high levels of skeletal strontium. Carnivores, on the other hand, eat very little plant matter and ingest their strontium from the animals they consume, leaving them with little of the element. Omnivores fall somewhere in the middle, depending on the relative proportion of plant to animal matter consumed (Connor & Slaughter, 1984:126).

Strontium in the Human Body

Strontium is incorporated into skeletal material in varying amounts, depending on regional geochemistry and trophic level of the species studied (Connor & Slaughter, 1984:126). For unknown reasons, terrestrial vertebrate intestine actively discriminates against strontium absorption in favor of calcium. Human intestine is constructed to absorb more calcium than strontium (this being known as calcium bio-purification or strontium discrimination) and, once absorbed, strontium may compete with calcium's often vital physiological functions (Aufderheide, 1989:243).

Metabolic processes most often referred to when considering strontium analysis include age, sex, and pregnancy and lactation (Sillen & Kavanagh, 1982:173-176). The strontium content of bone is directly associated with age mainly for sub-adults, with age related variations not appearing to be substantial beyond adolescence (Sillen & Kavanagh, 1982:173). Bone strontium levels rise throughout childhood, when the metabolic turn over rate is at its greatest due to fluctuations occurring from growth and development (Gilbert, 1977:93). The rates taper off through the young adult stage with little change thereafter (Aufderheide, 1989:243).

Gilbert (1977:93) reports that the metabolic discrimination of strontium increases with age in the later stages of life, therefore, according to Lambert et al. (1985:479), older individuals generally have lower levels of skeletal strontium. This may be interpreted as a natural physiological tendency much like the propensity of calcium absorption to decrease with age (Lambert et al., 1985:479). Since strontium is just below calcium on the periodic table, the two elements share many of the same qualities (Burton & Wright, 1995:274; Klepinger, 1984:75).

Since calcium and strontium are structurally similar, levels of bone strontium are mainly controlled by the amount of skeletal calcium present (Lambert & Weydert-Homeyer, 1993:221), with the two elements competing with one another for incorporation into skeletal material. Therefore, when high levels of calcium are in the diet, strontium tends to be low and when low levels of calcium are available, strontium levels are high.

Dietary fiber also plays a role in the amount of strontium in bone, since it can enhance the effect of strontium by binding to calcium and limiting its availability (Lambert & Weydert-Homeyer, 1993:224). For an individual to have a low strontium level, a diet high in meat, and to a lesser extent, casein (a phosphoprotein and main ingredient in milk), would have to be consumed (Lambert & Weydert-Homeyer, 1993:224). On the other hand, a diet full of strontium rich foods (such as freshwater mollusks, nuts, leguminous plants, and cereals) would lead to a higher skeletal strontium content (Blakely, 1989:181). In general, the implication in finding high strontium levels in excavated bone is that the individual had a high fiber diet, while a bone with low strontium would imply a protein rich diet (Lambert & Weydert-Homeyer, 1993:224).

Sex is an important metabolic consideration for strontium analysis, but usually only when it is coupled with pregnancy and lactation. Women generally have slightly higher levels of skeletal strontium than men in past populations, possibly due to food taboos placed on pregnant, lactating, or menstruating women (Blakely, 1989:173). Differences in skeletal strontium between the sexes does not occur in modern populations, but does in many archaeological samples.

Pregnancy and lactation may play a role in the difference in the amounts of strontium in skeletal populations. The higher level of strontium in female skeletons has usually been attributed to lower meat intake by women (Blakely, 1989:173). This assumption has been thwarted by research conducted on laboratory animals. In their research, Price et al. (1986) conducted in vivo and in vitro experiments with laboratory rats, which showed that pregnancy and lactation elevate maternal bone strontium and depress bone calcium. Reasons for this may be that strontium is discriminated against in favor of calcium in the transport of ions to the placenta and mammary glands, and that pregnancy and lactation facilitate absorption of alkaline earth metals from the gut.

Price et al. (1986) compared the strontium levels of adult males to adult females of reproductive age and post-menopausal women from an archaeological sample. Price et al. (1986) showed that strontium levels in men were random, while women of reproductive age (20 to 40 years) had levels 25% higher than the levels of post-menopausal women. Females in the study showed a pattern in strontium levels--the element peaked between the ages of 20 and 40 years, and declined steadily thereafter. For men, age did not significantly affect strontium levels. Price et al. (1986) concluded from this research that pregnancy and lactation could have caused the discrepancy in strontium levels, not a diet void of animal products. Diet and differences in fertility schedule, rather than differences in reproductive physiology or age alone, probably account for most variation in strontium observed in reproductive age females, when compared to similarly aged males (Price et al., 1986).

With pregnancy and lactation, more strontium accumulates in bone because of increased intestinal absorption, but continued placental discrimination against strontium transfer to the fetus causes the mother to retain strontium and lose calcium (Sillen & Kavanagh, 1982:75). The very low strontium content in human breast milk is responsible for low infant bone strontium level (Sillen & Kavanagh, 1982:75).

Anthropological Considerations

Strontium levels of individuals from a population can exhibit the social privileges of food consumption accorded them by factors such as age, sex, and status (Beck, 1985:495). Archaeological evidence can frequently identify which foods were available to a past population, but only rarely are all of these actual foods consumed--dietary reconstruction allows researchers to see the menu, but not the diet or nutrition (Aufderheide, 1989:240). Trace element analysis can help in estimating the amounts of which foods were eaten, who ate them, and the health value of each. From dietary reconstruction, the questions of when agricultural practices were introduced, what seasonal population movements were made, what food trading practices may have occurred, and possible effects of the diet on health can all be measured. Social patterns, such as status, subsistence practices, amount of aquatic resources in subsistence, and premarital residence patterns can also be deduced (Aufderheide, 1989:240; Brown & Blakely, 1985:461; Ericson, 1985503; Price et al., 1985:422; Schoeninger, 1979:295).

Gilbert (1977:85) suggests that analysis of strontium levels will allow for detection of reduced disease resistance, retarded growth, and retarded development in a skeletal population. Variations of skeletal content of certain elements may permit insights into status differences, the separation of sexes, ages, and social classes, the introduction and adoption of classes of cultigens, and the overall effect of these on past populations (Price et al., 1985:425; Schoeninger, 1979:295), in that researchers are able to predict the effects on health that are secondary to deficiencies or surpluses of specific trace elements (Aufderheide, 1989:238).

Schoeninger (1978) presents four examples of how strontium analysis can be applied anthropologically: (1) for comparing resource utilization with resource availability, (2) as an independent measure of protein malnutrition suggested by gross skeletal indicators, (3) to study differential access to animal protein by subgroups within a society, and (4) to indicate the introduction of agricultural practices to a society.

Ethnographic and archaeological evidence on chiefdoms and states (from North America, Mesoamerica, Africa, and the Philippines) show that dietary differences in the amount of meat consumed occur between social ranks, with higher ranks consuming more animal products and a more varied diet in general (Brown & Blakely, 1985:463). Brown and Blakely (1985) have also determined that through trace element analysis, differences between ascribed and achieved status can also be noted, since individuals living in an ascribed status population would be afforded a diet of high status foods throughout life, thus having generally better health. This would also be noted in the teeth of individuals, since strontium levels in tooth enamel are fixed at time of formation and do not remodel thereafter (Aufderheide, 1989:243).

The measurement of strontium ratios in human bone can provide information on the relative proportion of animal and plant protein in prehistoric diets (Szpunar et al., 1978:199). Strontium analysis is important since the amount of terrestrial animal matter vs. terrestrial plant matter actually consumed in a society can be determined. This is based on the well-documented reduction of strontium ratios in terrestrial food chains (Szpunar et al., 1978:199).

Differences in strontium levels between males and females of a population have often been attributed to gender preferences in food consumption (Blakely, 1989:173) and results of some analyses suggest the males eat more meat (Blakely, 1989:173).

Dietary preferences of certain people at certain times of their lives have not always been considered when analyzing strontium levels. Blakely (1989:173) notes that women of child-bearing age from an archaeological sample of Creek Indians had much higher strontium levels than all others of the same population, and has attributed this variation to a possible dietary preference for food rich in alkaline earths, such as nuts and corn. Blakely (1989) also notes that foods with a high percentage of magnesium, such as nuts, aid in the absorption of alkaline earth metals, thus allowing for a higher level of strontium to be absorbed in a diet rich in those types of foods. Another point made by Blakely (1989:175) concerning strontium levels and food preferences was that the Creek Indians had taboos against meat consumption by pregnant and menstruating females. In conclusion, food preferences associated with and influenced by sex have an impact on the levels of strontium between males and females, possibly enhancing absorption during metabolic fluctuations brought on by pregnancy and lactation (Blakely, 1989).

Weaning age of sub-adults can also be determined for populations through the analysis of strontium levels in children's deciduous teeth (Aufderheide, 1989:243). Since strontium is discriminated against by humans and little of the element is passed to the placenta and mammary glands, an infant subsisting solely on breast milk has almost no strontium in its skeleton (Aufderheide, 1989:243). With known rates of tooth development and the knowledge that tooth enamel does not remodel after formation, the amount of strontium in deciduous teeth may be measured, with measurements reflecting the amount of the element present at the time the enamel was formed. Once an infant has begun eating solid foods, the skeletal strontium level rises but the tooth enamel strontium level stays the same as it was at formation, therefore allowing an approximation of weaning age (Aufderheide, 1989:243).

In general, the use of strontium analysis for anthropological considerations allows for information from skeletal material to be used to understand subsistence shifts through time, adaptations to distinct environments, differing access to certain foods by particular people, and as an independent check on conclusions based on archaeological evidence or other more conventional and less certain techniques (Price, 1985:450; Sillen & Kavanagh, 1982:84).

Problems With Trace Element Analysis

There are many complications associated with strontium analysis. Individual physiological variation (through age, sex, and metabolism), geochemical environmental differences, and post-depositional changes may all figure into trace element analysis (Aufderheide, 1989:243).

When analyzing bones for strontium, problems can be alleviated by using the same bone from different people of the same age and sex. The same can be said when comparing two bones (the same portion of the same bone from different individuals should be used) (Price et al., 1985:429). It has been noted that cancellous bone has a higher turn over rate than cortical bone (Sillen & Kavanagh, 1982:77), and that the greater mineralization of cortical bone allows for better preservation of bone mineral in the post-mortem environment (Sillen & Kavanagh, 1982:77). Therefore, diagenesis is not as prevalent in cortical bone as it is in cancellous bone, and only the more stable cortical bone should be used for analysis of trace elements (Ezzo et al., 1995:471).

Sources of potential error in strontium analysis must be controlled. The amount of strontium in the biosphere varies regionally, depending on surface water sources and regional rock composition. Diagenesis is a major issue in trace element analysis, although it is not known to have any serious effects on strontium, barium, or zinc (Wolfsperger, 1992:280). A primary concern in elemental analysis is that the inorganic mineral component of bone is stable in the burial environment, since the interaction of skeletal material with soil can either raise or lower the levels of various elements.

Wolfsperger (1992:283) suggests that when doing strontium analysis, post-mortem changes can be excluded if the outer layers of a bone sample are removed with a surgical blade, supposedly ridding the bone of surface contaminants. Although this is plausible, Lambert et al. (1991:364) have concluded from a study of fifty mid-shaft femora samples from West-Central Illinois that strontium levels are virtually the same, with or without removal of the surface. According to Lambert et al. (1991:381), strontium is one of the few trace elements not affected by surface contamination.

Since strontium levels are not uniform throughout a geographical area, it has been suggested that both herbivore and carnivore skeletal remains from the same strata as the human remains (if possible) be used for comparison (Price, 1985:450). This would allow for controls in analyses so that measured levels from human and other remains could be compared. This is an important consideration, although usually not feasible, since carnivore remains are not often represented in an archaeological setting (herbivores, such as white-tailed deer, are typically abundant for North American sites) (Price, 1985:450). When present, canid carnivores may or may not be important as controls, in that domesticated dogs are known to eat the refuse of humans, which may include a large amount of dispelled plant foods, thus unnaturally raising strontium levels (Klepinger, 1984:79).

Another problem pertaining to trace element analysis is that most studies to date have been centered on terrestrial plant/ terrestrial animal ratios, giving little attention to aquatic or marine resources, and also other terrestrial food sources including grubs, insects, and root crops (strontium levels are known for none of these) (Klepinger, 1984:80). Also, the general interpretation of food preferences is somewhat biased, since not all food matter persists in the archaeological record. For example, researchers may conclude that a population was heavily dependent on animal resources because a high percentage of animal bone and shell was recovered from an archaeological setting, whereas the population may actually have been much more dependent on food resources such as seeds that may not have persisted archaeologically (Price, 1985:449). Food resources that endure through time may often be considered much more relevant to a society than they actually were.

It has generally been assumed that meat products were considered high status foods, whereas ethnographically this has been proven false for certain societies (Klepinger, 1984:80). There is a possibility that some cultural groups consider some meats to be high status, while other meats are reserved for low status individuals (the same holding true for grains) (Klepinger, 1984:80).

Another possible problem could be which individuals are used in trace element analysis. Sillen and Kavanagh (1982:84) have suggested that analyses should not be conducted on individuals in which a nutritional deficiency or other pathology is noted or suspected, with only healthy individuals being analyzed. This in itself poses another problem, since it is not always easy to accurately determine the health of the skeleton of an individual being studied.

Brown and Blakely (1985:463) and Gilbert (1977:90) have determined a series of specifications that should be regarded prior to an analysis of the trace elements from a skeletal population in order to combat potential errors. To begin, the researchers should have a realistic idea of the diet of the past society. If the society in question consumed a high amount of freshwater mollusks and the researcher does not take this into account, an error in the interpretation of diet may result (the elevated strontium levels of the society could be perceived as being due to a high fiber, low protein diet). Second, the degree of permanence of occupation of the population at the site of excavation should be known. If a site has been occupied for a long duration of time, the skeletal remains recovered may be from different time periods with completely different subsistence strategies. This could cause some confusion, since strontium levels would be different for a hunting and gathering group and a group depending on agriculture for subsistence. Third, use of primary interments, rather than secondary, for elemental analysis should be considered since, with the latter, there may be more of a time variable than with primary interments. Finally, all burials should be above water level, since ground water contamination could cause leaching of trace elements from skeletal material.

Other steps that can be taken to reduce potential errors and problems in the trace element analysis of strontium include use of only adult material between the ages of twenty and fifty years of age for analysis, since strontium levels are generally constant in that age range (Price et al., 1985); to guard against diagenesis, animal bone standards and only well-preserved skeletal samples should be considered (Blakely, 1989:177); and contemporary samples may be used as controls (Byrne & Parris, 1987:373).

Trace Element Measuring Techniques

There are many techniques for measuring trace element levels in skeletal material, including atomic absorption spectrometry (AAS) and inductively coupled plasma emission spectrometry (ICP) (Aufderheide, 1989; Byrne & Parris, 1987; Sandford, 1992). Both techniques are sensitive and relatively simple, with one or, in some instances, both available at many Universities.

General preparation of a sample to be analyzed involves at least some of the following steps (depending on which technique is chosen for analysis)--cleaning, ashing, grinding, and dissolution of the bone (Aufderheide, 1989; Sandford, 1992). According to Gilbert (1977), in selecting bones for trace element analysis, those with the thickest cortical dimensions should be used (such as femora or tibiae). This allows for less error because, depending on length of time the material has been in the ground, cortical bone is less susceptible to leaching and permeation by other elements than cancellous bone.

CHAPTER IV

MATERIALS AND METHODS

Non-Cremated Remains

The analysis of non-cremated skeletal material from the Knobloch site began with a summation of minimum number of individuals from the skeletal elements present (Tables 1, 2, 3, 4, 5, and 6). The remains were in varying degrees of fragmentation, ranging from relatively complete to extremely fragmented. Age classes for individuals were based on Buikstra and Ubelaker's system (1994:9), where fetal referred to prior to birth, infant referred to ages from birth to three years, child involved three to twelve year olds, adolescent was twelve to twenty years of age, young adult was twenty to 35 years old, middle adult was 35 to fifty years, and old adult referred to those fifty years and older.

Individuals were assessed for age and sex. Age was determined through the use of various techniques, including Bass (1987) for epiphyseal fusion of sub-adult remains; Lovejoy et al. (1985) for auricular surfaces; Meindl et al. (1985) for symphyseal surfaces of the pubis; and Ubelaker (1989) for eruption patterns of teeth. Sex was determined through the use of procedures described by Bass (1987) for femoral head diameters and sacral curvature; White (1991) for pelvic and cranial attributes; and Stewart (1979) for glenoid cavity length.

Table 1

Skeletal Inventory of Feature 1, Non-Cremated Remains, Lower Level

Bone	Individual Number									
	L1	L2	L3	L4	L5	L6	L7	L8	L9	L10
Femur										
L	1	1		1	1	1	1	1	1	
R	1	1		1		1		1	1	
Patella										
L	1					1				
R	1	1				1				
Tibia										
L	1	1					1		1	
R	1	1	1			1	1		1	
Fibula										
L	1	1					1			
U									1	
R	1	1					1			
Tarsal										
L	7		1			4	3			
U									1	
R	3		1	6		3	6			
Metatarsal										
L	4									
R			1							
Ilium										
L				1					1	
R								1	1	
Ischium										
L				1						
U							1			
R								1		
Pubis										
L										
R	1									
Vertebra (C)										
	2	6		F	6	F	2	F	F	F
Vertebra (T)										
	8	9	F		6	9	F	F	F	F
Vertebra (L)										
	7	5		F	3	F	5	F	F	F

Table 1--Continued

Bone	Individual Number									
	L1	L2	L3	L4	L5	L6	L7	L8	L9	L10
Sacrum										
		1				1				
Unfused								2		
Clavicle										
L				1	1		1			
R					1		1			
Scapula										
L	1				1		1	1	1	
R	1				1				1	1
Humerus										
L		1		1	1		1		1	1
R	1			1			1		1	
Radius										
L		1		1	1		1		1	
R	1	1		1	1		1		1	1
Ulna										
L	1	1		1	1		1		1	1
U			1							
R		1		1			1		1	1
Carpals										
L	4		2				4			
U					1					
R	8		2				4			
Metacarpals										
L	2		2		4		1			
U				5					1	
R	4				3		5			
Phalanx										
L	12						3			
U			3	2	9					10
R	6						9			
Ribs										
L				10	10		2		10	
U	1	1						1		1
R				4	9		10		10	

L1 - L10 refers to Lower Level Individual Numbers
R = right, U = unsided, L = left, F = fragmentary

Table 2

Skeletal Inventory of Feature 1, Non-Cremated Remains,
Upper Level and Fill

Bone		U1	U2	U3	U4	U5	Fill
Femur							
	L	1	1			1	
	R	1	1				
Patella							
	L	1					
	R	1					
Tibia							
	L		1		1	1	1
	R	1				1	1
Fibula							
	L		1			1	
	R	1				1	
Tarsal							
	L	3	1				
	R	6					
Metatarsal							
	L						
	R	3					
Ilium							
	L		1				
	R						
Ischium							
	L		1				
	R		1				
Vertebra (L)							
		5					
Sacrum							
		1					
Clavicle							
	L						
	U	1					
	R						

Table 2—Continued

Bone		U1	U2	U3	U4	U5	Fill
Scapula							
	L	1					
	R						
Humerus							
	L	1	1				
	R	1	1	1			
Radius							
	L		1				
	R	1	1		1		
Ulna							
	L						1
	R	1	1				
Carpal							
	L	7					
	R	6					
Metacarpal							
	L	4					
	R	3					
Phalanx							
	L						
	U	14					
	R						
Rib							
	U	9				1	

Cranial: Temporal (right) -- U1
Occipital (right) -- U1
Parietal (right) -- U1
Fill - refers to individual recovered from fill of Feature 1
U1 - U5 refer to Upper Level Individuals
L = Left, U = Unsided, R = Right

Skeletal remains were examined for evidence of pathology to determine whether any of the skeletal material should be eliminated from the study due to diseases

Table 3

Skeletal Inventory , Feature 3

Bone			Bone		
Femur			Humerus		
	L			L	1
	R	1		R	
Patella				Ulna	
	L			L	
	R	1		R	1
Tibia			Radius		
	L	1		L	
	R	1		R	1
Innominate			Scapula		
	L	1		L	1
	R	1		R	1
Sacrum			Clavicle		
		1		L	1
				R	1

Cranial: Left Parietal/ Frontal, 1 Vault Fragment

Table 4

Skeletal Inventory, Feature 5

Bone			Bone		
Femur			Rib		
	L	1		U	1
	R		Vertebra		
Tibia					2
	L	1	Phalanx		
	R			L	
Sacrum				U	1
		1		R	
Teeth 1 (lower second molar)					

Table 5

Skeletal Inventory, Feature 6

Bone		Individual Number 1	2	3
Femur				
	L	1		
	R	1	1	
Tibia				
	L	1	1	
	R	1		1
Fibula				
	L	1	1	
	R	1		
Humerus				
	L			
	R	1	1	1
Ulna				
	L	1	1	
	R	1	1	
Radius				
	L		1	
	R	1	1	
Carpals				
	L			
	R		1	
Metacarpals				
	L			
	R		3	
Phalanx				
	L			
	U		1	
	R			
Scapula				
	L			
	R		1	
Rib				
	R			
	U		2	2
	L			

Table 5--Continued

Bone	Individual Number 1	2	3
Sacrum	1	1	
Cranial			
Parietal			2 (left and right)
Temporal			1 (left)
Occipital			1
Maxilla			1 (left)

Table 6

Skeletal Inventory, Feature 7

Bone	(N)	Bone	
Femur		Cranial	
L	1	Parietal	1(L)
R		Temporal	2 (L and R)
Innominate		Occipital	1 (R)
L	1	Frontal	1 (R)
R		Zygomatic	1 (L)
Sacrum		Nasal	2 (L and R)
	1	Maxilla	1 (U)
Clavicle		Mandible	1 (L)
L	1	Teeth (all Left)	
R			1st Upper Incisor
Scapula			2nd Incisor
L	1		2nd Upper Molar
R			
Rib			
L	3		
R			
Vertebra (C)			
	2		
Vertebra (T)			
	3		

which would affect the outcome of the strontium analysis. No pathology of this type was noted. Evidence for trauma was also examined for, particularly on the cervical vertebrae and occipital bones, in order to dispel the lore surrounding the Knobloch site skeletal assemblage. When the site was excavated, very little cranial material was recovered from the burial component. This phenomena was initially attributed to removal of heads from bodies immediately prior to death or soon after for ceremonial purposes. No evidence for this type of ceremonial beheading was found.

Cremated Remains

The cremated remains of Feature 1 were mixed with the non-cremated remains from the upper level of the ossuary. As with the non-cremated upper level remains, the cremations were highly fragmented and dispersed over a large area (within a six by six meter radius) by historic agricultural activity. Any relationship existing between the cremated and non-cremated remains was ultimately destroyed by many years of farming at the site (DePuydt 1978:2).

Determination of minimum number of individuals for the Feature 1 cremations was done through consideration of the skeletal component with the highest repeating number. Buikstra and Goldstein (1973:16) note that bones cremated in the flesh that tend to last the longest include the upper cervical vertebrae and the femoral head and associated bony structures, since these are either well protected, dense, or both.

Trace Element Analysis

Seven skeletal samples were chosen for analysis of trace elements from the Knobloch site by meeting certain criteria regarding the geological area of the site as well as certain characteristics of the skeletal elements themselves. To begin, all burials were above water level, which controls for ground water contamination. Skeletal material was chosen according to certain standards, such as presence of cortex and thickness of cortical bone; only bone from well-preserved skeletal samples was used in this analysis; and, due to the fact that immature remains have fluctuating strontium levels in their skeletons, only adult material was used.

Seven samples from the Knobloch site were analyzed for the trace element strontium. The small sample size used in this unfunded research can be attributed to two factors. First, most of the skeletal remains from the site were quite fragmentary, with cortex having been destroyed on numerous samples, making them inappropriate for use. Second, out of respect for the Native American Graves Protection and Repatriation Act (NAGPRA), long bones, such as femora and tibiae, that were whole and in good condition were not cut and used as samples for trace element analysis. The remains that were used, though, were good quality femora or tibiae with cortex intact.

The small sample size used in this analysis can be qualified when compared to other analyses. For example, Pate and Brown (1984) examined the trace elements from eight individuals from the Roonka IIIa site in South Australia; Sillen (1981) analyzed fourteen individuals from Hayonim Cave in Israel; and Wolfsperger (1992) evaluated a total of ten individuals from two medieval sites in Western Austria. In North America, Byrne and Parris (1987), Connor and Slaughter (1984), Lambert et al. (1991), Price et al. (1986), and Price and Kavanagh (1982) all used small sample sizes for trace element analysis to draw conclusions regarding social ramifications and subsistence strategies from past populations. Of these, the lowest number of individuals used from one site was two samples, while the highest number was ten (see Table 7).

Seven samples (S1 - S7) were analyzed for strontium levels: S1 -- distal left tibia from the fill of Feature 1 (adult, sex and age indeterminate); S2 and S3 -- distal right tibia and proximal left femur from the lower level of Feature 1 (male, 35 - 50); S4

Table 7

Sites With Small Sample Sizes Used for Trace Element Analysis

Site Name	Location	(N)	Reference
Abbott Farm	New Jersey	9	(Byrne and Parris, 1987)
Aztalan	Wisconsin	8	(Price and Kavanagh, 1982)
Cape Krusenstern	Alaska	12	
Battle Rock	Alaska	total	
Kipuqlak	Alaska	for	
Kugok Ravine	Alaska	all	
Utquiagvik	Alaska	Alaska	
Bowerville	Alaska	sites	(Connor and Slaughter, 1984)
Gibson	Illinois	10	(Lambert et al., 1991)
Millville	Wisconsin	3	(Price and Kavanagh, 1982)
Oconto	Wisconsin	12	(Price et al., 1986)
Reigh	Wisconsin	4	(Price and Kavanagh, 1982)
Todd Mounds	Ohio	10	(Price et al., 1986)
Trempealeau	Wisconsin	2	(Price and Kavanagh, 1982)

--distal right tibia from the upper level of Feature 1 (female, 35 +); S5 -- proximal left tibia from Feature 6 (male, 35 +); S6 -- femoral shaft from cremation 1 of Feature 1 (adult, sex and age indeterminate); and S7 -- tibial shaft from cremation 2 of Feature 1 (adult, sex and age indeterminate) (see Table 8).

A sample from a white-tailed deer (Odocoileus virginianus) humerus was analyzed as a representative herbivore. Since no animal remains were recovered from either the habitation portion or the burial component of the Knobloch site, the white-tailed deer remains used in the analysis were from the Zemaitis site (20OT68), Ottawa County, Michigan. Use of deer remains from sites other than the one in question for trace element analysis has been done by Price (1985). In that study, deer remains were lacking from the site being studied, as is the case for the Knobloch site, so samples were taken from two sites with comparable environmental and geomorphological

Table 8

Skeletal Components Used in Trace Element Analysis

Sample Number	Location	Element
Sample 1	Feature 1 - Fill	Distal Left Tibia
Sample 2	Lower Level, Feature 1 - Individual 2	Distal Right Tibia
Sample 3	Lower Level, Feature 1 - Individual 2	Proximal Left Femur
Sample 3	Lower Level, Feature 1 - Individual 2	Proximal Left Femur
Sample 4	Upper Level, Feature 1 - Individual 1	Distal Right Tibia
Sample 5	Feature 6 - Individual 2	Proximal Left Tibia
Sample 6	Feature 1 - Cremation 1	Femur Shaft
Sample 7	Feature 1 - Cremation 2	Tibia Shaft
	Deer - Zemaitis Site (20OT68)	Proximal Humerus

characteristics. Although earlier than the Knobloch site, the Zemaitis site is known to have a Late Woodland component (A.D. 1174 - A.D. 1293) (Brashler and Mead 1996:235), is relatively close to a river water source, and has some similar biological and geological attributes as the Knobloch site in contemporary times.

The analysis of the trace elements from the Knobloch site skeletal assemblage was done with the inductively coupled plasma emission spectrometry technique (ICP) at Grand Valley State University's Water Resources Institute. According to Sandford (1992) each trace element has electrons revolving around a nucleus in a known pattern specific to the element, but when energy, such as heat, is introduced, the electrons become excited and are transmitted into orbits away from the nucleus. During the return to the normal orbit following reduction of energy, the electrons create a line spectra, or wavelength. ICP is a form of light spectrometry in which line spectra are measured to identify and quantify trace elements (Sandford 1992:95). The size of the wavelengths emitted determines which element is present, while the number of wave-lengths determines the amount of the element present in the skeletal sample.

To begin the procedure, samples were removed from the cortex of either tibiae or femora, depending on which was available for use. Sandford (1992:93) states that "sections of approximately 3 - 4 cm in length, taken from the middiaphyseal region of the femur or tibia should be more than adequate for most purposes." A sample of this size is chosen to allow the researcher a choice as to which portion of the bone should be used (for example, a portion of the 3 - 4 cm sample may have thicker or more intact cortex than another that would be more suitable for trace element analysis). Skeletal samples were removed with a surgical steel saw that had been washed with distilled-deionized water.

Next, samples were washed with distilled-deionized water to remove soil particles or other contaminants and allowed to dry for at least 24 hours, which was followed by the removal of a small portion from the sample (only 0.2 - 0.5 grams of bone are used per sample). According to Lambert et al. (1991:382), strontium does not show a statistically significant variance in levels from remains that have at least 1 mm of cortex surgically removed as compared to those that are surgically cleaned but do not have any cortex removed. For this reason, the skeletal remains from the Knobloch site and the animal remains from the Zemaitis site were not surgically abraded.

The small amount of skeletal material used in ICP was then ground in a mortar and pestle to a powder, which was then diluted with 10 ml of nitric acid (HNO3). Each sample was then placed in a Questron Q 4000 Microwave for a total of ten minutes at temperatures of up to 180 degrees Celsius. Then, using the general method for evaluating solid waste (EPA 3051), the strontium line spectra emitted from the sample solutions were measured and results were tabulated (see Table 9).

Table 9

Trace Element Levels in Parts Per Million (ppm)

Number	Location	Age and Sex	Strontium (ppm)
Sample 1	Feature 1 - Fill	Adult, age and sex indeterminate	150
Sample 2	Lower Level, Feature 1	Individual 2, Male, 35 - 50	210
Sample 3	Lower Level, Feature 1	Individual 2, Male, 35 - 50	180
Sample 3	Lower Level, Feature 1	Individual 2, Male, 35 - 50	190
Sample 4	Upper Level, Feature 1	Individual 1, Female, 35 +	170
Sample 5	Feature 6 - Individual 2	Male, 35 +	120
Sample 6	Feature 1, Cremation 1	Adult, age and sex indeterminate	150
Sample 7	Feature 1, Cremation 2	Adult, age and sex indeterminate	150
	Deer - Zemaitis Site		350

CHAPTER V

RESULTS

Burials from the Knobloch site were composed of one large ossuary, a single burial one meter to the northwest of the ossuary, and three burials laid out in an east-west orientation approximately fifteen meters south of the ossuary. The skeletal material from this site was in varying degrees of fragmentation, with samples ranging from relatively complete skeletons to extremely fragmentary and incomplete remains. Most of the remains were in generally poor condition, probably due to many years of farming at the site which caused considerable damage to the upper level. Feature 1 (the ossuary) contained sixteen non-cremated individuals and seven cremations, while Feature 3 (to the northwest of Feature 1) contained only one non-cremated individual. Features 5, 6, and 7 were uncovered in a trench running east-west south of Feature 1 and contained a total of six individuals (one of whom was cremated). Only Features 1, 3, 5, 6, and 7 held skeletal remains, while Feature 2 was determined to be a cremation hearth. All other features were determined to be related to the habitation portion of the site and will not be discussed here.

Analysis of the skeletal remains from the Knobloch site indicates that approximately thirty cremated and non-cremated individuals were interred in at least three separate episodes.

Non-Cremated Remains

It was concluded that there were twenty-two non-cremated individuals recovered from Feature 1 (16 individuals), Feature 3 (one individual), Feature 5 (one individual), Feature 6 (three individuals), and Feature 7 (one individual) (Tables 10 and 11). Due to fragmentation of skeletal remains, sex could be determined for only a small portion of the non-cremated assemblage and included five males and three females. Age was determined for eighteen of the non-cremated individuals and ranged from infancy to middle/old adulthood (Table 12).

Table 10

Demography of the Knobloch Site Skeletal Assemblage, Feature 1

Feature 1	Lower Level	Feature 1	Upper Level
1. Male	Middle Adult	1. Female	Middle/ Old Adult
2. Male	Middle Adult	2.	Child
3. Female	Adult	3.	Child/ Adolescent
4. Child		4.	Child/ Adolescent
5. Child		5.	Infant
6. Child/ Adolescent			
7. Child/ Adolescent		Feature 1 Cremations	
8. Child		1. Male	Adult
9. Infant		2.	Adult
10. Infant		3.	Adult
		4.	Adult
Feature 1 Fill		5.	Adult
1. Adult		6.	Child
		7.	Infant

Fetal - prior to birth; Infant - birth to 3 years; Child - 3 to 12 years; Adolescent - 12 to 20 years; Young Adult - 20 to 35 years; Middle Adult - 35 to 50 years; Old Adult - 50 years and over

Table 11

Demography of the Knobloch Site Skeletal Assemblage,
Features 3, 5, 6, and 7

Feature 3		Feature 5	
1. Female	Middle Adult	1. Adult	
Feature 6		Feature 6 Cremation	
1. Adolescent		1. Adult	
2. Male	Middle Adult		
3. Male	Adult		
Feature 7			
1. Male	Middle Adult		

Fetal - prior to birth; Infant - birth to 3 years; Child - 3 to 12 years; Adolescent - 12 to 20 years; Young Adult - 20 to 35 years; Middle Adult - 35 to 50 years; Old Adult - 50 years and over

Table 12

Demographic Profile

Fetal	Infant	Child	Child/ Adolescent	Adolescent	Young Adult	Middle Adult	Middle/ Old Adult	Old Adult
0	4	5	4	1	0	5 (1 female, 4 males)	1 (1 female)	0

Adults of Indeterminate Age
10 (1 female, two males, and seven of indeterminate sex)

Cremated Remains

The Knobloch site yielded the cremated remains of eight individuals from Features 1 and 6. Feature 1 cremations were of five adults, one child, and one infant. Due to fragmentation, sexing was possible for only one individual (an adult male), while ages of all the adult individuals could not be determined (Tables 10 and 11). Trauma and pathology were not noted for any of the cremated remains.

For this assemblage, the skeletal element with the highest repeating number (for adults) was the odontoid process of the axis vertebra (N = 5). Since sub-adult skeletons are not fully developed, the skeletal components are not as dense as those of older individuals and are not as heavily protected by muscle and other tissue, which makes them much more susceptible to incineration and subsequent erosion. Due to fragmentation stemming from this, tooth fragments were used for the determination of minimum number of sub-adult individuals (N = 2).

The reason the odontoid process had the highest repeating number for this assemblage was probably due to the protection provided the second cervical vertebra by the inferior portion of the occipital bone and the muscles and flesh of the neck and back surrounding it. During the cremation process, bones with little protection are destroyed much more quickly, while those that are protected persist longer. The Feature 1 cremations show random burning patterns, with some skeletal elements being highly calcined for some individuals and only slightly burnt for others.

Most of the unburnt bone is from the distal portion of the lower limbs. The posterior portion of the ribs and spinous processes of the vertebrae (minus the superior cervical vertebrae) were generally highly calcined, indicating that the individuals may have been in the supine position at the time of incineration, with the fire probably centered near the middle of the torso, underneath the body. The anterior portions of the ribs tended to be not as highly calcined as the posterior parts. Placement of the fire in this position may explain why the phalanges of the feet tended to be unburnt.

Dry bones that are unburnt "exhibit superficial checking, fine longitudinal striae, deep longitudinal fracturing, or splintering, and no warping" (Baby, 1954:4), while "bone burned green is characterized by warping, deep checking of the outer surface, and frequent curved transverse fractures" (Buikstra & Goldstein, 1973:21). The presence of unburnt bones mixed with burnt bones can also be interpreted as a flesh cremation since entire fleshed bodies do not normally completely and uniformly burn (Baby, 1954:3).

Pre-incineration dismemberment may account for some differences in the appearance of some cremated bone, with certain elements appearing to have been dry bone cremations and others appearing to have been in the flesh. Feature 2 has been determined to be the cremation hearth for Feature 1, Feature 6, or both. This feature was 71 cm in diameter at the base of the plow zone and was located one meter west of Feature 1. Feature 2 was also the most shallow feature excavated from the Knobloch site. DePuydt (1978:8) notes that a lens of oxidized sand was found beneath Feature 2, which has been attributed to a hot fire. According to DePuydt (1978:8), for bodies to have been incinerated in Feature 2, they would have had to have been at least partially dismembered to fit in such a small cremation hearth. If this feature was the cremation hearth of Features 1 and/ or 6 and although the cremated remains of Feature 1 show mainly flesh cremation characteristics, it can be speculated that the bodies may have been allowed to decompose partially prior to incineration, allowing for easier dismemberment for placement in the cremation hearth.

Although this is plausible, and would explain why such a small cremation hearth was used, DePuydt (1978) did not consider that Feature 2 was 71 cm in diameter at the plow zone, and could easily have been much larger above the plow zone. If this were the scenario, a larger cremation hearth (either above or in the ground) would have allowed for full body, in the flesh cremations to occur. This would explain how individuals could have been cremated in the extended supine position and would explain the cremation characteristics that are present with the majority of the incinerated remains.

Feature 6 contained one flesh cremation. The majority of the skeletal elements were at least partially incinerated, the odontoid process being incompletely calcined. Most of the skeletal components exhibited warping and longitudinal fractures, characteristic of a flesh cremation.

Trace Element Analysis

The levels of the trace element strontium from the Knobloch site samples are shown in parts per million (ppm) in Table 9, with levels being relatively close for all individuals from the site. Levels of strontium for the human remains were between

120 ppm and 210 ppm, with an average of 165.5 ppm. The white-tailed deer sample from the Zemaitis site used as a control was considerably higher at 350 ppm. As is noted by Price (1985), white-tailed deer remains are always proportionately higher in strontium than humans, which is the case with the remains analyzed in this study. One sample, a 35 - 50 year old male from the lower level of Feature 1, had two separate bones analyzed (S2 -- tibia and S3 -- femur), with one of the bones being evaluated twice (S3). Accordingly, the three trace element levels for this single individual were very close (210 ppm for the tibia, and 180 ppm and 190 ppm for the femur). The femur was examined twice to protect against possible flaws in the equipment and technique used or for unforeseen problems with the samples themselves. The fact that the levels from the samples were so close validates the technique used and the results of the ICP.

Due to geologically fluctuating levels of strontium, intersite comparisons are not feasible when great distances are considered. Trace element analysis has not been conducted on other skeletal materials from southwestern Michigan, so comparable information does not exist at this time. Strontium levels vary widely from region to region, which can be noted when regarding levels recorded by White (1986, in Armelagos et al. 1989:242) for a site in Belize (64.9 - 154.2 ppm) and Beck (1985: 498) for the Etowah site in Georgia (546.5 - 638.2 ppm). When considering other analyses of strontium levels from different regions, though, the levels reported here generally coincide with reports where white-tailed deer are used as controls. Sites such as Price III (Wisconsin) and Williams (Ohio) (Price, 1985) both use prehistoric white-tailed deer remains as controls. Price (1985) reports that at the Price III site, human strontium averaged 155 ppm, while deer were at 279 ppm, at the Williams site, human levels averaged 308 ppm, while deer were at 582 ppm. The mean strontium levels for humans is close to half that of the deer in both instances, reminiscent of levels determined for the Knobloch site (humans averaged 165.5 ppm, while the deer remains were at 350 ppm). Both the Price III site and the Williams site are from the Late Archaic period and were not occupied by agricultural populations (Price, 1985).

CHAPTER VI

DISCUSSION

Research questions posed earlier regarding the trace element analysis of the skeletal remains from the Knobloch site can be answered through interpretation of the resulting levels. First, use of both non-cremated and cremated remains in this analysis was done to see if previously burnt bone would have strontium levels in the same range as non-cremated remains. According to the results from this analysis, strontium levels did not appear to be affected by cremation practices. The cremated remains used were from Feature 1 and were adults of indeterminate sex and age and were found to have strontium levels in the same range as the non-cremated remains.

Second, the levels of strontium for each individual were relatively close, leading to an assumption that most, if not all, individuals consumed basically the same diet. Since the non-cremated skeletal remains recovered and analyzed did not represent young adults (20 - 35 years of age), these individuals may have been cremated, buried elsewhere and not recovered, or were simply not as likely to succumb to death as often as their adolescent or middle/ old adult counterparts. If young adults were in fact cremated, the two cremated samples (S6 and S7) may account for two individuals in this age range. The two cremations had levels of 150 ppm each, roughly coinciding with the site mean of 165.5 ppm, thus exhibiting no difference by age in strontium levels.

Many of the skeletal remains were of indeterminate sex. Although five males and three females were identified for the entire assemblage, the ratio of males to females may have been even closer, with the fragmentation of the remains causing a disproportionate ratio of sexes to be identified. The one known female analyzed for strontium had a level of 170 ppm, also near the average for the site as a whole. Therefore, dietary differences by sex may not have occurred in this population.

The relatively equal levels of strontium in each individual are reminiscent of what would be expected of an egalitarian society with few, if any, restrictions on food consumption for the population. These assumptions are, of course, dependent on the samples providing a good representation of the population as a whole. Due to the low amount of viable non-cremated skeletal material for trace element analysis, the individuals analyzed were the best the available from the assemblage.

Second, the very low levels of strontium in the human skeletal remains as compared to the deer remains indicate that this population probably did not rely heavily on cultivated plant resources as a major form of sustenance. The Knobloch site population probably depended predominantly on wild food resources for subsistence with little, if any, reliance on small-scale horticulture. According to Walz' theory (1991:62), people in the Kalamazoo River Valley during the Berrien phase (A.D. 1400 to 1600) may have relied on seasonal moves from possible agricultural settlements to harvest spring and early summer resources in other areas. Since the Knobloch site burial component lies in the beginning of the Berrien phase (A.D. 1440 +/- 90), and since the Kalamazoo River tributaries were probably not conducive to agricultural endeavors, the Knobloch site inhabitants may have followed this strategy for subsistence. With this type of subsistence, agriculture would play a small role in the overall diet of the population, thus allowing for a diverse diet not dependent on one main food type.

With the mean level of strontium for humans at 165.5 ppm and the level of strontium for the white-tailed deer remains of 350 ppm, it can be surmised that the Knobloch population did not subsist on a diet with an agricultural base. Rather, as is noted for the Late Archaic pre-agricultural Price III and Williams sites, with the proportion of strontium in human vs. deer remains at roughly half, the data suggest that a diet rich in animal resources was consumed by populations with these types of human vs. deer strontium level ratios.

CHAPTER VII

CONCLUSIONS

The skeletal remains from the Knobloch site (20AE633) may have been quite fragmentary, but still allowed for an examination of this past population's subsistence strategies. Although a small sample was used in the trace element analysis for strontium, the results and conclusions drawn from them seem reasonable when compared to other studies with small sample sizes. Conclusions from these studies were considered reliable when certain criteria were met, such as use of controls (i.e., herbivorous and/ or carnivorous animal remains are also analyzed). Comparison of trace element levels from the Knobloch site to others of known age and subsistence practices also suggest the analysis was credible. Levels of the trace element strontium are known to be low in animals that consume low amounts of plant matter and high amounts of animal matter, and high in those that consume large quantities of plant matter and little, if any, animal matter. When considering a human population with a mean level of strontium at 165.5 ppm and a white-tailed deer specimen with a level of 350 ppm, it can be assumed that the humans consumed much less plant matter than the deer. When this information is analyzed in conjunction with known levels and ratios of strontium from other sites with human and deer specimens, it can be assumed that, if the ratios of strontium for humans to deer are roughly the same as the site in question, then the subsistence bases of the two human populations was probably similar. The Price III and Williams sites (Price, 1985) from Wisconsin and Ohio are both known to be pre-agricultural Late Archaic sites with strontium ratios of humans to deer being roughly 1:2. Since the Knobloch ratios have been determined to be approximately the same as the Price III and Williams sites, it can be hypothesized that these three populations shared the same generalized type of subsistence base. This coincided nicely with information available regarding the types of subsistence strategies available to Late Woodland populations in the Kalamazoo River Valley and its tributaries (i.e., little, if any, agricultural endeavor, with populations relying heavily on seasonally available foods).

Future research for the Knobloch site should include in-depth analyses of the lithic and ceramic assemblages and comparisons of these to other sites located in and around the Kalamazoo River and its tributaries. Comparisons such as this will provide new data regarding Late Woodland subsistence strategies in southwestern Michigan.

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