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# SECRETS OF SOIL: A GEOCHEMICAL INVESTIGATION AND SPATIAL ANALYSIS OF THE EARLY LIVING FLOORS OF HOUSEPIT 54, BRIDGE RIVER, BRITISH COLUMBIA

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# SECRETS OF SOIL:

# A GEOCHEMICAL INVESTIGATION AND SPATIAL ANALYSIS OF THE EARLY LIVING FLOORS OF HOUSEPIT 54, BRIDGE RIVER, BRITISH COLUMBIA

By

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Bachelors of Art, The University of Montana, Missoula, Montana, 2015

Thesis

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# Abstract

Perhay, Nathaniel, May 2020, Anthropology

**Secrets of Soil: A Geochemical Investigation and Spatial Analysis of the Earliest Living Floors of Housepit 54, Bridge River, British Columbia**

Chairperson: Dr. Anna Marie Prentiss

This is an exploratory study to assess the ability of using geochemical sampling to give insight into the subsistence behavior of the inhabitants of Housepit 54 and a look at the spatial organization of activity areas on floors IId, IIe, and IIf. The geochemical make-up of soils can give great insights into former actives that have disturbed or occurred in or around the soil. Anthropogenic soils are formed through the complex interplay between humans and natural factors. This geochemical study will use chemical signatures to tease out the daily activities that were performed by the inhabitants of Housepit 54. A geochemical investigation of the early floors of Housepit 54 provides insight into the daily activities of household occupants. Excavations of Housepit 54 revealed 17 superimposed floors and roofs. The earliest dating floors were excavated in 2016 with sediment samples systematically collected across each floor level. 65 (n=65) samples associated with floors IId, IIe, and IIf were collected and analyzed for this study. This study utilized an Environmental Analyzer/Isotope Ratio Mass Spectrometry (EA IRMS) for carbon and nitrogen ratios and Energy Dispersive X-ray Fluorescence (EDXRF) for calcium and phosphorus ratios to provide reliable compositional data on the floor sediments. With the use of the gathered data and geospatial tools, we are able to reconstruct variation in the organization of activities across floors that may or may not be reflected in distributions of artifacts and subsistence remains. Implications for understanding household activity areas and recommendations for future research of this nature are offered.

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# Chapter 1: Introduction

## *Introduction*

Soil is all around us and it covers everything on earth in one degree or another. There are endless amounts of data contained in just a handful of soil. The geochemical make up of soil can give great insight into any activities that have disturbed or occurred in or around the soil. For the purpose of this study both terms soil and sediment are used, a definition of each term is needed to understand the differences between each of them. Soils are vertical weathering stratigraphy that develop in place and needs time and a stable ground surface to develop (Smith 2012). Sediments are particles that have been transported to a place by water, wind, and for this project people. A simpler definition is sediments are the result of movement while soil needs the absence of movement. When humans perform an activity once, it leaves behind ephemeral evidence of said activity. When humans perform the same activity repeatedly the evidence left behind from the activity is more abundant and lasts longer. Repeating the same activity over and over creates anthropogenic sediments. Anthropogenic soils are formed through the complex interplay between humans and natural factors. Daily activities such as food preparation (breaking down animals and plant materials), cooking, flint knapping, and disposing of waste can leave distinct chemical residues into the underlying soil. The soil is well preserved unless significantly altered, and the original residues are preserved in their original depositional contexts and are chemically detectable.

Geochemical analysis of anthropogenic soils can be an incredible source of information when studying past social organization in a household context. Elemental characterization of sediments from the living surfaces of Housepit 54 in British Columbia may aid in establishing a spatial organization and human behavioral adaptations that were present throughout the lifespan of the house. This study utilizes sediment samples from the 2016 excavation, which includes floors identified as Strat IId, Strat IIe, and Strat IIf. A stable isotope analysis (EA IRMS), energy dispersive x-ray fluorescence (EDXRF) techniques were employed for this study to look at the isotopic and elemental signatures of different chemicals compounds present in the floor sediments. EA/IRMS and EDXRF techniques coupled with geospatial tools are employed to understand the daily activities associated with certain areas of each floor. EA/IRMS instrumentation determines the ratios of N and C present in the soil, while EDXRF measures the ratios of many major and trace elements present in the soil, such as Ca and P. Geospatial tools help display and interpret the results.

Although the techniques are technical and drawn from the natural sciences, a geochemical analysis of the sediment from these older floors could provide a useful understanding of the organizational and the use of house space. Ultimately, the goal is to understand the household, because "The household is the fundamental socio-economic unit of many societies and may be linked to the organization of domestic space reflecting broader cultural dynamics, including the social division of labor, inequality, and demography" (Goodale et al. 2017:446; see also Terry et al. 2004).

Chemical and isotopic signatures can provide a framework on which one can view and help construct the past. All activities performed within Housepit 54 leave a trace or evidence of one kind or another. These residual traces will be visible within the archaeological record in all types of mediums, such as lithics, faunal remains, fire-cracked rock (FCR), macrobotanical remains, and/or concentrations of chemical or isotopic residues. These types of artifacts, ecofacts, residues, and chemical signatures collectively comprise the archaeological record of Housepit 54.

The Bridge River Village site is located in the Middle Fraser Canyon in Southern British Columbia, Bridge River is one of several large winter village sites in the Mid-Fraser occupied during approximately the same time periods ranging from approximately 1800 BP to the contact period (Hayden 1997; Prentiss et al. 2008). The Mid-Fraser Canyon is a significant area of study for complex hunter-gatherers because of its rich ethnographic record as well as well-preserved stratigraphic sequences that span at least 2000 years (Prentiss et al. 2011, 2008). While there have been multiple pithouses excavated at the Bridge River site, but Housepit 54 is the focus of this study will focus on.

## *Research Goals*

The research methodology for this project largely follows the approach outlined by Goodale et al. (2017), although his work focused on a later floor level. Housepit 54 was occupied during three periods (BR 2-3) within the range of ca. 1500-1000 cal. B.P. and again (BR 4) ca. 500-100 cal. B.P. (Prentiss et al. 2018). Here, only the BR 3 period will be utilized, and only data from floors IId, IIe, and IIf within that period of time will be used. The at-times tumultuous history of the Bridge River site had major impacts on Housepit 54. BR 1 (ca. 1600-1800 cal. B.P.) experienced a slow-growth phase, which led to a stable demographic occupation for much of BR 2 (ca. 1300-1600 cal. B.P.). However, during the late BR 2 period there was a dramatic downshift in the population of the village, which led to a mass abandonment prior to the BR 3 period. At the start of BR 3 there was a population boom led to the establishment of many new pithouses (Prentiss et al. 2018). Several factors could have contributed to changes during the lifespan of Housepit 54, such as ecological or population crises, which likely affected the amount and availability of crucial resources. This thesis seeks to contribute to ongoing research that seeks to understand this dynamic period.

Combining geochemical analysis and faunal data, spatial analysis can provide a clear picture of the organization of activities during a portion of the lifespan of Housepit 54. Spatial data can be used to compare the living surfaces of each floor to see what the inhabitants were using and consuming. If certain areas of the Housepit 54 floors exhibit an association between chemical signatures and faunal remains, then that could mean that certain resources were being utilized more so than others, and this could potentially give insights into the nature of activities on the house floors. They may also provide reflections on cultural processes during the early BR3 period.

This is an exploratory study to assess the feasibility of using geochemistry to give insight into the subsistence behavior of the inhabitants of Housepit 54 and to look at the spatial organization of activity areas on floors IId, IIe, and IIf. This geochemical study will use isotopic and geochemical signatures (hereafter, chemical signatures) to tease out the daily activities that were performed by the inhabitants of Housepit 54.

## *Significance of Research*

A varied distribution of chemical signatures throughout the living surfaces would coincide with varied activities that were performed in Housepit 54. The chemical signatures coupled with certain faunal remains could potentially help solidify our interpretation of the daily activities of the inhabitants. Data from multiple floors, chemical signatures, and faunal remains permit us to tease out trends in the geospatial data. Interesting insight into human behavior over a period of multiple occupations could be revealed with the results of this research project.

Geochemical data as distributed on Housepit 54 floors would be compared to distributions of faunal remains in order to develop comprehensive conclusions regarding spatial organization of food processing.

## *Thesis Outline*

This paper is presented in five chapters.  Chapter One outlines the basis of this study, the research questions, and the significance of the research, and how it fits into the grander scheme of the Bridge River Housepit 54 Project.  Chapter Two addresses the regional background the Bridge River Housepit 54 project.  This chapter will look more in-depth at the periods of occupation at Bridge River that are associated with Housepit 54.  There is also an overview of Housepit 54 and the background of the Bridge River Housepit 54 Project.  Chapter Three outlines the field methods focusing in particular on procedures used to gather sediment samples.  The laboratory methods utilized for this project include preparation of samples for analysis using the EA IRMS and EDXRF instruments.  My hypothesis and expectations are outlined in the chapter.  Chapter four consists of the results of the study of each respective floor (IId, IIe and IIf).  My analysis of the data is also included in chapter four.  Lastly, chapter five presents my conclusions and further research ideas and questions.

# Chapter 2: Cultural Context

## *Regional Background*

Within Canada, there is a large province called British Columbia (BC) and within that province is a region called the Mid Fraser Canyon.  “The Mid-Fraser region includes the Fraser River and its flood plains, adjacent talus slopes and terraces, and surrounding mountains and high valleys” (Prentiss and Kujit 2012:2). The Fraser Canyon has been and is still home to a great number of people, and has a long history of people settling there, from ancient hunter-gatherers to gold rush settlers. The region is covered in high mountain peaks and deep narrow valleys (Figure 1) in which small streams, creeks, and rivers flow. The climate in this region is quite peculiar. The summers are deceptively warm and the winters are cold with little precipitation, as the region is located within a “rain-shadow”, which occurs because moist weather conditions are constrained or diverted by the Coast Range. Because of the location of the region, it experiences extreme fluctuations in the temperature, which can reach lows of -28ºC (-18ºF) and highs of 41.5ºC (107ºF) and an average high temperature of 21.6ºC (71ºF) and an average low temperature of -2.4ºC (23ºF) (climate.weather.gc.ca 2019). The climate within the Mid Fraser is semi-arid (French 2013). A strong hot wind blows through the valleys in the summer making it a superlative place for the wind drying salmon.

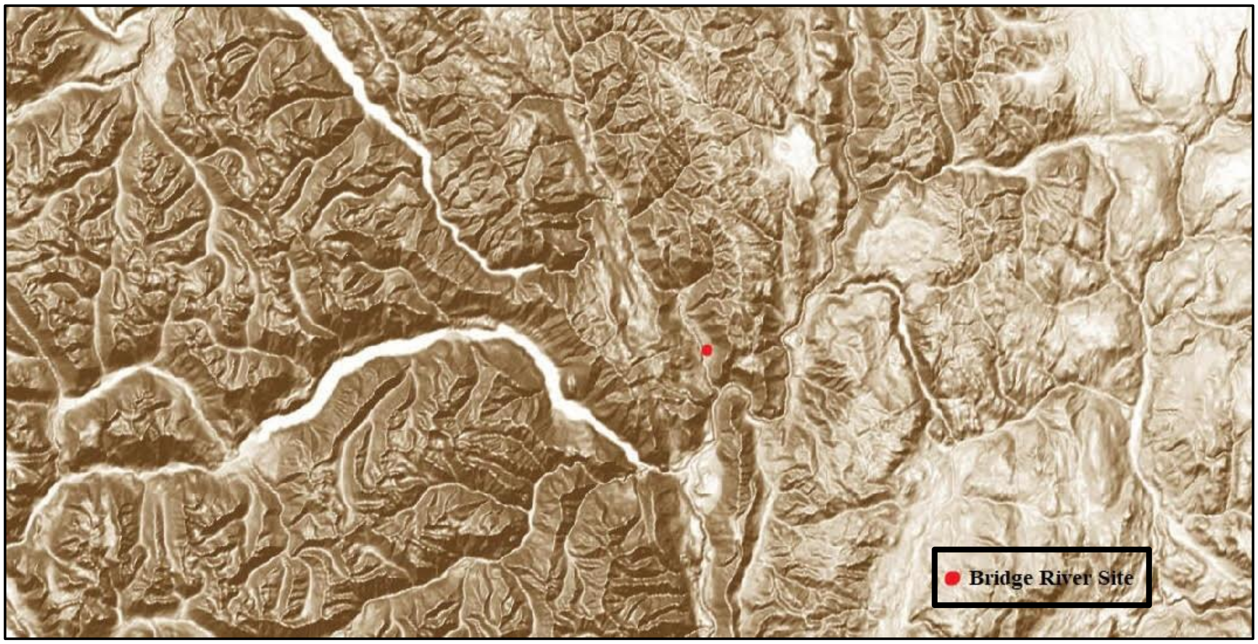


**Figure 1. The mountainous terrain of the Fraser Valley surrounding the Bridge River site (gov.bc.ca 2019).**

The major lifeline within the area is the Fraser River and its tributaries. It is the longest river in British Columbia, Canada at 1,375 km long, with its headwaters located high in the Rocky

Mountains and flows through rolling hills and flatlands of the interior plateau, through the Coast Mountains and Fraser Canyon where the Bridge River Village is located and eventually enters the broad flood plain that extends 130 km to Vancouver and the Strait of Georgia in the Salish Sea (chrs.ca). The river is fed by multiple tributaries, such as Cayoosh, Lochnore, Nesikep, Texas, Gibbs, Fountain, Sallus, Keatley, Pavillion, and Kelly (Prentiss and Kuijt 2012).

Housepit villages were generally located in places of optimal access to salmon, edible roots, and land mammals (Prentiss and Kuijt 2012). The main staple of food for the area was salmon, as the Fraser River provided optimal conditions for salmon runs, and some of the smaller tributaries that branch off of the Fraser River were highly productive spawning grounds. Salmon wasn't the sole source of sustenance for the people of the region. There was also a wide variety of flora and terrestrial fauna available.

The Mid-Fraser Valley has a diverse assemblage of plant life. The majority of plants within British Columbia and the Pacific Northwest are C3 photosynthesis type plants. C3 plants are plants in which the initial product of the assimilation of C dioxide through photosynthesis is 3-phosphoglycerate, which contains 3 C atoms (Liang et al. 2012).

The River Valley is in the River Terrace ecological zone (Alexander 1992), which supports an abundance of Ponderosa (*Pinus ponderosa*) and lodge pole pine (*Pinus contorta*) with a thick understory of herbaceous shrubs and grasses. There are a wide variety of different flora species that are found within the region, such as Ponderosa pine (*Pinus ponderosa*), bunch grass (*Tussock*), sagebrush (*Artemesia tridentate*), and Bitter brush (*Prusahi tridentate*), which are all found on glacial till. There are other dominant flora species that are found within the area around the Bridge River Village, such as vine maple (*Acer circinatum*), cottonwood (*Populus*), huckleberry

(*Vaccinium parvifolium*), Saskatoon berries (*Amelanchier alnifolia*), chokecherry (*Prunus virginiana*), lodge pole pine (*Pinus contorta*), snowberry (*Symphoricarpos albus*), big sagebrush (*Artemisia tridentate*), Idaho fescue (*Festuca idahoensis*), blue wildrye (*Elymus glaucus*), bluebunch wheatgrass (*Pseudoroegneria spicata*). Edible plants include western springbeauty *(Claytonia lanceolate)*, balsamroot (*Balsamorhiza*), wild onion, yellow elder (*Tecoma stans*), Goatsbeard/salsifies (*Tragopogon*), and triplet lilies (*Triteleias*). Stands of quaking aspen (*Populus tremuloides*), serviceberry (*Amelanchier*), chokecherry (*Prunus virginiana*), hawthorn (*Crataegus*), dogwood (*Cornus*) are present in the riparian zone (Carlson 2010; Krajina 1965).

There is an equally diverse array of fauna in the Mid-Fraser Canyon. The Bridge River Valley is home to many different faunal species. The valley supports the typical north temperate mammalian fauna, which includes nine species of ungulates. Deer and elk occur in groups, particularly in winter, when they migrate to the lower elevations to avoid the snow. (Carlson 2010: Wallmo 1981). Large mammals include elk (*Cervus canadensis*), moose (*Alces alces*), white-tail (*Odocoileus virginianus*) and mule deer (*Odocoileus hemionus*), big horn sheep (*Ovis canadensis*), mountain goat (*Oreamnos americanus*), brown (*Ursus arctos*) and black bears (*Ursus americanus*). Medium-sized mammals include beaver (*Castor canadensis*), fishers (*Pekania pennant*), marten (*Martes Americana*), wolf (*Canis lupus*), coyote (*Canis latrans*), wolverine (*Gulo gulo*), weasel (*Mustela*), porcupine (*Erethizon dorsatum*), marmot (*Marmota caligata*), and rabbit (*Chordata*). Small mammals include a variety of mice (*Rodentia*), shrews (*Soricidae*), voles (*Arvicolinae*), ground squirrels (*Marmotini*), and tree squirrels (*Sciurini*) (Carlson 2010). Many of these species do not just provide a good source of sustenance they also provide a good source for goods, providing skins and hides, bones, teeth, claws and other such items. There are various fish species also found within the rivers and lakes of the Valley these include four species of anadromous salmon: Chinook (*Oncorhynchus tshawytscha*), Coho (*Oncorhynchus kisutch*), Sockeye (*Oncorhynchus nerka*), and Pink (*Oncorhynchus gorbuscha*); sturgeon (*Acipenser transmontanus*), white fish, and various species of trout. A number of bird species are also found within the area, such as spruce grouse (*Falcipennis canadensis*), ptarmigan (*Lagopus muta*), raptors, and migrating waterfowl such as ducks and geese. In addition to all the other fauna present there are also amphibians that are present within the area which include various toads, frogs, and lizards (Carlson 2010).

Different food sources leave distinct isotopic signatures when they are processed, cooked, eaten, and disposed of. The chemical signatures left behind by plant-based resources will leave a concentration of C while a high concentration of N could mean the presence of marine or terrestrial animal remains. P and Ca concentrations can coincide with marine and terrestrial animal remains processing areas or cooking areas as they are both also coincide with burned areas and wood ash.

There are numerous Housepit villages within the region surrounding the Bridge River site, such as are Keatley Creek, the Little S7istken site, the Lochnore-Nesikep sites, and the Bell site (Figure 2). Keatley Creek site is an unusually large prehistoric pithouse village site located on the terraces of the Fraser River, about 20 km upstream from the town of Lillooet, British Columbia (Hayden 1996). The Keatley Creek Housepit village is about the same age as the Bridge River Housepits with dates post-2,000 years ago. There are over a hundred pithouses located in Keatley creek, which is significantly more than in Bridge River. There are other sites in this area that are not as large as Keatley Creek and the Bridge River site, such as the Bell site, and the Lochnore-Nesikep sites just south of Lillooet. With only a handful of pithouses excavated at each of these sites, it is difficult to know what life was like in these ancient housepit villages in detail, but we have an outline of the history and life of these ancient villages. The pithouse villages in the Mid-Fraser Canyon were composed of semi-subterranean Housepits that were seasonally occupied primarily during the winter by corporate groups or multi-family households (Prentiss et al. 2007). Ames (2006) describes three ratios of corporate groups: (1) several families living together in the same structure; (2) families living in structures close together such as a compound; and (3) large corporate groups as might be reflected in neighborhoods (Hocking 2013).

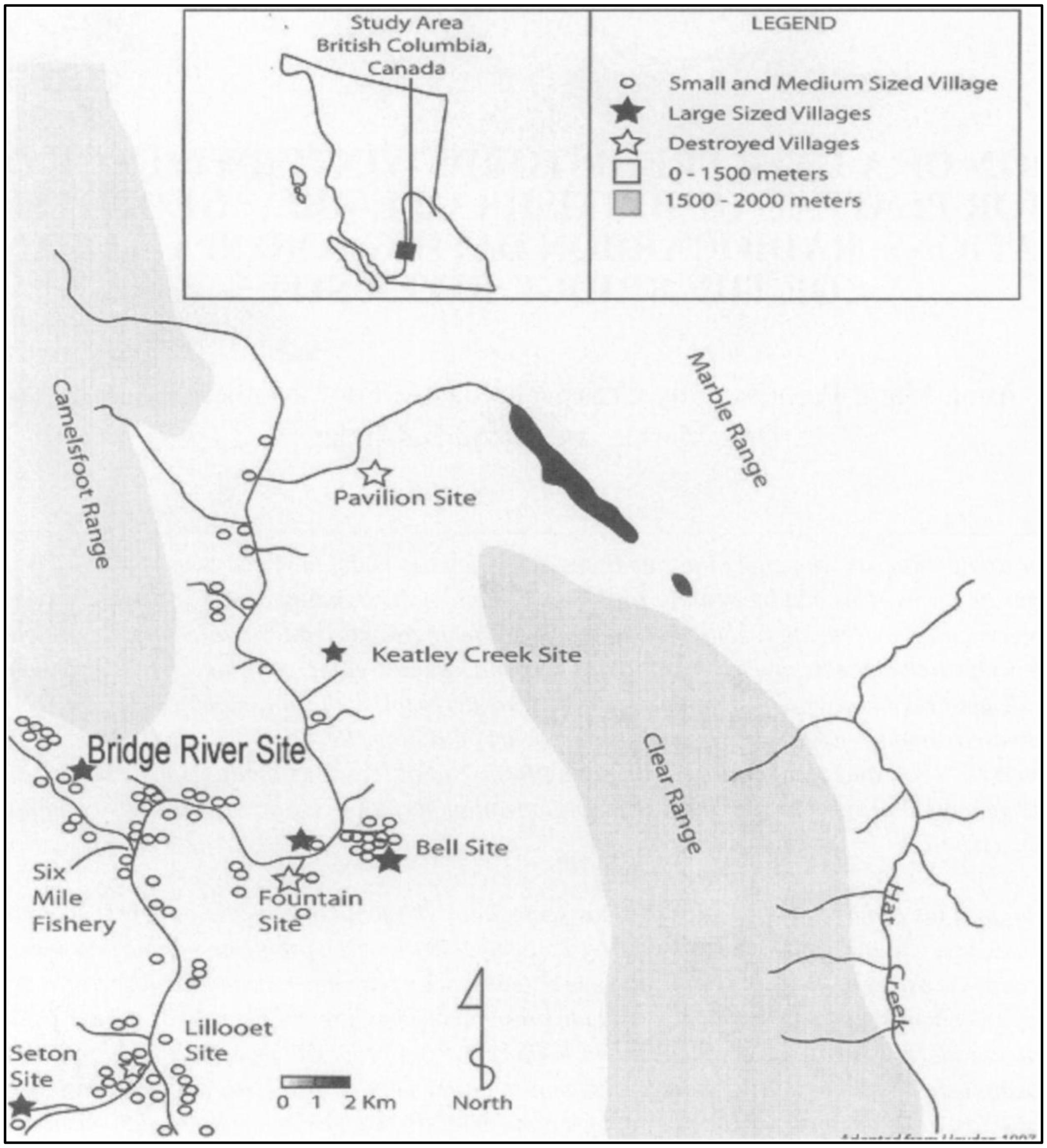


**Figure 2. Bridge River site location and other nearby Housepit villages within the Mid-Fraser Canyon area (Prentiss et al 2008).**

Starting from a contemporary perspective, there are multiple bands that make up the St'át'imc First Nation have been in living and thriving within the area for hundreds of years, with their ancestors living in the vicinity for thousands of years (Figure 3). There are eleven Bands that make up the St'át'imc Nation. They are the Xwísten-Bridge River, Xaxl'ip-Fountain, Ts'kw'aylaxw-Pavilion N'Quatqua-Anderson Lake, Samahquam, Lil'wat-Mt. Currie, Xa'xtsa7-Douglas, T'it'q'et-Lillooet, Sekw'el'was-Cayoose Creek, Chalath-Seton Lake, and Skatin (xwisten.wordpress.com 2019). The region that the Xwísten Band calls home is located in a steep, vertical landscape, with impressively tall mountains enclosing the community and Bridge River running through the valley. Most of the band members lived on the multitude of terraces that line the river and its tributaries. One of the most culturally important aspects of the environment. People have been fishing in the area for thousands of years. They are known for their wind-dried salmon. The unique climate in the region helps with the preparation of the salmon. The hot dry wind is a key component in the technique used in preparing it. Salmon has been the major food source for thousands of years and is also of high cultural significance to the people in the area. It was one of the largest salmon runs in the world (xwisten.ca).

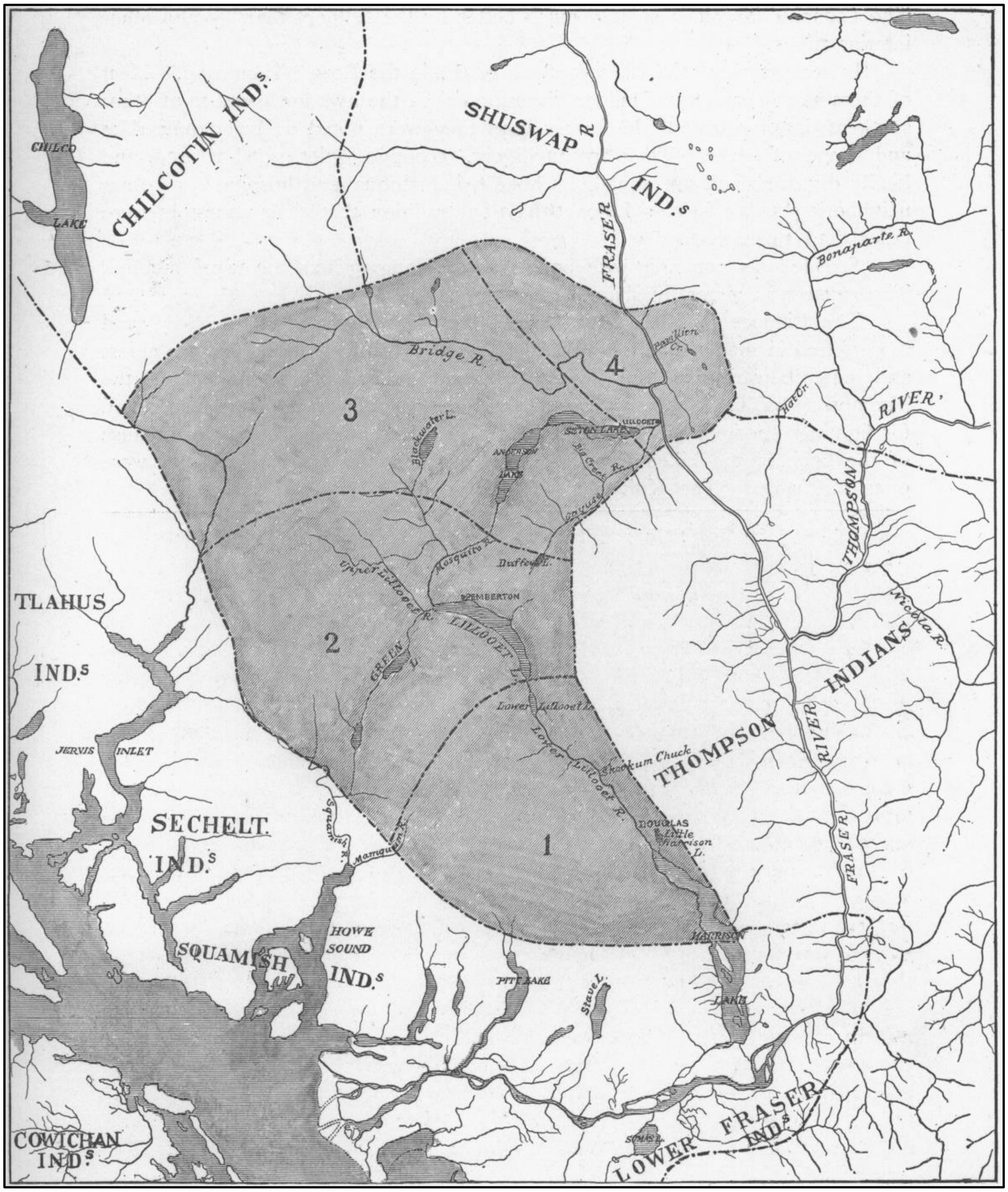


**Figure 3. Traditional territory of the St'át'imc First Nation in British Columbia (Teit 1906).**

## *What is a Pithouse?*

The main focus of this study is trying to understand the past of Housepit 54. But what is a pithouse or a Housepit in this context? A pithouse is a semi-subterranean domicile that used for seasonal winter habitation (Figure 4). A Housepit is the archeological manifestation of a pithouse which is found in the archeological record, basically "the remains of these pithouses, known to archaeologists as Housepits, generally include floor layers derived from clay-rich sediments often transported from elsewhere, capped by collapsed roof deposits and surrounded by rim-middens consisting of household debris and old roof material" (Prentiss et al. 2020:5).

Pithouse villages were occupied seasonally, usually during the cold winter months. The inhabitants would venture out in the warmer months to hunt and gather resources and return to these pithouse villages to live out the winter. Pithouses were often clustered together to form a small to large village depending on the occupancy of the village and they were generally found along rivers, lakes, or on terraces that were near a water source. The interior of British Columbia and the Mid-Fraser Canyon held an abundance of pithouse villages (see above, Figure 2) as the climate in that region was harsh and the inhabitants needed exceptional protection from the elements and reliable food storage to survive.

Pithouses did not start to appear on the Canadian Plateau until around 4,400 B.P., with the oldest radiocarbon date from a pithouse being 4,450 ± 100 B.P. (Alexander 2000; Stryd and Rousseau 1996). Choosing a location to build a pithouse was one of the more important decisions to be made before construction. Many variables that had to be considered when constructing one, such as environmental and social constraints (Alexander 2000). The area had to be close to valuable resources, such as water, food, and building materials. Since pithouses use large logs to construct the frame and roof, there needed to be mature trees near the building site. Hunting and fishing areas needed to be in close proximity in part to protect access from unauthorized users (Alexander 2000; Nastich 1954). Another factor that one had to considered when constructing a pithouse was the climate, it was critical to select a warm, southern facing exposure. A sheltered location afforded protection from the cold winter winds that blow through the river valley (Alexander 2002). Since pithouses were semi-subterranean, a flat easily dug area was needed to aid in the construction. The Bridge River Village location met and exceeded all these variables making it an ideal place to construct a village.

Constructing a pithouse was not an easy task and required a combined effort of many people. The people who live in the house could build it on their own, but the construction of a small or moderately house with 25 to 30 people could last from one week to twenty days (Alexandra 2000; Green 1972; Post and Commons 1958). First, a large pit had to be dug, for the walls of the structure. Large trees were needed to be felled and processed, which includes stripping the branches and bark off of the log. These felled logs were used to build the frame and roof of the pithouse, main support posts and beams (Figure 4 and Figure 5), and were generally made from green timber (Alexander 2000; Teit 1900). After the frame and support posts and beams were positioned, the inhabitants placed small sticks over the beams and wove branches and grasses together to make the first layer of the roof and on top of that layer they would cover it with soil to make it secure and waterproof.

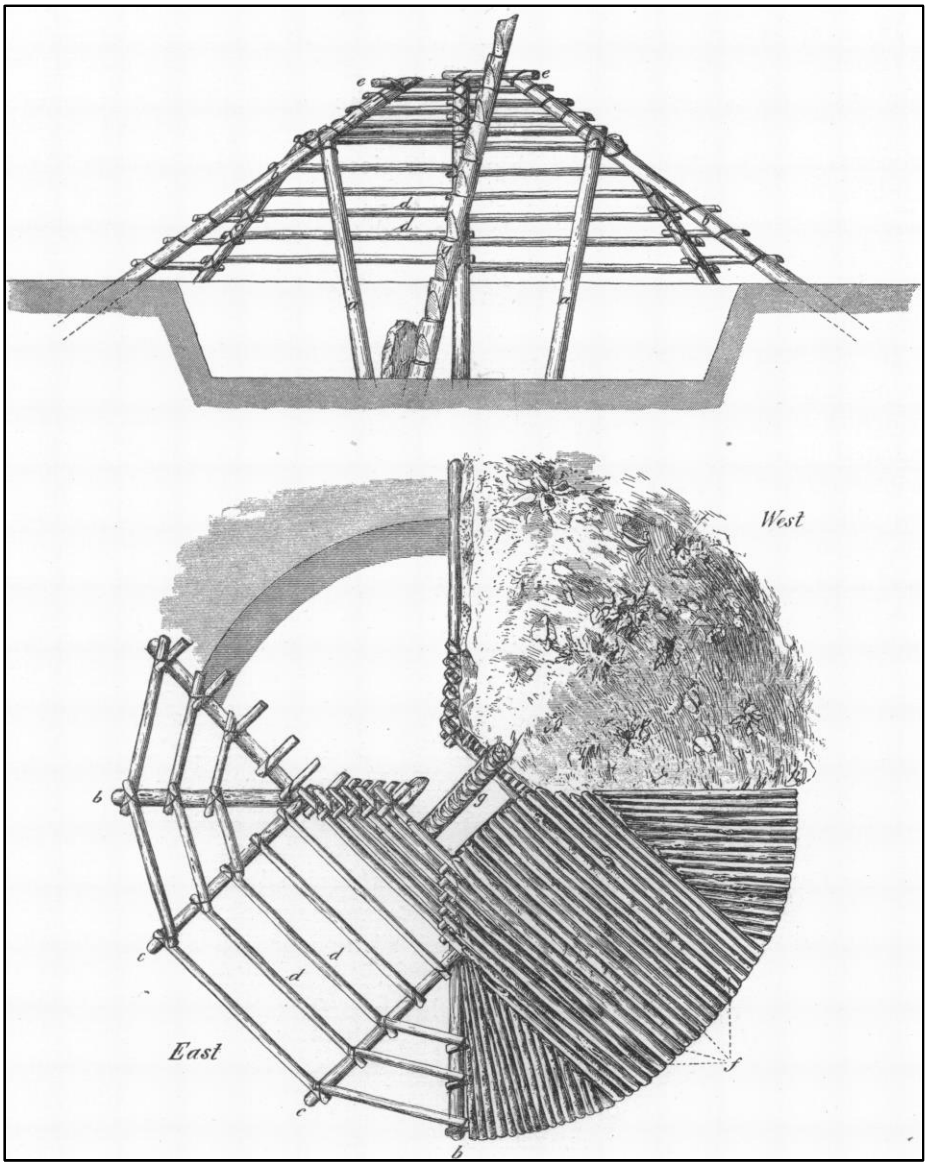
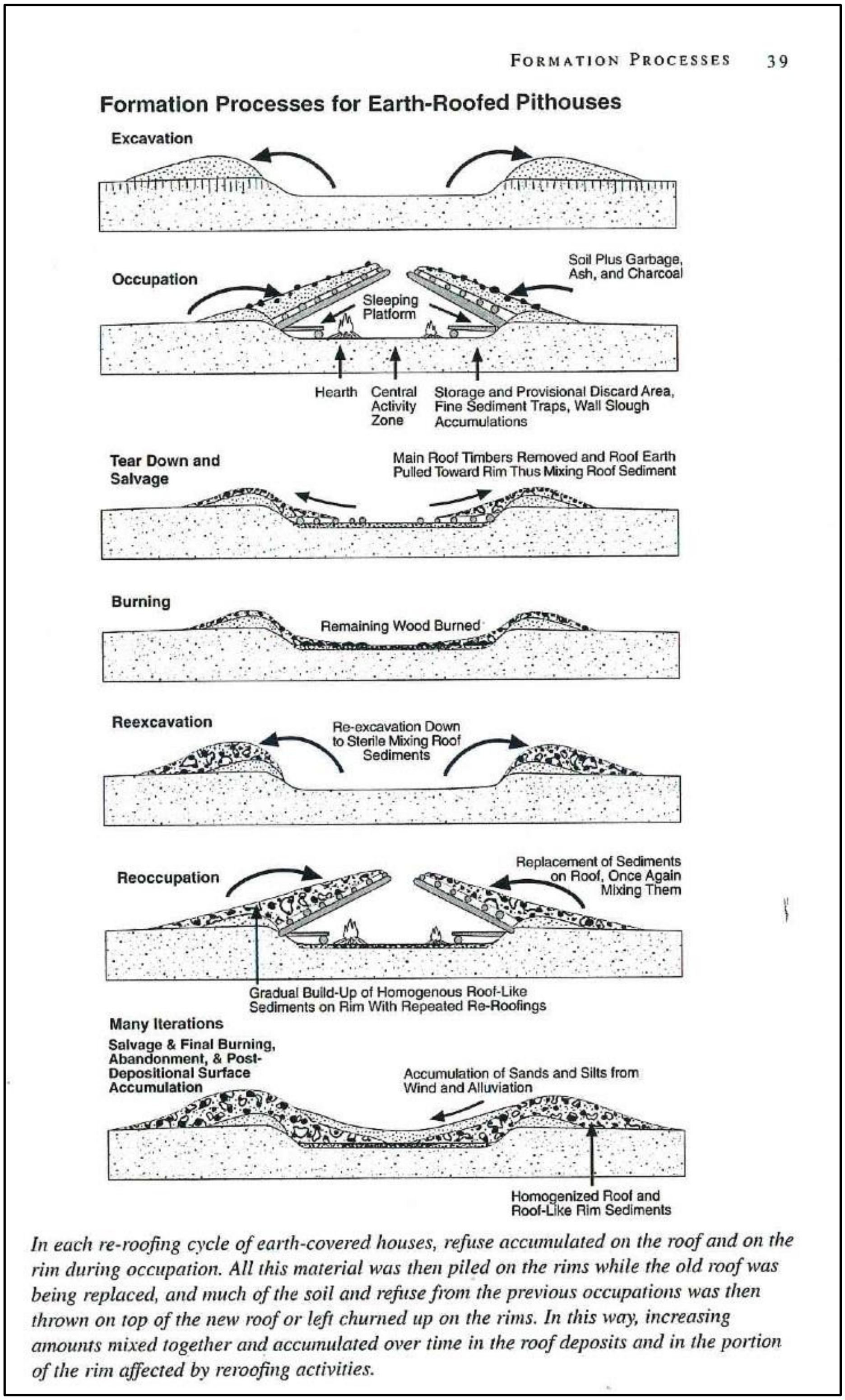


**Figure 4. Example of a northern Plateau pithouse (Teit 1900).**

**Figure 5. Modern re-constructed pithouse in Kamloops, British Columbia, Canada.**

When a pithouse's roof became damaged, degraded, or unsafe to live under, the inhabitants would reroof it (Figure 6). The process used at the Keatley Creek site involved tearing the roof down and salvaging anything that was still in good shape. After the roof was torn down, they burned any remaining wood and any other organic material associated with it. After it was burned with only charcoal left, they re-excavated to sterile sediments at many villages, such as Keatley Creek. The excavated soil would be deposited it in the rim area. Last, they would establish a new floor and construct a new roof and continue the occupation of the pithouse. This re-roofing cycle would be undertaken multiple times throughout the life of the pithouse.

The building and rebuilding processes of the pithouses at the Bridge River site were different than the process at Keatley Creek. At Bridge River, the inhabitants would clear the roof and pour a new layer of floor sediment over the old one, thus preserving the older floor materials, "many Bridge River occupants did not remove their old floors but simply covered them with new layers of floor material" (Prentiss et al. 2020:5; see also Prentiss et al. 2008; 2012). After the new flood sediment was in place they would repair the roof or fully replace it. This is why there are only seven roof layers present compared to the 17 superimposed floors present at Housepit 54.



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**Formation Processes for Earth-Roofed Pithouses**

*In each re-roofing cycle of earth-covered houses, refuse accumulated on the roof and on the rim during occupation. All this material was then piled on the rims while the old roof was being replaced, and much of the soil and refuse from the previous occupations was then thrown on top of the new roof or left churned up on the rims. In this way, increasing amounts mixed together and accumulated over time in the roof deposits and in the portion of the rim affected by reroofing activities.*

**Figure 6. Formation process for earth-roofed pithouses, Keatley Creek model (Hayden 1997).**

## *Cultural Chronology of the Area*

The region surrounding the Bridge River Site has been continually occupied for more than 10,000 years. The region has gone through multiple evolutions and cultural horizons. For the purpose of this study only the three horizons associated with the Plateau Pithouse Tradition will be discussed, because that is when the Bridge River village site and Housepit 54 were most prevalent. The three horizons are labeled Shuswap, Plateau, and Kamloops (Figure 7). These three horizons of occupation have been described and defined by Prentiss and Kuijt (2012), Richards and Rousseau (1987), and Rousseau (2004). The definitions of the Plateau Pithouse tradition and its component cultural horizons were developed by adopting an empirical approach, utilizing data from virtually every excavated component on the Canadian Plateau (Richards and Rousseau 1987).

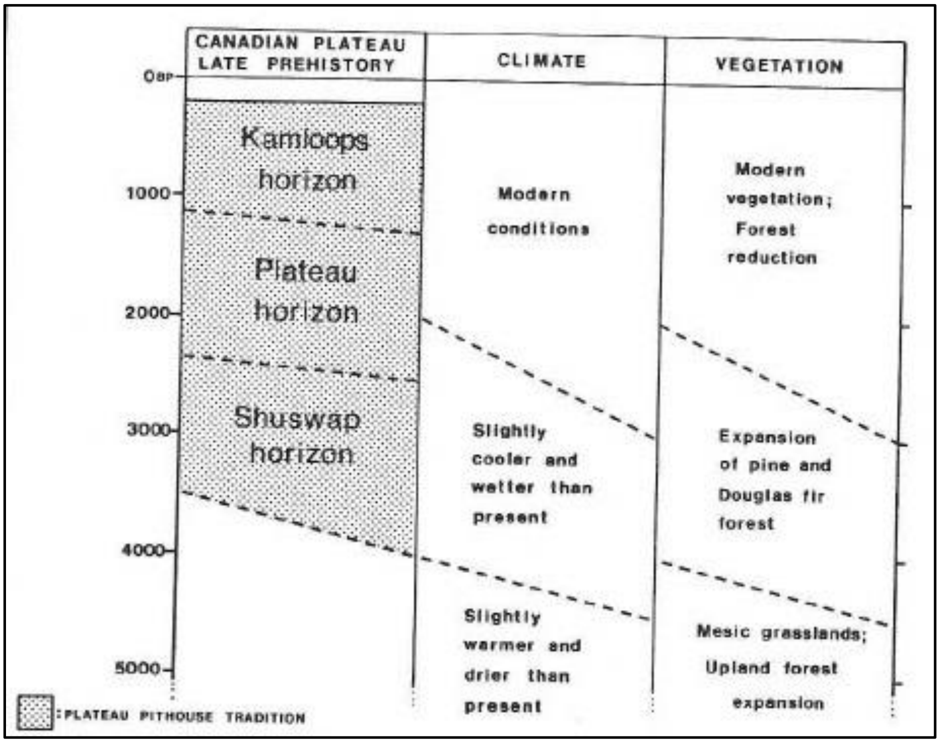


**Figure 7. Cultural and paleoenviromental sequences for the late prehistoric period on the Columbia Plateau (Richards and Rousseau 1987).**

### *Shuswap Horizon (3,500 – 2,400 B.P.)*

Dating about 3,500 years B.P., the Shuswap Horizon is the earliest period of the Plateau Pithouse tradition. This horizon marks the initial common use of semi-subterranean pithouses as seasonal winter habitation (Richards and Rousseau 1987). With the rise of these pithouse communities, a collector-based strategy with a focus on food storage and regular winter residency started to emerge (French 2013). This helped sustain steady population growth. The initial pithouses during this period were smaller with an average size of 10.7 meters in diameter and lacked raised earth rims, circular to oval in plan and usually flat bottomed with steep walls, and the floors tend to be rectangular in plan. (Richards and Rousseau 1987). The houses had side entrances and usually a single central hearth that indicates residents lived in individual egalitarian households (Prentiss et al. 2005).

During the Shuswap Horizon, the subsistence items are not well known. The lack of storage pits within the Shuswap-era houses until about 3,000 years ago points to a lack of formal food storage within them. The little evidence that is available points to groups subsisting off of large and small land mammals and birds, collecting fresh-water mussels, and fishing salmon, trout, and other fresh-water species (Richards and Rousseau 1987). There is little to no evidence for the utilization of plant resources during this period because no modern era excavations have focused on this period. There has also been no botanical analysis completed for this period wither.

During the Shuswap Horizon the prominent lithics were believed to represent expedient tools (Hocking 2013; Prentiss and Kujit 2012. These types of tools were quickly produced tools that needed little to no production effort. They were intended to be made on the go and then discarded with no concerns. In short, the lithic assemblages for this period were relatively simple in composition, workmanship, and technological sophistication compared to the later horizons (Richards and Rousseau 1987). These relatively crude tools also could be the result of low to medium quality raw materials that were used.

During the Shuswap Horizon, evidence of trade started to appear in the form of dentalium shells from the coast and Shuswap projectile point resembling some from the Locarno Beach Phase and the McKean Complex, which indicated that contact between the regions existed (French 2012).

### *Plateau Horizon (2,400 – 1,200 B.P.)*

The Plateau Horizon is the second of the three horizons of the Plateau Pithouse tradition. The pithouses present during the Plateau period are similar to the Shuswap horizon as they are small in size, with the average diameter 6.14 m. This pattern does not hold true with the pithouses located within the Mid-Fraser region, where they are markedly larger, averaging 9.9 meters in diameter (Richards and Rousseau 1987). Most of the Plateau Horizon pithouse depressions were circular to oval in plan, lacked raised earth rims, a central hearth feature was usually present, small cooking or storage pits are found near floor/wall junctions (Richards and Rousseau 1987). Just like the Shuswap Period, the walls of the house pit were steep and the floors flat, which resulted in basin shaped profiles. Pithouses had substantial wooden superstructures covered in earth. Large complex aggregated winter villages appeared in late Plateau horizon times, with some containing over 100 pithouses (Prentiss et al. 2005). The pithouses during this period showed an increase in storage and cooking pits within them. This increase in storage and cooking features could point to an increased focus on a sedentary lifestyle. This likely involved the increased reliance on salmon and supplemented their diets with root and big and small game (French 2012).

During this period, status inequality starts to emerge after 1,300 B.P. within some pithouse villages (Prentiss et al. 2007 and 2012). Evidence of hunting and quarrying territories start to emerge and multi-family corporate groups appear too (Hayden 1997). During this period evidence of a large trading/exchange network emerges. The trans-Rocky Mountain exchange network involving Plateau, East Kootenay, Rocky Mountain, and Northern Plains cultures was created to create links between each of these regions (Richards and Rousseau 1987). This trade network is evidenced in the archaeological record as nephrite, argillite, top of the world chert, dentalium, and olivella shells (French 2012; Prentiss et al. 2009; Richards and Rousseau 1987). These items were all considered to be prestige goods that helped the elites demonstrate and establish wealth.

The lithic technology during the Plateau Horizon is similar to the technology found during the Shuswap Horizon. The lithic technology from this horizon includes incised tools, groundstone tools, unifacial and bifacial tools, and key-shaped scrapers (Prentiss and Kujit 2012). During this period the bow and arrow were adopted. This possibly led to the reorganization of ungulate hunting parties and strategies (Carlson 2012). This is also confirmed with the increased presence of antler and bone tools.

There was a population boom in the Mid-Fraser region during this period. The population of the area reached its peak during the late Plateau Horizon. Bridge River was occupied during the latter half of this period (ca. 1,800 - 1,100 cal. B.P.). These high populations eventually resulted in a depression of the local food resources, which lead to the intensification of fish/roots and other secondary foods (Carlson 2012; Rousseau 2004). This overextension of the region is one possible cause of the abandonment that occurs during the early Kamloops Horizon (Kuijt and Prentiss 2004, Prentiss et al. 2007, 2008, 2014).

### *Kamloops Horizon (1,200 – 200 B.P.)*

The Kamloops Horizon in the last prehistoric cultural horizon of the Mid-Fraser Canyon. The subsistence and settlement strategies utilized in the previous horizons have remained unchanged with the winter pithouse village occupation and heavy reliance on salmon hallmarks (French 2012). The pithouse sizes for this time period were highly variable and averaged about 8.66 meters in diameter. The pithouses ranged in shape from oval, circular, or square in plan, and usually had prominent raised earth rims. (Richards and Rousseau 1987). A large number of them had side entrances.

The lithics during this period were similar to the previous ones as the technology and reduction strategies were similar. There was an increase in ground stone tool usage during this period. Individuals were heavily reliant on bow and arrow technology and fine pressure flaking is evident on small, precise projectile points (Richards and Rousseau 1987). There was an abundance of high-grade raw material and nonlocal materials. The importance of ground stone and high-quality materials indicated that there were effective exchange networks and increased craft specialization.

The inhabitants of these pithouse villages were still heavily relied on salmon and supplemented with deer, small animals, and wild roots, but they also continued hunting ungulates. These subsistence patterns are evidenced in the large amount of storage and cooking pits found within pithouses. It was during this horizon at about 800 – 1,000 B.P. that there were regional population collapses. There are several theories on why this collapsed happened. Hayden (1997) suggests that the Texas Creek landslide and the subsequent blockage of salmon runs was the cause of the regional population collapse, but Prentiss et al. (2005) suggests a broader systematic population decline due to an abrupt warming/drying of the climate and its subsequent impact on the salmon and root resources. With the subsequent arrival of Euro-Americans in the region around 200 B.P., the Kamloops Horizon ends.

## *The Bridge River Village Project and Site*

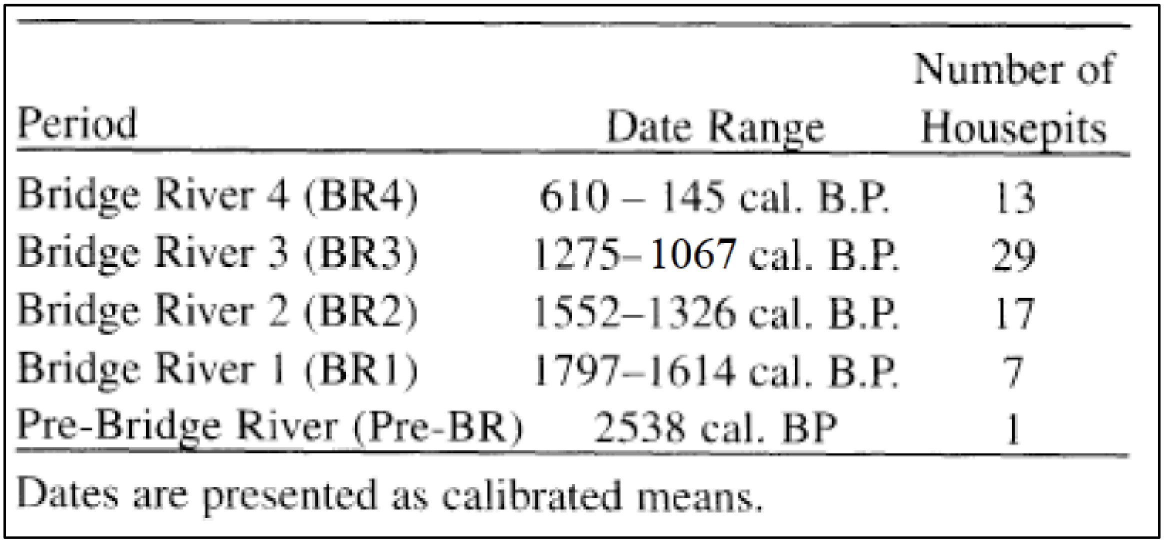
The Bridge River project is a partnership between The Department of Anthropology at the University of Montana and Xwísten, the Bridge River Indian Band (Lillooet, B.C.) to study the ancient history of the Bridge River Valley and Middle Fraser Canyon in South-Central British Columbia (Prentiss 2013). The Bridge River archaeological site is located in the Bridge River valley within the Mid-Fraser Canyon area of British Columbia, Canada. The Bridge River site is located in a canyon on a terrace that juts out and overlooks the current Bridge River Community and the Bridge River. The landscape in this area is dotted with depressions that are from 10 to 20 meters in diameter. (Prentiss and Kujit 2012). Those depressions are the remains of old pithouses or *s7istkens*. These are some of the only remnants left from the ancient people that occupied these lands. The life of the ancient village was fairly long "The village was first established about 1800 years ago and steadily grew in size until approximately 1000 years ago, at which time it was temporarily abandoned. The village was re-established during the past 400 years and was in use through the mid-19th century" (hs.umt.edu/bridgeriver 2015).

The Bridge River archaeological project has been ongoing since 2003, but the first field research at Bridge River was conducted during the early 1970s by archaeologist Arnoud Stryd (Prentiss et al. 2008; Stryd 1973, 1974). The Bridge River Band or the Xwísten First Nation are presumably the descendants of the people that occupied the Bridge River site. The site is made up of over 80 Housepits (Figure 8).

**Figure 8. Aerial image of the Bridge River site, looking west across the site (Prentiss et al 2008:63).**

### *Bridge River 1-3*

The Bridge River Site has a well-defined chronology. Following extensive testing of Housepits within the Bridge River site, 77 radiocarbon dates were extracted from roof and floor strata. After analysis of the 77 calibrated dates, four major occupational periods were defined: BR 1, BR 2, BR 3, and BR 4 (Figure 9 and Figure 10).



| Period | Date Range | Number of Housepits |
|---|---|---|
| Bridge River 4 (BR4) | 610 – 145 cal. B.P. | 13 |
| Bridge River 3 (BR3) | 1275–1067 cal. B.P. | 29 |
| Bridge River 2 (BR2) | 1552–1326 cal. B.P. | 17 |
| Bridge River 1 (BR1) | 1797–1614 cal. B.P. | 7 |
| Pre-Bridge River (Pre-BR) | 2538 cal. BP | 1 |

Dates are presented as calibrated means.

**Figure 9. Bridge River Chronology (Prentiss et al. 2008).**

BR 1 is the earliest occupational period at 1,797 – 1,614 B.P.; it had the smallest number of occupied pithouses of the Bridge River chronology (Figure 10). BR 2 is the second period of occupation of the Bridge River village, which was 1,552 – 1,326 B.P. (Figure 10). This period saw steady growth, with most of the occupied pithouses belonging to the north section of the site. The steady growth of the village continues into BR 3, which was 1,275 – 1,067 B.P. (Figure 10). Towards the end of BR 3 period, a major abandonment occurred, which affected all major villages in the region. However, the major re-occupation of the Bridge River village did not occur until 610-145 B.P. (Figure 10). This final occupation corresponds to BR 4 (Prentiss et al. 2008).

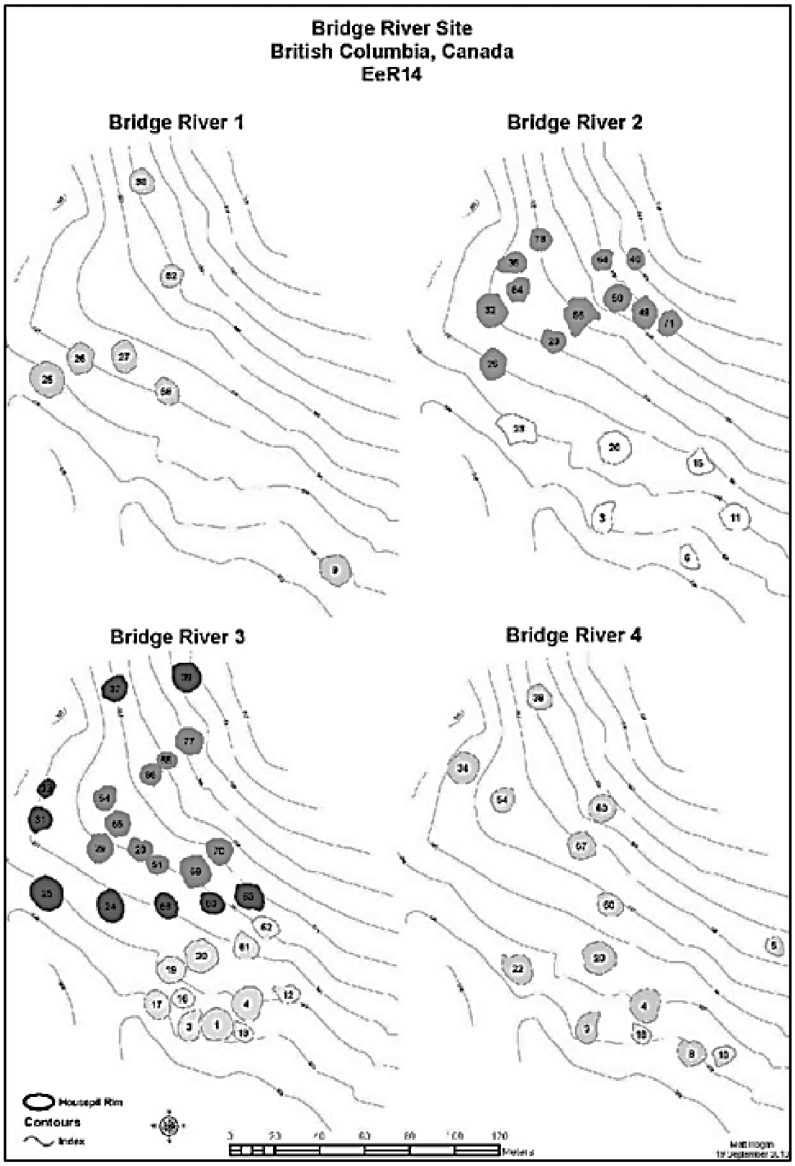


**Figure 10. Map of Bridge River site showing pattern of change in The distribution of Housepits through time (Prentiss et al. 2008).**

## *Housepit 54*

Housepit 54 is not the largest or oldest pithouse located within the Bridge River village site (Figure 11). It was occupied during three of the four occupation periods, those being BR 2, 3, and 4 (post-contact fur trade era).

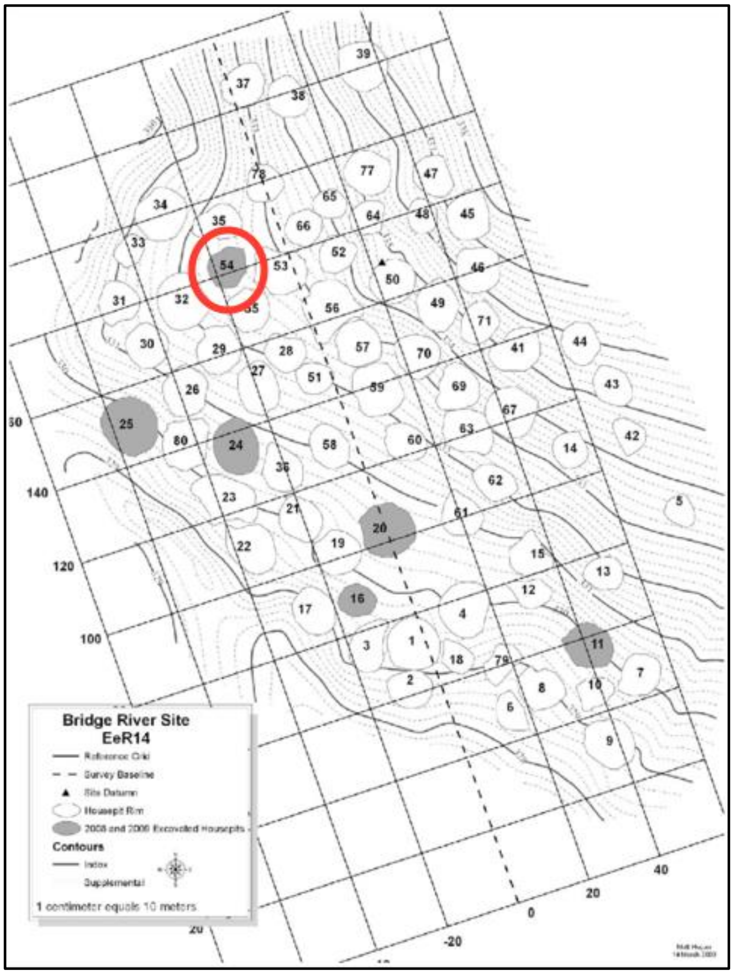


**Figure 11. Pithouses tested within the Bridge River site with Housepit 54 circled in red during the 2008-2009 field season (Prentiss et al 2008).**

Housepit 54 has been the subject of ongoing excavation since 2004. The first test pit was dug in 2004, with trench excavations in 2008, and large scale excavations starting in 2012 and closing in 2016. The field season in 2012 focused mostly on the Fur Trade period (1850s). The 2013 field season focused on the first six floors of the house which dates to about 1100-1300 years ago. The 2014 field season focused on excavating the remaining floors with dates ranging from 1100-1400 years ago. Finally, the 2016 excavation finished up what was left of Block A and furthered teased out the history of the house. Housepit 54 was selected for complete excavation because of its extensive stratigraphy. "Housepit 54 was built and occupied during the periods of about 1500-1000 years ago and again during the middle portion of the 19th century." (hs.umt.edu/bridgeriver).

Housepit 54 incorporates 17 superimposed floors and seven roofs (Table 1). This is from the occupants re-flooring and re-roofing during the occupation of the house pit. There have been a multitude of different artifacts excavated from each floor of the house. These artifacts range from fire-cracked rock (FCR), stone and bone tools, to animal remains. There are also the remains of hearths and storage features throughout the house. Each floor represents a time capsule of life during a particular generation (Prentiss 2013). The excavation is broken up into four blocks, each representing a different quadrant of the house: Block A, Block B, Block C and Block D (Figure 12 and Figure 13).

**Table 1. Cultural strata at Housepit 54. (Prentiss et al. 2019)**

| Stratum | Description |
|---|---|
| I | Surface |
| V | BR 4 (Fur Trade period) Roof |
| II | BR 4 (Fur Trade period) Floor |
| XVI | BR 3 Bench/Rim (as identified in 2012 field season) |
| III | BR 2 and 3 Rim |
| Va1 | Remnant final BR 3 Roof |
| IIa1 | Remnant final BR 3 Floor |
| XVII | BR 3 Rim-like fill in depression within Block D (likely IIa1 cache pit remnant) |
| Va | Final Complete BR 3 Roof |
| IIa | Final Complete BR 3 Floor |
| Vb1 | BR 3 Roof (Blocks B and D) |
| IIb | BR 3 Floor |
| IIc | BR 3 Floor |
| Vb1 | BR 3 Roof (Block A) |
| IId | BR 3 Floor |
| VBb3 | BR 3 roof (Block B) |
| IIe | BR 3 Floor |
| IIf | BR 3 Floor |
| IIg | BR 3 Floor |

| Stratum | Description |
|---|---|
| Vc | BR 2-3 Transition Roof (Block A) |
| IIh | BR 2-3 Transition Floor |
| IIi | BR 2 Floor |
| IIj | BR 2 Floor |
| IIk | BR 2 Floor |
| IIl | BR 2 Floor |
| IIm | BR 2 Floor |
| IIn | BR 2 Floor |
| IIo | BR 2 Floor |
| IV | Substrate (non-cultural |

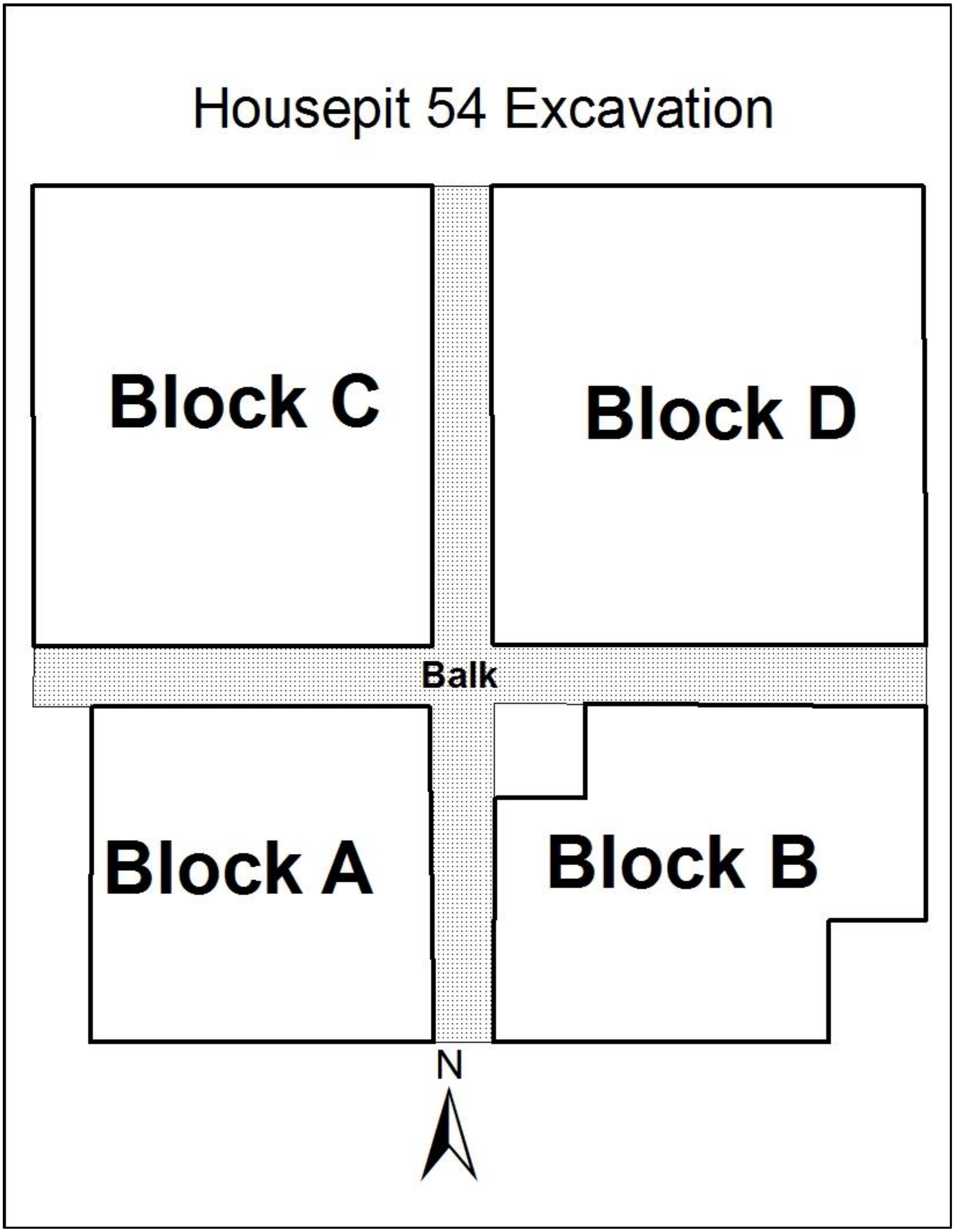


**Figure 12. Housepit 54 block locations.**

**Figure 13. Housepit 54 excavation, with Block A in the foreground, Block B to the right, Block C to the left and Block D in the back.**

# Chapter 3: Methodology

This chapter focuses on the special field and laboratory methods that are essential to a successful study of geochemical variation in sediments. I will outline the process of collecting a sample out in the field and how samples are treated within the laboratory. Secondly, I will outline how to process samples for analysis in an EA IRMS and EDXRF machine and the process of analysis in the EA IRMS and EDXRF machine.

## *Field Methods*

This section will map out how a small sample of soil can be turned into data that can be utilized to help our understanding of the life that occurred over the floors within Housepit 54. If the methods are not followed specifically then the end product could be flawed. All samples need to have the same meticulous care taken to produce accurate results. Any deviation from the process will result in skewed results and present an incorrect finding/analysis.

### *Soil Samples*

Sediment samples were systematically collected throughout the excavation of Housepit 54. Each sample was gathered from the 50x50cm SE quadrant of each 1x1 m excavation unit. If there was no area for a sample to be taken or there was not enough soil for one, the sample was taken from an alternate quadrant within the same unit. For this study, samples were processed from all 4 blocks (A, B, C, and D) and the corresponding units within Housepit 54 (Figure 14), and from floors IId, IIe, and IIf. All samples were collected in a 2-liter bag and labeled with the corresponding provenience information.

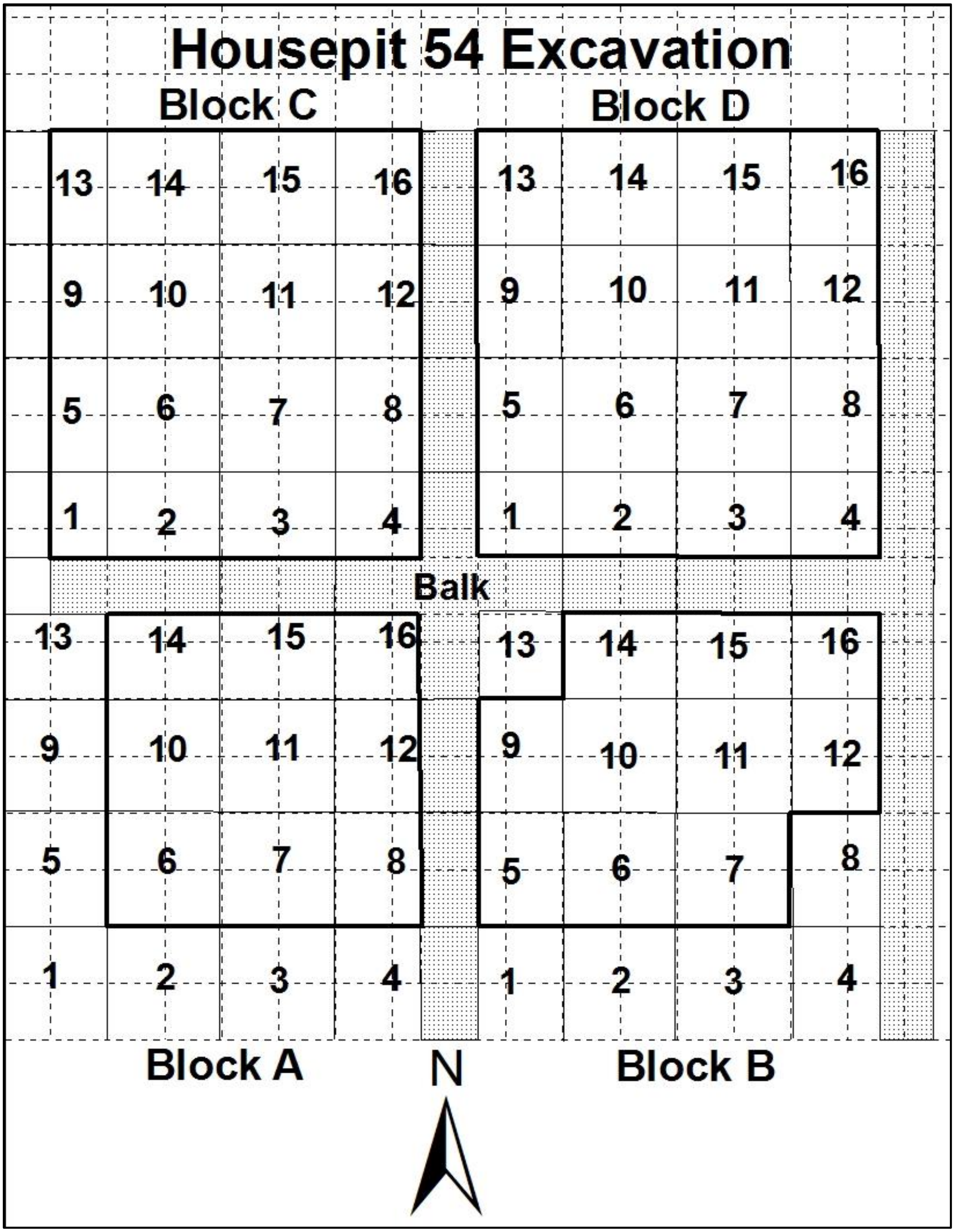


Figure 14. Housepit 54 blocks and units map.

## *Laboratory Methods*

Sediment samples (n=65) were processed and prepared for this study. The soil samples were processed by first sifting the soil through a 2mm sieve and then through a 1mm sieve to separate any larger pieces of organic material or rock. 40g of the sifted soil from each sample were set aside for IRMS analysis whereas 100g were set aside for the EDXRF. Each sample was prepped separately depending on its intended use for EA/IRMS and EDXRF.

### *Elemental Analyzer/Isotope Ratio Mass Spectrometry (EA/IRMS)*

The procedure to prep soil samples for IRMS analysis involves acid washing the soil sample. This acid washing procedure is intended to minimize the organic C that is present in the sample, which would interfere with the $\delta^{13}$C measurement desired for the inorganic C present in the sample (Santoro 2011).

The 15 gram sifted soil samples needed to have all organic material (wood, grass, and roots) removed. Removing the organic material within the samples helped to removes "interfering amounts" or organic carbon that would provide inaccurate $\delta^{13}$C values specifically desired for the inorganic carbon component of the sample (Santoro 2011). To do this each sample had to undergo acid washing. The samples were mixed with a 10% hydrochloric acid solution. The samples were then decanted[1] with water until the soil reached a pH of 7. This process could take up to a week. The samples were then dried out in a 60°c oven for 24 hours. After samples were sufficiently dried out the sample was scraped out of the beaker with a metal spatula into a glass vial for storage.

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[1] The careful separation of a supernatant from the precipitate that involves discarding the supernatant while leaving the precipitate intact at the bottom of the container (i.e., beaker) (Santoro 2011).

### *EA IRMS Analysis Sample Procedure*

A microbalance (measuring to 0.001mg) was used to measure out 2mg (C) and 20mg (N) of the dried out soil for C analysis and for N analysis. Weight information was recorded on a Sample Weighing Form, listing the name of the sample[2] or standard, the target weight, the actual weight, and the location of the weighed sample in the autosampler. A stainless steel spatula was used to load samples into cylindrical sample tins[3]. Forceps were used to pinch the top of the filled capsule closed. An additional pair of forceps was required to create a "Z," consisting of three vertical folds. The top of the capsule was then folded over two times, creating a small box-like package. All prepared samples were placed into a sample tray[4] prior to sample loading (Goodale et al 2017; Wegter 2010).

Each IRMS sample was loaded into a 50 sample Zero-Blank Autosampler. Samples were analyzed for C and N stable isotopes using a Costech Elemental Combustion System/Analyzer coupled, via an interface, to a Thermo Scientific Delta V Advantage IRMS. To bracket the data collection to ensure accuracy, in-house standards were analyzed at the beginning, middle, and end of each test run. The values of the internal standards (JGC20, fishmeal, and caffeine) have been verified by comparison against certified standard reference materials purchased from outside sources (Goodale et al 2017; Wegter 2010).

The accuracy of the instrument is +/-0.05 for $\delta^{13}$C and $\delta^{15}$N reporting. Preliminary values were normalized and reported on the International Stable Isotope Reference Scale. The analysis

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[2] Generically refers to both an unknown sample and a Standard (Primary or Secondary) (Wegter 2010).

[3] A container, which comes in various sizes, used to contain the sample for analysis and which also aids the combustion (Wegter 2010).

[4] Typical a 48 or 96-well plate used to contain weighed samples prior to sample loading (Wegter 2010)

required a few minor corrections and the data set delivered by the IRMS system included blank corrected values[5] for each sample/standard, which were used to normalize the values (Wegter 2010).

Sediment samples from Housepit 54 were analyzed for C and N stable isotopes using a Costtech Elemental Combustion system/Analyzer coupled, via an interface, to a Thermo Scientific Delta V Advantage IRMS (Figure 15). Standards were calibrated against NIST Standard Reference Materials. Preliminary values were normalized and reported on the International Stable Isotope Reference Scale, based on the known value of laboratory standards.

Prior to analysis by IRMS, samples are converted to simple gases such as $CO_2$ and $N_2$, which were the stable isotopes of interest for this study. IRMS measures the ratio of ions that correspond to these gases. Isotope ratios, at natural abundance ratios, are measured relative to international standards (primary materials), which define the measurement scale for particular isotopes, for this study the C isotopic compositions are standardized to caffeine, fish meal and JGC and N isotopic compositions are standardized to caffeine, USGS 40, and USGS 41 (Carter and Barwick 2011). Heavy stable isotopes comprise a small part of the distribution of an element and differences in the natural abundance of stable isotopes are usually very low (a few thousandths of a percent). T). To express he ratio of the heavier to the lighter isotope is measured relative to a standard as follows (McKinney et al. 1950): **δsample (‰) = (Rsample/Rstandard – 1) x 1000** where R is the ratio of the heavier to the lighter isotope (13C and 15N for the current study) (Diaz 2019).

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[5] Refers to an empty sample tin being used.

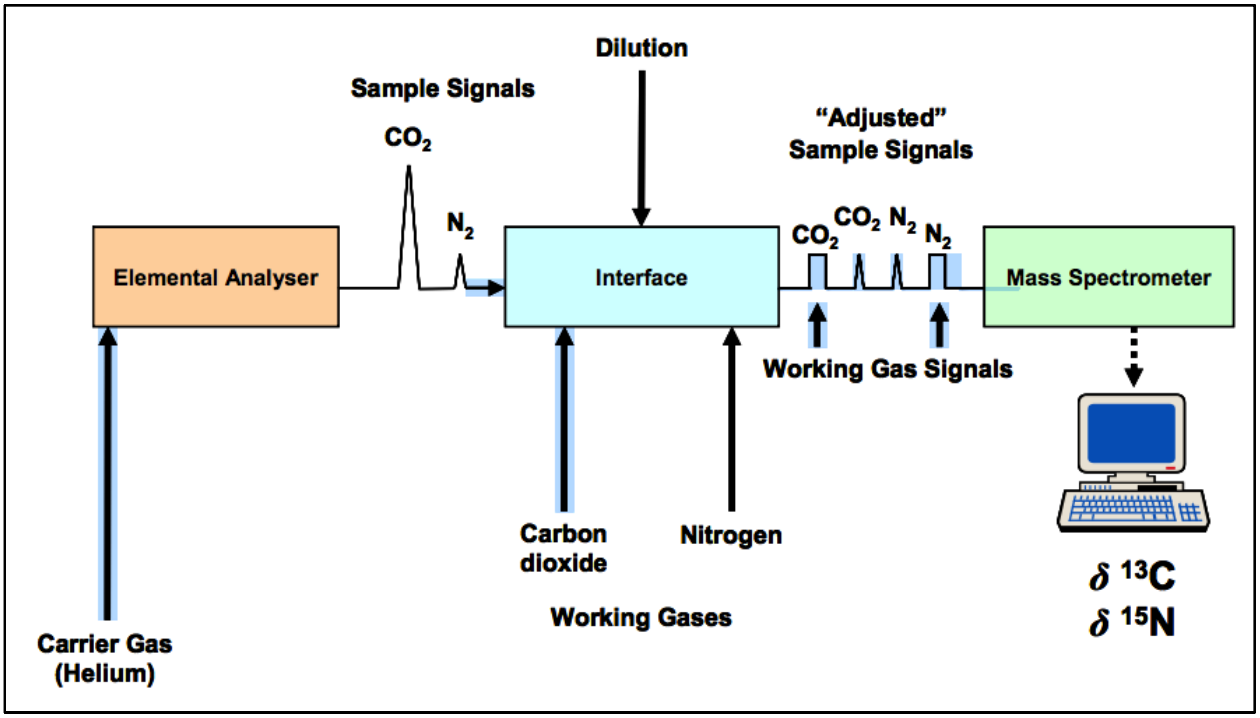


**Figure 15. Simple schematic diagram of an EA-IRMS for the determination of δ13C and δ15N. (Carter and Barwick 2011)**

### *X-Ray Fluorescence (EDXRF)*

X-Ray Fluorescence (EDXRF) is an analytical technique that uses x-rays, an energetic portion of the electromagnetic spectrum that includes microwaves and visible light, to determine the elemental composition of materials ranging from rocks to minerals to soil.

In an EDXRF spectrometer, high-energy x-rays are used to excite the atoms within a sample causing those atoms to emit x-rays of their own. These fluorescent x-rays are characteristic of each element, such as Ca, P, or Iron present in the sample. The x-rays that are counted by the instrument's detectors per unit of time (intensity) are then converted to element concentrations via a computer algorithm (hamilton.edu 2019)

SPEX CertiPrep 31mm X-Cell Sample Cups were filled to the top (but not compacted) with the dried, powdered sediment.  Each sample cup was covered with an ULTRALENE (4µ thick) pre-cut circular window to produce the smoothest seal possible. Films were secured with snap-on rings. Sample cups were labeled and stored in individual sealable plastic bags to protect the film and avoid cross-contamination (Goodale et al 2017).

Sixty-five samples were analyzed using a state-of-the-art Thermo ARL Perform'X EDXRF spectrometer at Hamilton College. The in-house EDXRF instrument was specially calibrated for archaeological research. Proper detection limit, accuracy, and precision of EDXRF instruments for use requires correct subtraction of background and spectral interferences for a variety of matrices. Calibrations were determined on a per elemental basis. It has been calibrated using seven international standards for those elements most relevant to study including National Institute of Standards and Technology (NIST 278), the United States Geological Survey (RGM-1), the University of Georgia Center for Applied Isotope Studies (GBOR-01, MTNM-01, SATU-07) and an in-house standard (OBS-1 Glass Butte, OR). Test results were saved and exported to a PC for analysis.

### *Data Presentation*

The northing and easting coordinates of the SW corner of each excavation unit were coded, and the analytical data were plotted onto the Housepit 54 block and floor map. For visual analysis of the house floor data, Kriging, Spatial Interpolation maps were created from the IRMS and EDXRF data for concentrations of each element using ArcGIS 10.8, which were then georeferenced and placed over the Housepit 54 floor map to look at the spatial patterning. Through the use of a Kriging Spatial interpolations we can gain a basic understanding of the spatial distribution of the data provided for this study. Kriging Spatial Interpolation is a powerful type of spatial interpolation that uses complex mathematical formulas to estimate values at unknown points based on the values at known points (Scheeres 2016). This method of spatial analysis helps give an indication of the distribution of concentrations located within the floor of the pithouses. This method does have its shortcomings as it is predicting data for areas with none. The surface plots were visually examined for patterning in elemental concentrations. Attention was only given to Ca, P, C, and N elements because they would exhibit the best evidence of past activity areas, which also appeared to exhibit highly variable concentrations across floor IId, IIe, and IIf. (Table 2, Table 3, and Table 4). IRMS data including the $\delta^{13}C$ and $\delta^{15}N$ ratios are included in Tables 1, 2, and 3.

## *Geo-Chemical Signatures of Activities on Pithouse Floors*

Geochemical analysis of archaeological soil sediments can be a pragmatic tool when understanding past social organization in a household context. Archaeological investigations of modern domestic spaces allow researchers to refine their methodology through the direct observation of the use of space within an area (Goodale et al. 2017). Human occupation in an enclosed semi-sterile environment leaves traces in the form of elemental chemical signatures with the archaeological sediments (Lubos et al. 2016; Wilson et al. 2005). This holds true for Housepit 54 the archaeological sediments left on each superimposed floor within the pithouse show us glimpse into their everyday life of its inhabitants. The correlation of chemical signatures and human actives can help us discover and understand why certain activities leave certain chemical signatures. If certain areas of the Housepit 54 floors exhibit a fluctuation in chemical signatures and faunal remains, then that could mean that certain resources or activities were being utilized more so than others, and this could potentially give an insight into the daily lives of the inhabitants.

Activity areas can provide a plethora of information on the daily lives of the inhabitants of Housepit 54. These activity areas were used for a myriad of different activities, such as cooking, processing of fish, terrestrial animals or plant materials, the production of stone tools, and/or disposal/storage areas such as cache pits, "Housepit floors are marked by in situ activity areas that include cooking and storage features and clusters of well-preserved faunal and botanical remains as well as a variety of lithic, bone and botanical artifacts" (Prentiss et al. 2020:5). Activity areas are present within the archaeological record as hearth and storage areas, "Storage features generally consist of pits ("cache pits") excavated into subfloor sediments. When in use these pits were generally lined with birch bark and filled with layers of dried food such as salmon" (Prentiss et al. 2020:5; see also Alexander 2000; Hayden 1997; Prentiss and Kuijt 2012; Teit 1906). Activity areas are where most of the housepits history is preserved as it is the most intact surface with the best spatial patterning. The rim and roof sediments usually contain artifacts distributed with little to no spatial patterning. "Roof deposits are quite different from those of floors in featuring a nearly random assortment of artifacts and other remains, little spatial patterning, and frequent evidence of burning. Rim sediments thus preserve a record of many household activities, but they remain in a mixed state" (Prentiss et al. 2020:5).

The distribution of activity areas within Housepit 54 are not random, they are strategically placed within the housepit to maximize useable living space and not interfere with the daily activities undertaken within the housepit. Given the size and number of hearths within each floor of Housepit 54 we can conclude that multiple families were living within the housepit at the same time. Cache pits were usually found on the edges of the living areas. The centers of the housepit were usually kept clear because a typical feature of a housepit is a central hole in the roof that contained a ladder. A chemical analysis of the floor surface can help identify activity areas based on the chemical signatures.

Isotopic analysis the detection of subtle changes in the natural abundance of stable isotopes. Elemental Analyzer Isotope Ratio Mass Spectrometry (EA IRMS) instruments are specifically designed to measure precisely small differences in the abundances of isotopes, such as H/$^{1}$H (Hydrogen), $^{13}$C/$^{12}$C (Carbon), $^{15}$N/$^{14}$N (Nitrogen), and $^{18}$O/$^{16}$O (Oxygen). For the use of this study, only $^{12}$C and $^{14}$N were analyzed.

EDXRF analysis allows for the detection of subtle changes in the amount of a particular element. X-Ray Fluorescence (EDXRF) instruments specifically designed to measure precisely small differences in the amount of specific elements, such as Aluminum (Al), Phosphorus (P), Potassium (K), Calcium (Ca), Iron (Fe), Zinc (Zn), and Titanium (Ti) elements. However, for the use of this study only Calcium and Phosphorus were analyzed. The elements will be compared to the number of fish bones and mammal bones recovered on the floor to see if there is a correlation between a certain chemical and the type of faunal remain found in that area.

The Bridge River Village site is located in a C3 vegetation and terrestrial fauna zone and the stream and rivers are inhabited with marine fish and freshwater fish. These types of vegetation, terrestrial mammals, marine fish and freshwater fish all leave varying levels of C and N behind. This is turn will produce varying ratios of each chemical compound. These ratios can be used to help understand what types of activities and what were involved were performed (Figure 16).

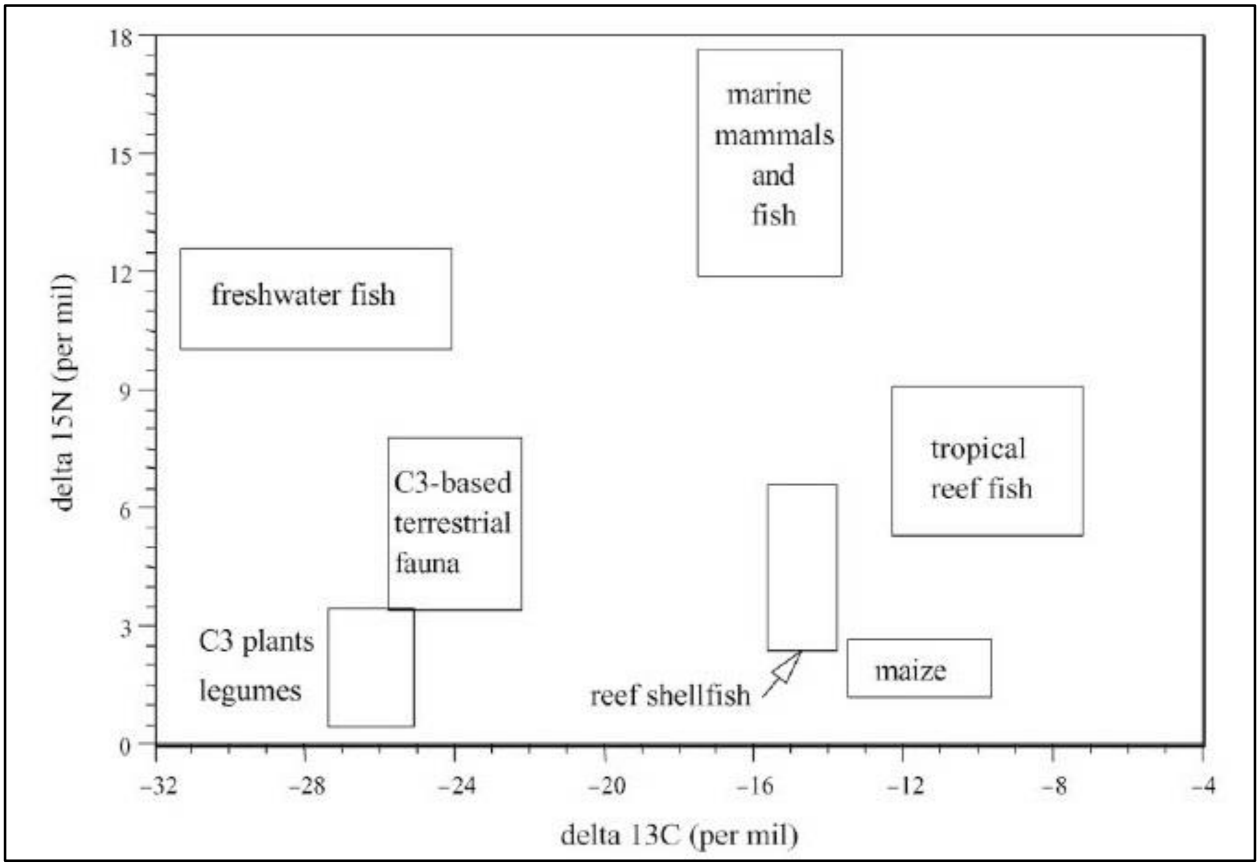


**Figure 16. Example of stable Carbon Vs Nitrogen isotope ratios for plant and animal groups (Tykot 2006).**

The results of this research will offer insights into the daily life and the living arrangement of Housepit 54’s inhabitants over a period of three different living surfaces (IId, IIe, and IIf). A varied distribution of chemical signatures throughout the living surfaces would coincide with varied activities that were performed in Housepit 54. The varied chemical signatures coupled with certain faunal remains would help solidify our interpretation of the daily activities of the inhabitants.

# Chapter 4: Results and Discussion

The purpose of this chapter is to review the results of soil samples that were analyzed for their chemical and isotopic signatures. The results are presented by each individual floor (IId, IIe, and IIf). The data presented for each floor consists of the results of the C and N study conducted with EA-IRMS and the results of the Ca and P study conducted with EDXRF. In addition, the ratios and concentrations of fish and mammal bones are for comparison with the chemical and isotopic concentrations. Lastly, the results are compiled and compared to other contemporary studies of the same nature.

## *Results*

### *Floor IId*

Stratum IId is the second established floor in Housepit 54 (Figure 17) during its maximum size phase—and, floor IId represents the house at its maximum size. All four blocks were occupied, likely by distinct domestic groups (Prentiss, et al. 2018). IId sediments are dominated by clay at up to 70% with the exception of Block D where clay content is generally equal to or slightly less than that of silt. IId sediments in all blocks have lower percentages of sand, gravel, and pebbles (Prentiss et al. 2020). Stratum IId in Block A was partially buried by a thin roof layer (Vb), whose sediments are only evident in the western and southern portions of the block. Hearths are found in Blocks A, C, and D (Prentiss et al. 2020).

#### **Faunal Remains (Fish and Mammal)**

During the excavation, a large number of faunal remains were observed within the IId strata. 574 fish bones (Figure 18) were recovered and 325 mammal bones (Figure 19). These remains were either found in situ or when screening soil. The highest concentrations of fish bones were observed in Block C and D, and the highest concentrations of mammal bones were observed in Block C and D, but Block B also had an elevated concentration of mammal bones.

### Elemental Analyzer Isotope Ratio Mass Spectrometry (EA IRMS)

Twenty-five samples were prepared for IRMS analysis of $\delta^{13}C$ and $\delta^{15}N$. Both of the $\delta^{13}C$ and $\delta^{15}N$ samples produced reliable $\delta^{13}C$ signatures and $\delta^{15}N$ signatures, and both produced sufficient quantities that could be measured for the use of interoperation estimation (Table 2). The range of $\delta^{13}C$ (Figure 20) is between -23.997‰ to -20.032‰, and the average level of $\delta^{13}C$ being -22.286‰. The range of $\delta^{15}N$ (Figure 21) is between 22.216‰ to 14.909‰, and the average level of $\delta^{15}N$ being 18.502‰. The highest ratios of $\delta^{13}C$ for floor IId are concentrated around the outer edges of the blocks closest to the rim with the center of the housepit having the lowest ratios of $\delta^{13}C$. The distribution of $\delta^{13}C$ is almost identical with that of $\delta^{15}N$ with just a few areas that deviate from the pattern.

### Energy-Dispersive X-Ray Fluorescence (EDXRF)

The geochemical data observed revealed distinct patterns in the elemental composition of floor sediments in Housepit 54. These findings suggest that different functional areas display characteristic geochemical signatures (Table 2). The soil samples provided a sufficient amount for the analysis of both Ca and P. The range for Ca (Figure 22) is between 3.046 and 11.034 with an average of 4.780. High concentrations of Ca occur within the area of the floor nearest to the outer edge/rim of the housepit. The range for P (Figure 23) is 0.134 to 0.648 and has an average of 0.370. P is concentrated in and around the periphery of the floor, away from the central entrance. Both P and Ca have a similar distribution pattern but there are some areas of variation between the two elements.

**Table 2. Strat IId faunal and geochemical results.**

| Block | Unit | Strat | FishCountN | MammalCountN | δ13C (‰) | δ15N (‰) | CaO (wt.%) | P2O5 (wt.%) |
|---|---|---|---|---|---|---|---|---|
| A | 6 | IId | 4 | 13 | 0 | 0 | 0 | 0 |
| A | 7 | IId | 8 | 4 | -21.608 | 20.78 | 5.16 | 0.22 |
| A | 8 | IId | 1 | 7 | -21.376 | 22.22 | 5.18 | 0.14 |
| A | 10 | IId | 3 | 0 | -20.546 | 17.02 | 4.09 | 0.55 |
| A | 11 | IId | 0 | 1 | 0 | 0 | 0 | 0 |
| A | 12 | IId | 0 | 1 | -20.740 | 18.37 | 4.69 | 0.21 |
| A | 14 | IId | 1 | 10 | -20.762 | 15.30 | 3.05 | 0.20 |
| A | 15 | IId | 0 | 7 | 0 | 0 | 0 | 0 |
| A | 16 | IId | 0 | 0 | -20.032 | 18.80 | 6.02 | 0.25 |
| B | 5 | IId | 0 | 1 | -23.5 | 19.3 | 3.21 | 0.20 |
| B | 6 | IId | 0 | 2 | 0 | 0 | 0 | 0 |
| B | 9 | IId | 0 | 2 | -23.3 | 19.3 | 4.41 | 0.36 |
| B | 10 | IId | 0 | 2 | 0 | 0 | 0 | 0 |
| B | 11 | IId | 26 | 11 | -23.2 | 19.0 | 5.00 | 0.41 |
| B | 14 | IId | 0 | 0 | -23.4 | 19.2 | 4.39 | 0.65 |
| B | 15 | IId | 1 | 1 | -22.9 | 20.0 | 4.08 | 0.43 |
| B | 16 | IId |  |  | -24.0 | 20.3 | 4.47 | 0.23 |
| C | 2 | IId | 12 | 7 | -23.8 | 19.0 | 11.03 | 0.60 |
| C | 6 | IId | 32 | 11 | -21.886 | 16.49 | 4.77 | 0.62 |
| C | 7 | IId | 0 | 9 | 0 | 0 | 0 | 0 |
| C | 9 | IId | 16 | 10 | -21.228 | 17.59 | 5.02 | 0.49 |
| C | 10 | IId | 0 | 4 | 0 | 0 | 0 | 0 |
| C | 11 | IId | 20 | 41 | -23.2 | 18.5 | 5.08 | 0.51 |
| C | 12 | IId | 0 | 5 | 0 | 0 | 0 | 0 |
| C | 13 | IId | 26 | 15 | -23.1436 | 18.2349 | 5.04 | 0.5 |
| C | 14 | IId | 26 | 28 | -23.1983 | 18.50371 | 5.13 | 0.48 |
| C | 15 | IId | 94 | 52 | -20.322 | 14.91 | 5.24 | 0.49 |
| C | 16 | IId | 12 | 23 | -20.334 | 19.30 | 4.42 | 0.40 |
| D | 2 | IId | 0 | 7 | 0 | 0 | 0 | 0 |
| D | 3 | IId | 41 | 25 | 0 | 0 | 0 | 0 |
| D | 6 | IId | 1 | 9 | 0 | 0 | 0 | 0 |

| Block | Unit | Strat | FishCountN | MammalCount N | δ13C (‰) | δ15N (‰) | CaO (wt.%) | P2O5 (wt.%) |
|---|---|---|---|---|---|---|---|---|
| D | 7 | IId | 67 | 3 | -22.9 | 17.7 | 5.11 | 0.13 |
| D | 8 | IId | 156 | 12 | -23.1 | 18.3 | 3.47 | 0.23 |
| D | 11 | IId | 27 | 0 | -23.1 | 17.8 | 3.07 | 0.28 |
| D | 12 | IId | 0 | 2 | -22.8 | 18.8 | 4.33 | 0.16 |
| D | 15 | IId | 0 | 0 | -22.8 | 17.9 | 3.93 | 0.47 |

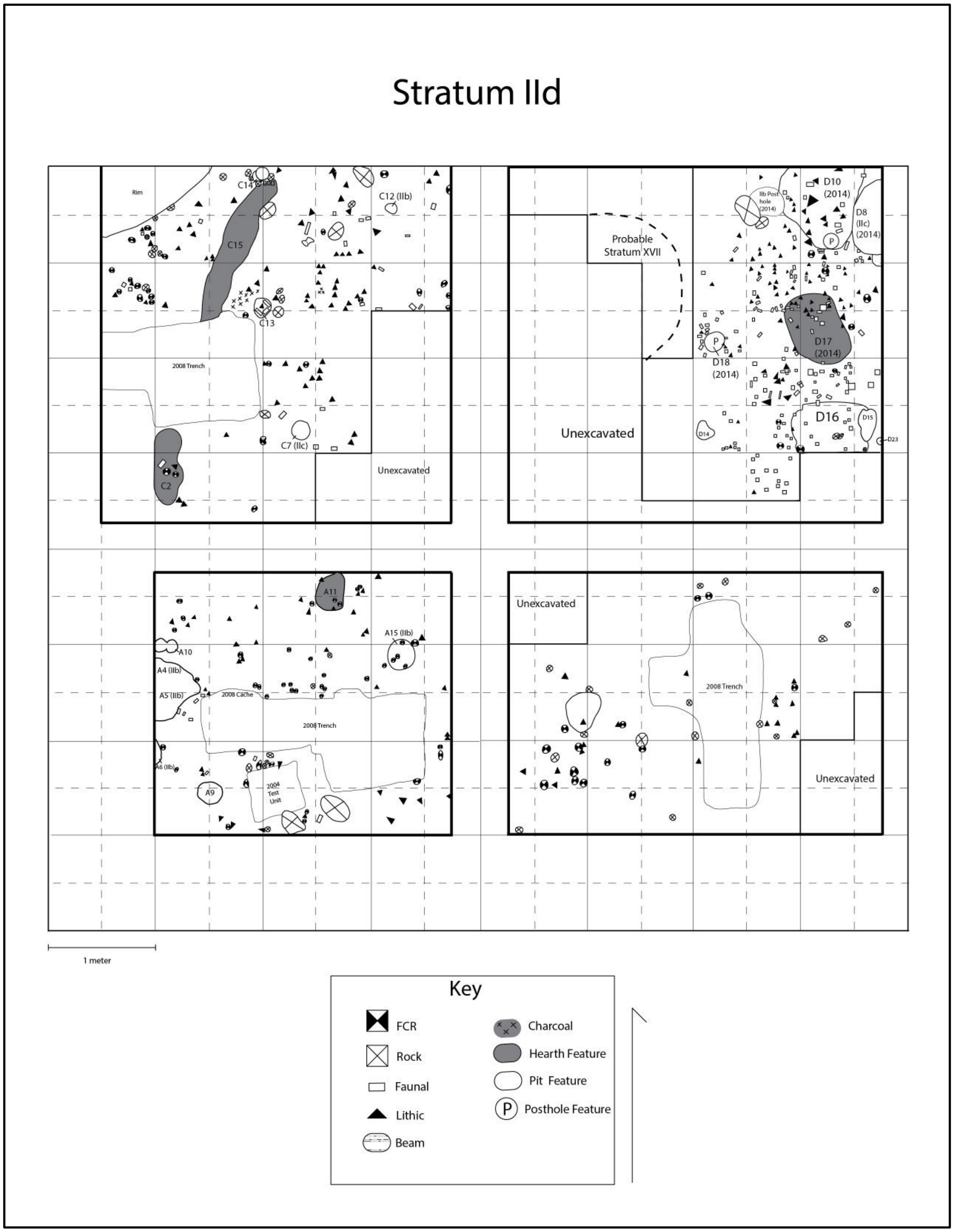


**Figure 17. Map of stratum IId with provenienced artifacts, faunal, FCR, features, and prior excavated areas.**

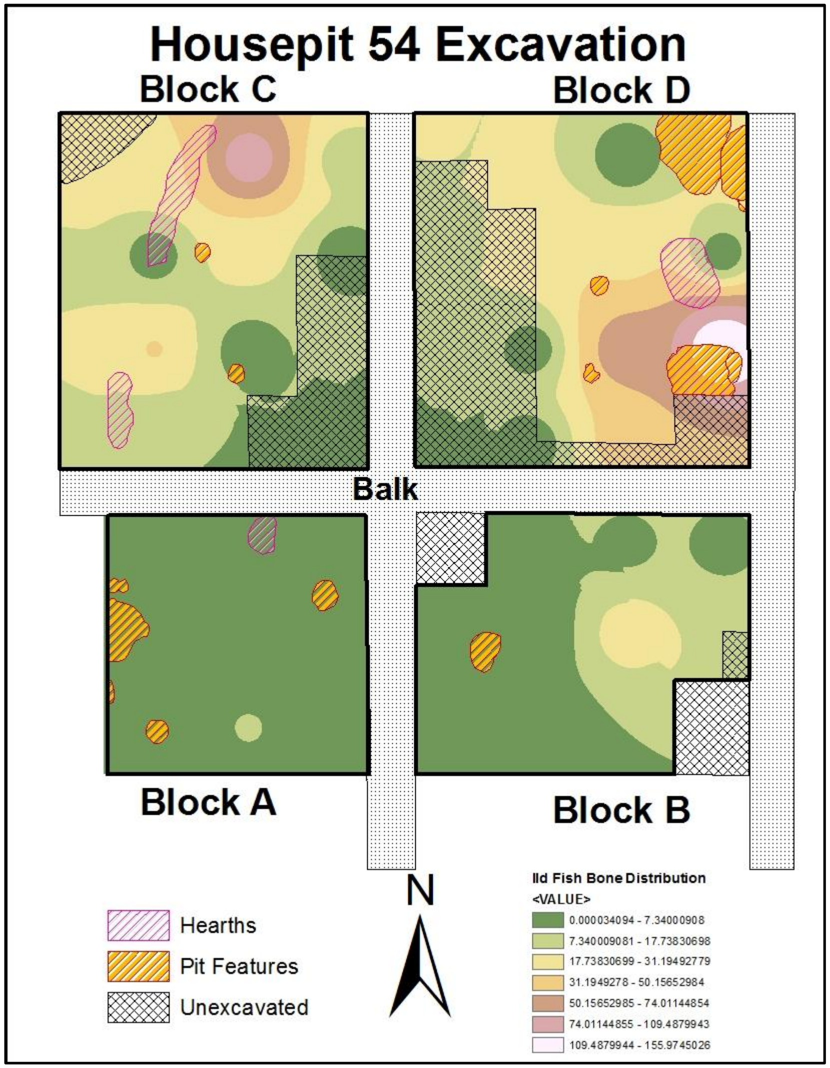


**Figure 18. Strat IId fish bone distribution.**

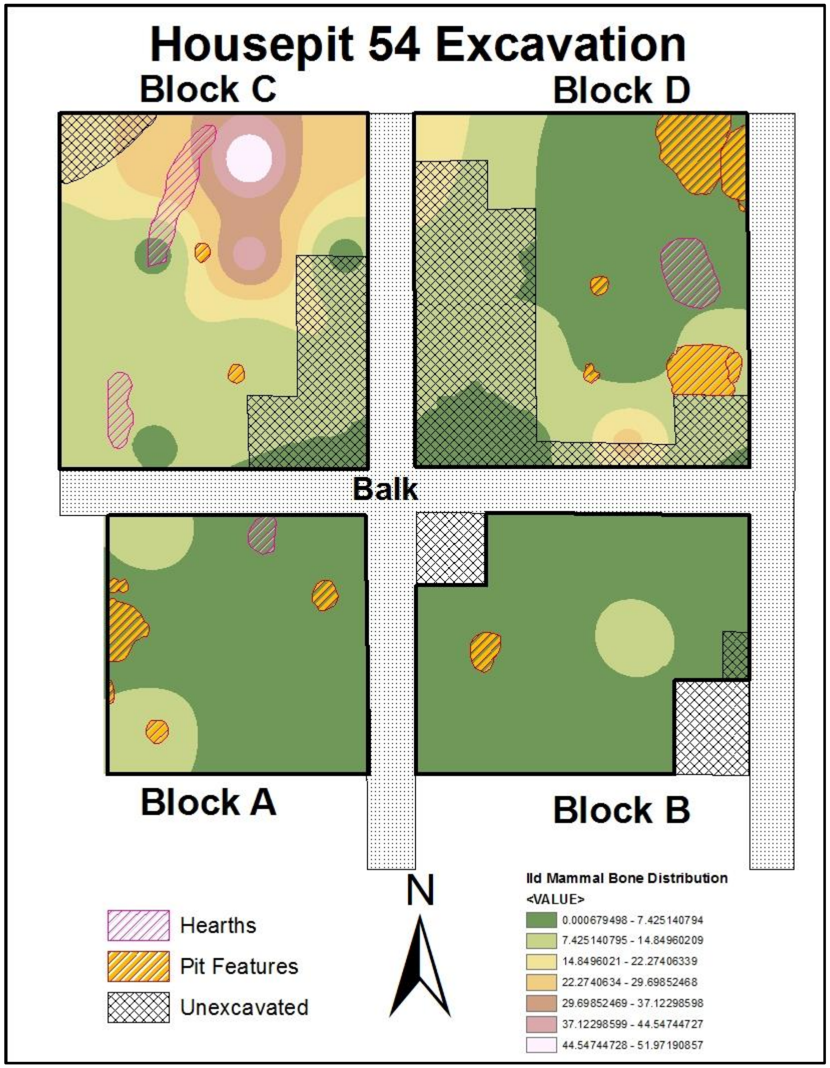


**Figure 19. Strat IId mammal bone distribution.**

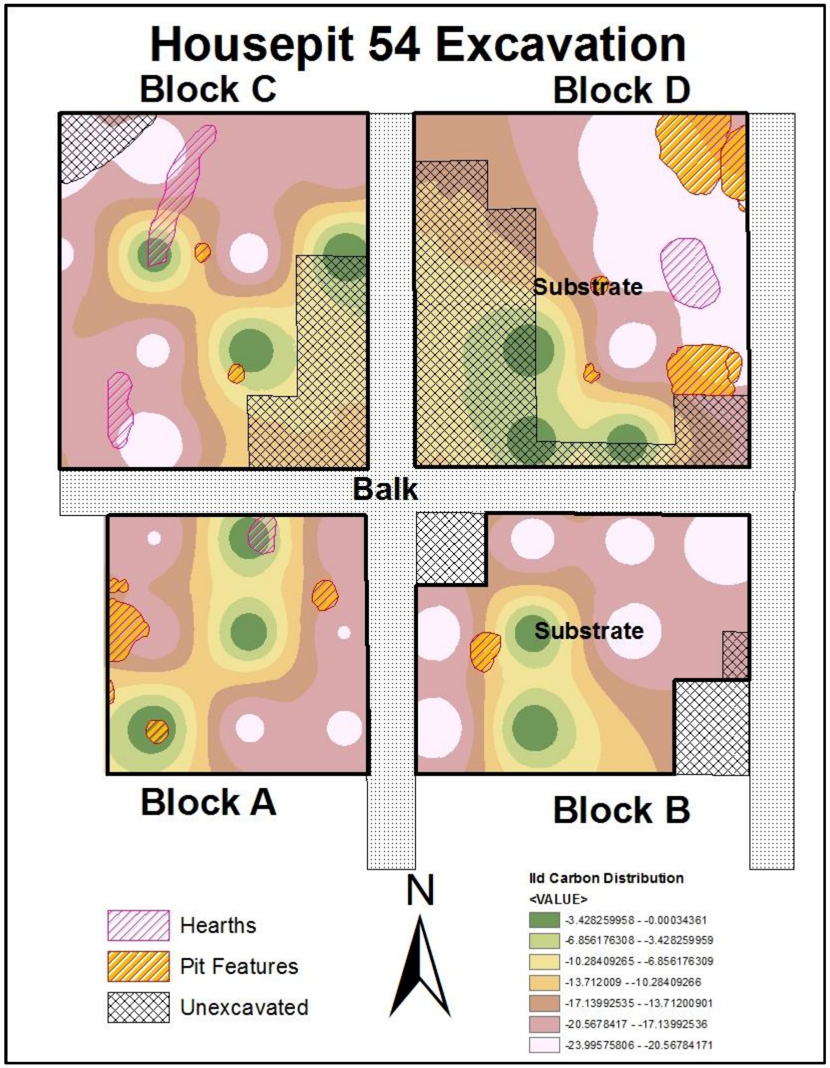


Figure 20. Strat IId Carbon [δ13C (‰)] chemical signature distribution.

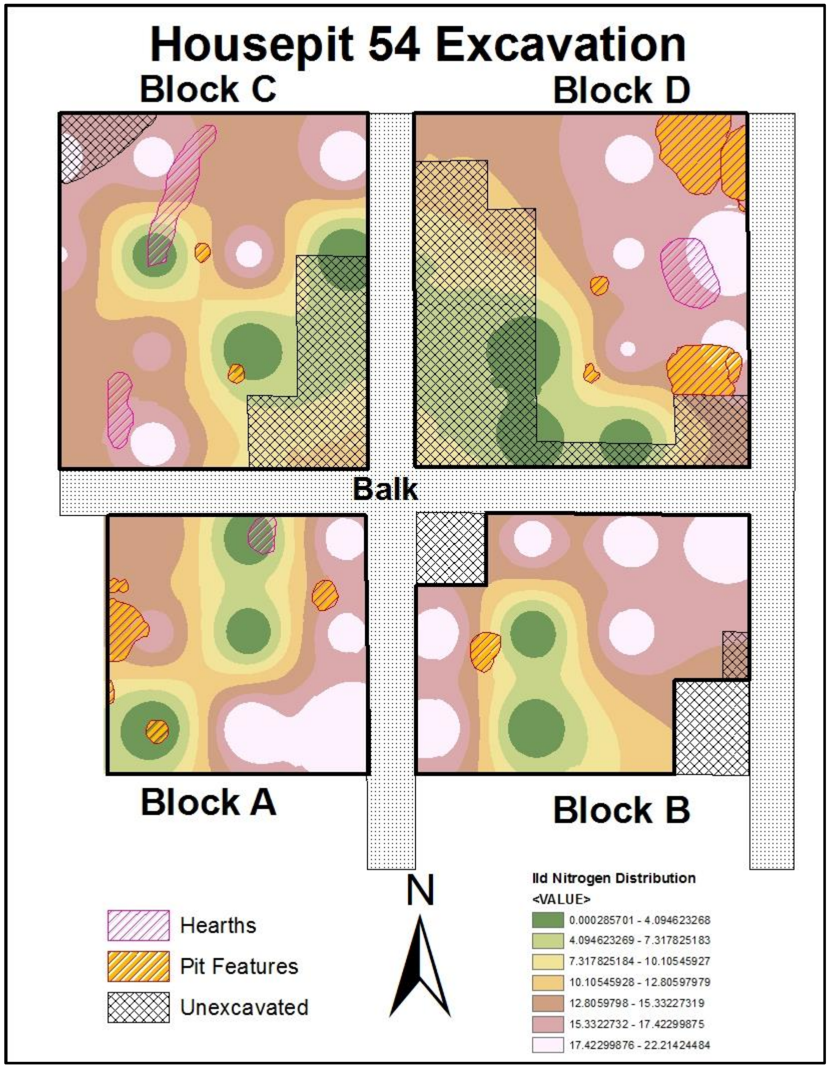


Figure 21. Strat IId Nitrogen [δ15 N (‰)] chemical signature distribution.

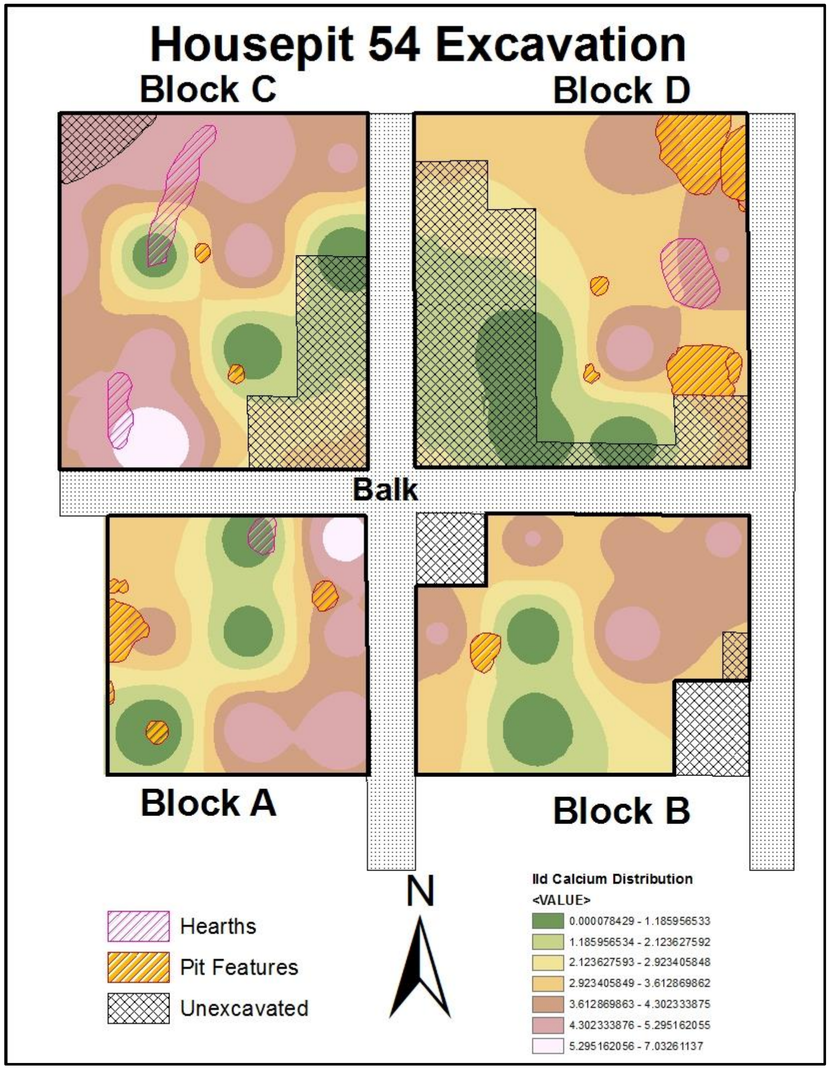


Figure 22. Strat II Calcium (wt.%) chemical signature distribution.

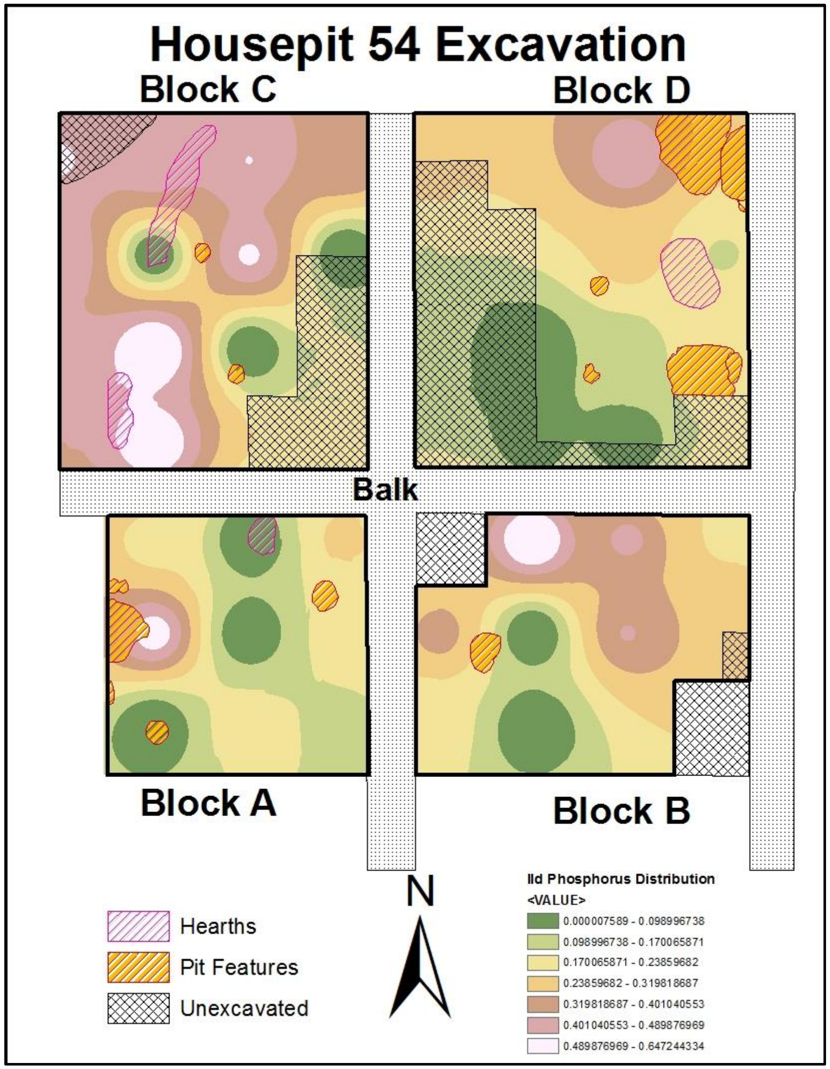


Figure 23. Strat II Phosphorus (wt.%) chemical signature distribution.

### *Floor IIe*

Stratum IIe is the first of the series of floors representing Housepit 54 at its maximum size (Figure 24) (Prentiss et al. 2020). As with floor IId, the whole house was occupied. Sediments from IIe contain consistently higher percentages of clay than those of later floors. Clay content ranges from 40-60%, followed by silt varying in the 10-30% range, and dramatically lower percentages of sand, gravel, and pebbles (Prentiss et al. 2020). Stratum IIe is partially buried by a thin roof deposit (Vb3) in Block B and otherwise is entirely covered with IId sediments. The Vb3 roof contains burned sediment, abundant charcoal, and fire-cracked rock (FCR). As was the case in some other sparse roof deposits, including Vb and Vb1, this roof appears to have been only a remnant of a much large roof that was likely cleared prior to burning of the Block B portion and the subsequent establishment of the IId floor. There are 11 hearth features scattered throughout the blocks on the IId surface (Prentiss et al. 2020).

## Faunal Remains (Fish and Mammal)

A larger number of faunal remains were recovered from IIe compared floors IId and IIf. In all, 1,078 fish bones (Figure 25) and 993 mammal bones (Figure 26) were recovered. These remains were either found in situ or when screening soil. The highest concentrations of fish bones were observed in Block D and C, and the highest concentrations of mammal bones were observed in Block C and D, but Block B also had a higher number of mammal bones compared to floor IId.

## Elemental Analyzer Isotope Ratio Mass Spectrometry (EA IRMS)

Twenty-three samples were prepared for IRMS analysis of $\delta^{13}$C and $\delta^{15}$N. Both of the $\delta^{13}$C and $\delta^{15}$N samples produced reliable $\delta^{13}$C signatures and $\delta^{15}$N signatures, and both produced sufficient quantities for the use of interoperation estimation (Table 3). The range of $\delta^{13}$C (Figure

27) was between -25.968‰ to -14.728‰, and the average level of $\delta^{13}$C being -22.286‰. The range of $\delta^{15}$N (Figure 28) was between 20.645‰ to 14.961‰, and the average level of $\delta^{15}$N was 17.390‰. The highest ratios of $\delta^{13}$C for floor IIe are concentrated within the center of the Housepit and around the outer edges of the blocks closest to the rim having the lowest ratios of $\delta^{13}$C. The distribution of $\delta^{13}$C is almost identical with that of $\delta^{15}$N with just a few areas that deviate from the distribution pattern.

## Energy-Dispersive X-Ray Fluorescence (XRF)

The geochemical data observed revealed distinct patterns in the elemental composition of floor sediments in Housepit 54. These findings suggest that different functional areas display characteristic geochemical signatures (Table 3). The range for Ca (Figure 29) is between 3.643 and 7.525 with an average of 4.77. High concentrations of Ca occur within the area of the floor nearest to the outer edge/rim of the Housepit. The range for P (Figure 30) is 0.187 to 0.729 and has an average of 0.44. High concentrations of Ca and P are concentrated within the central area of the Housepit away from the periphery. Both Ca and P have a similar distribution pattern but there are some areas of variation between the two elements.

**Table 3. Strat IIe faunal and geochemical results.**

| Block | Unit | Strat | FishCountN | MammalCountN | δ13C (‰) | δ15N (‰) | CaO (wt.%) | P2O5 (wt.%) |
|---|---|---|---|---|---|---|---|---|
| a | 6 | IIe | 22 | 10 | -14.728 | 14.96 | 5.30 | 0.20 |
| a | 7 | IIe | 7 | 3 | -21.194 | 16.38 | 3.72 | 0.44 |
| a | 8 | IIe | 27 | 4 | -21.104 | 18.24 | 6.00 | 0.25 |
| a | 10 | IIe | 15 | 10 | 0 | 0 | 0 | 0 |
| a | 11 | IIe | 0 | 0 | -21.037 | 16.35 | 4.07 | 0.48 |
| a | 12 | IIe | 0 | 6 | -21.940 | 18.84 | 3.78 | 0.49 |
| a | 14 | IIe | 0 | 5 | -20.381 | 17.33 | 3.85 | 0.22 |
| a | 15 | IIe | 0 | 0 | -22.303 | 15.99 | 6.28 | 0.19 |
| a | 16 | IIe | 0 | 0 | -20.269 | 20.65 | 4.61 | 0.64 |
| b | 5 | IIe | 0 | 1 | 0 | 0 | 0 | 0 |

| Block | Unit | Strat | FishCountN | MammalCountN | δ13C (‰) | δ15N (‰) | CaO (wt.%) | P2O5 (wt.%) |
|---|---|---|---|---|---|---|---|---|
| b | 6 | IIe | 2 | 0 | 0 | 0 | 0 | 0 |
| b | 9 | IIe | 0 | 1 | -23.3 | 16.4 | 7.35 | 0.46 |
| b | 10 | IIe | 0 | 2 | -23.4 | 15.6 | 6.84 | 0.20 |
| b | 11 | IIe | 0 | 2 | 0 | 0 | 0 | 0 |
| b | 14 | IIe | 0 | 1 | -26.0 | 17.5 | 5.54 | 0.27 |
| b | 15 | IIe | 8 | 9 | 0 | 0 | 0 | 0 |
| b | 16 | IIe | 0 | 5 | -23.1 | 18.6 | 4.72 | 0.37 |
| c | 2 | IIe | 69 | 35 | -23.3 | 19.3 | 4.55 | 0.57 |
| c | 6 | IIe | 2 | 2 | 0 | 0 | 0 | 0 |
| c | 7 | IIe | 0 | 22 | -23.4 | 18.1 | 5.57 | 0.66 |
| c | 9 | IIe | 104 | 26 | 0 | 0 | 0 | 0 |
| c | 10 | IIe | 0 | 102 | -23.2 | 17.7 | 6.33 | 0.72 |
| c | 11 | IIe | 0 | 40 | -22.8 | 18.6 | 5.92 | 0.73 |
| c | 12 | IIe | 0 | 36 | -23.5 | 19.1 | 6.54 | 0.50 |
| c | 13 | IIe | 14 | 13 | -23.4 | 16.3 | 6.92 | 0.73 |
| c | 14 | IIe | 24 | 47 | 0 | 0 | 0 | 0 |
| c | 15 | IIe | 0 | 56 | 0 | 0 | 0 | 0 |
| c | 16 | IIe | 219 | 25 | 0 | 0 | 0 | 0 |
| d | 3 | IIe | 210 | 434 | 0 | 0 | 0 | 0 |
| d | 6 | IIe | 11 | 23 | -23.2 | 18.1 | 4.14 | 0.72 |
| d | 7 | IIe | 236 | 50 | -22.9 | 16.5 | 3.88 | 0.47 |
| d | 8 | IIe | 4 | 8 | 0 | 0 | 0 | 0 |
| d | 11 | IIe | 92 | 8 | -23.1 | 17.4 | 4.64 | 0.57 |
| d | 12 | IIe | 7 | 5 | 0 | 0 | 0 | 0 |
| d | 15 | IIe | 4 | 1 | -23.2 | 15.9 | 3.64 | 0.34 |
| d | 16 | IIe | 1 | 1 | -24.0 | 16.6 | 7.52 | 0.25 |

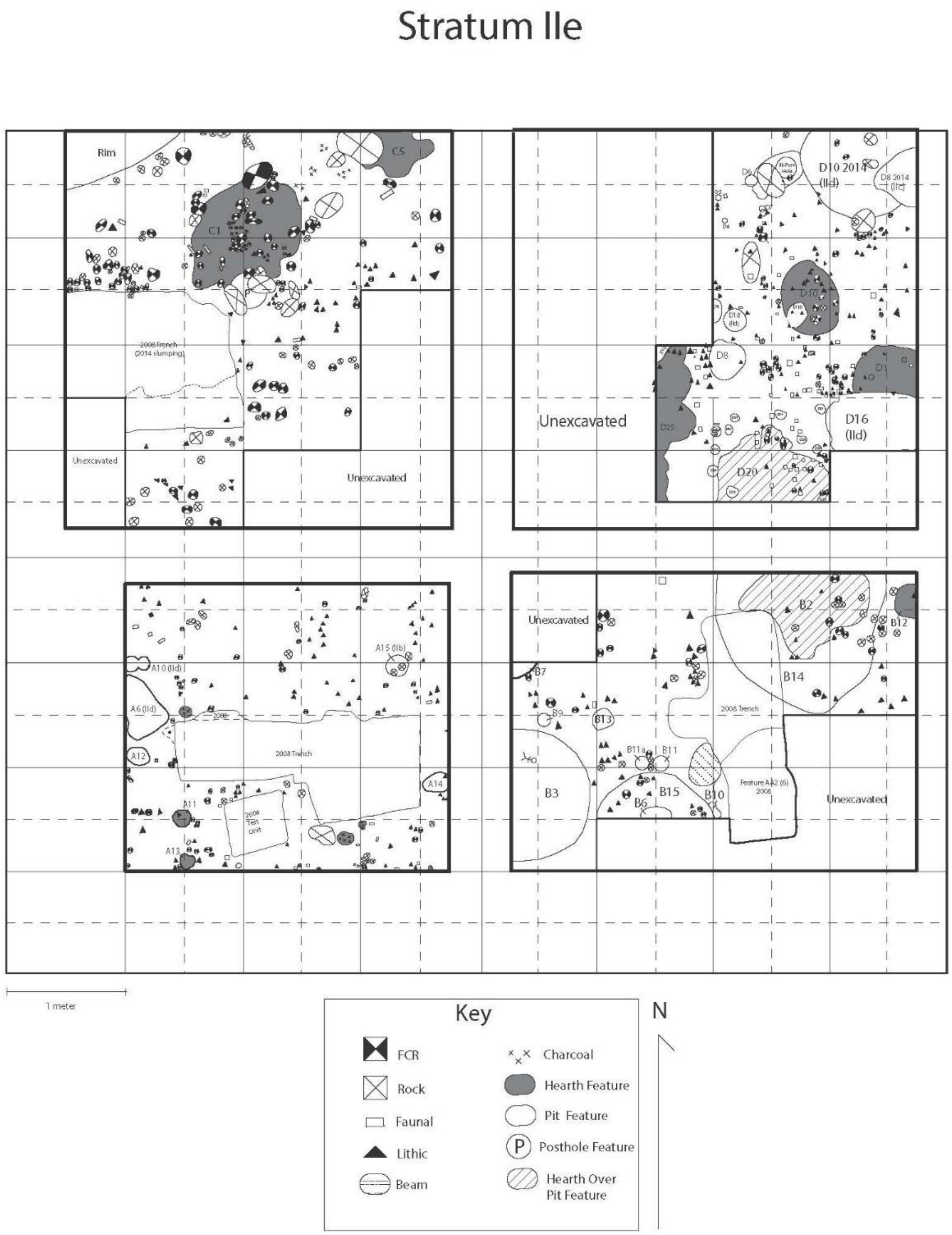


**Figure 24. Map of stratum IIe with provenienced artifacts, faunal, FCR, features and prior excavated areas.**

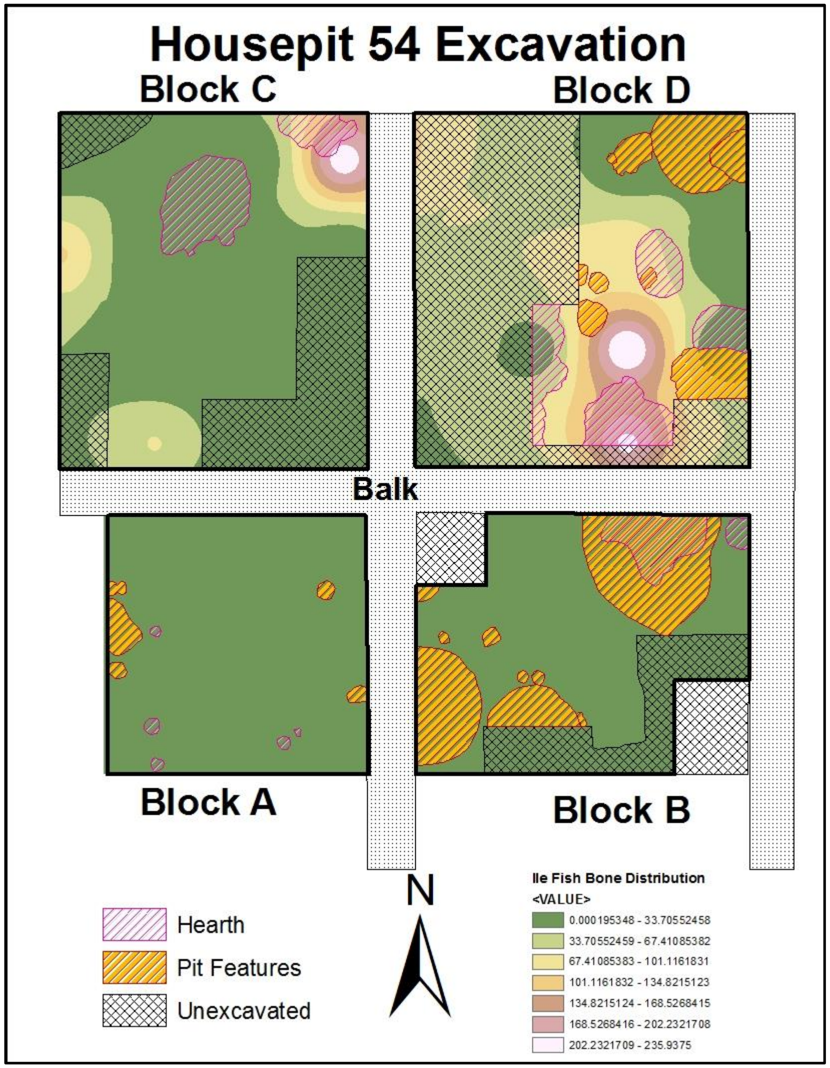


Figure 25. Strat IIe fish bone density counts.

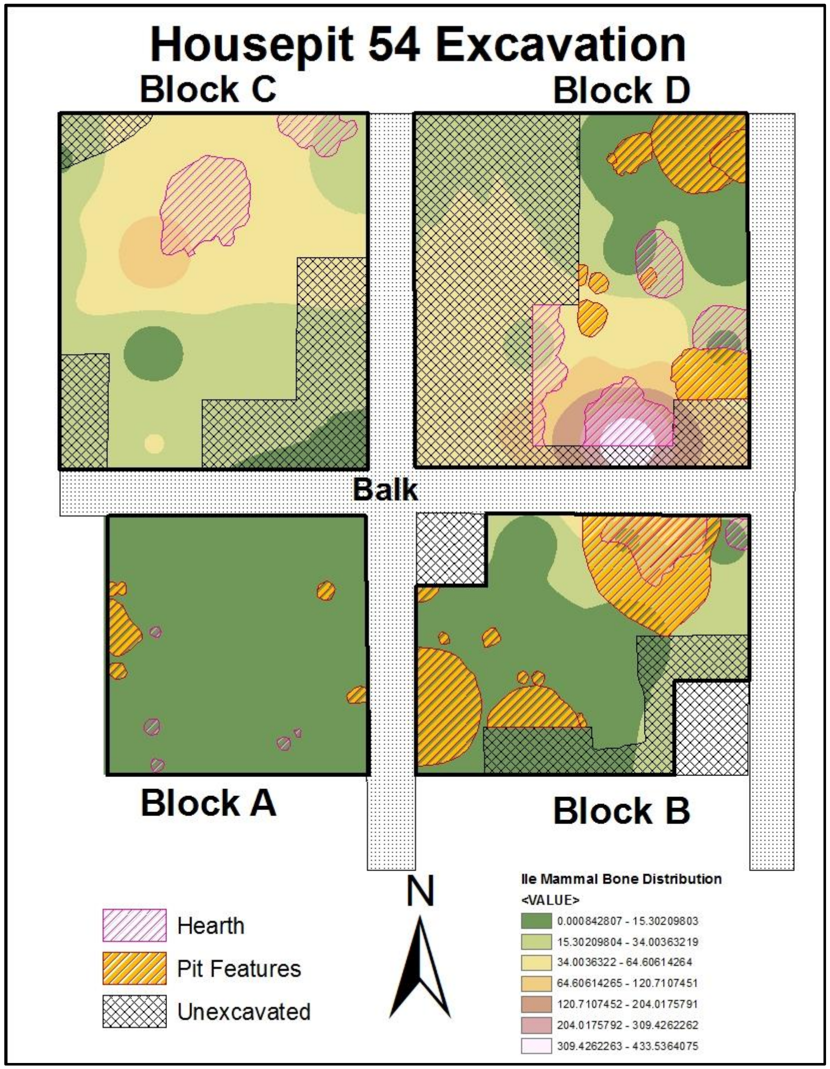


Figure 26. Strat IIe mammal bone density counts.

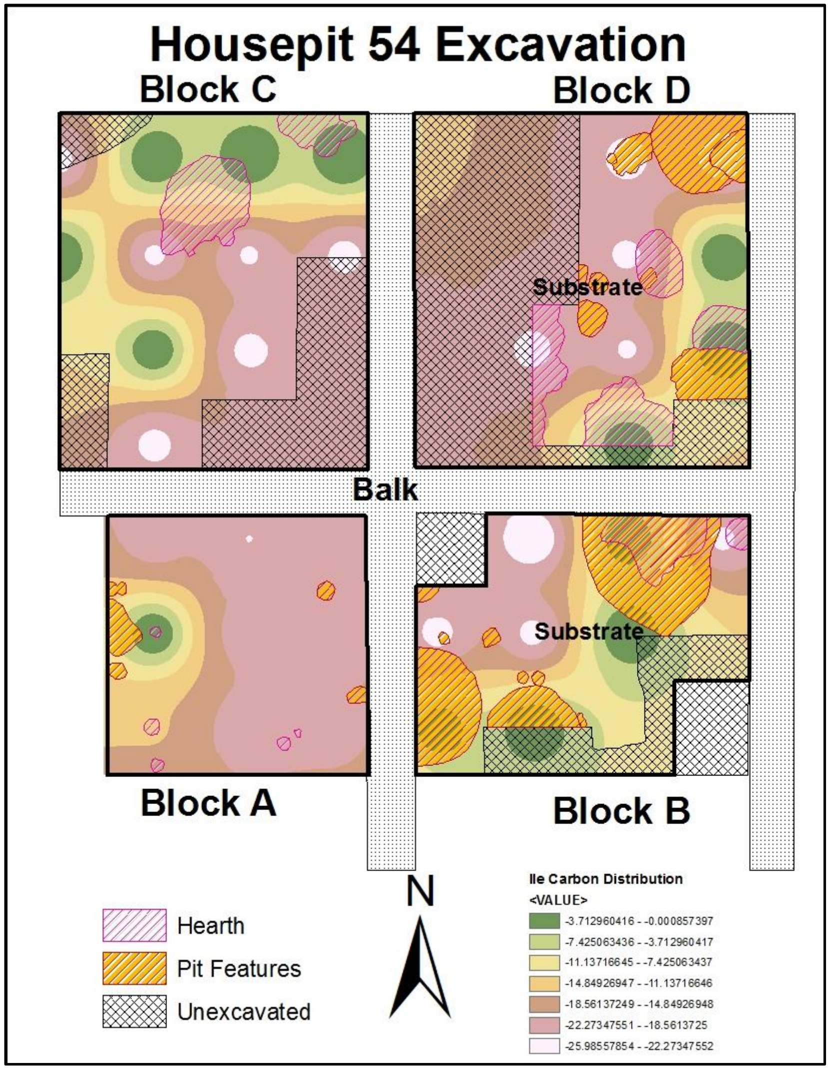


Figure 27. Strat IIe carbon [δ13C (‰)] chemical signature distribution.

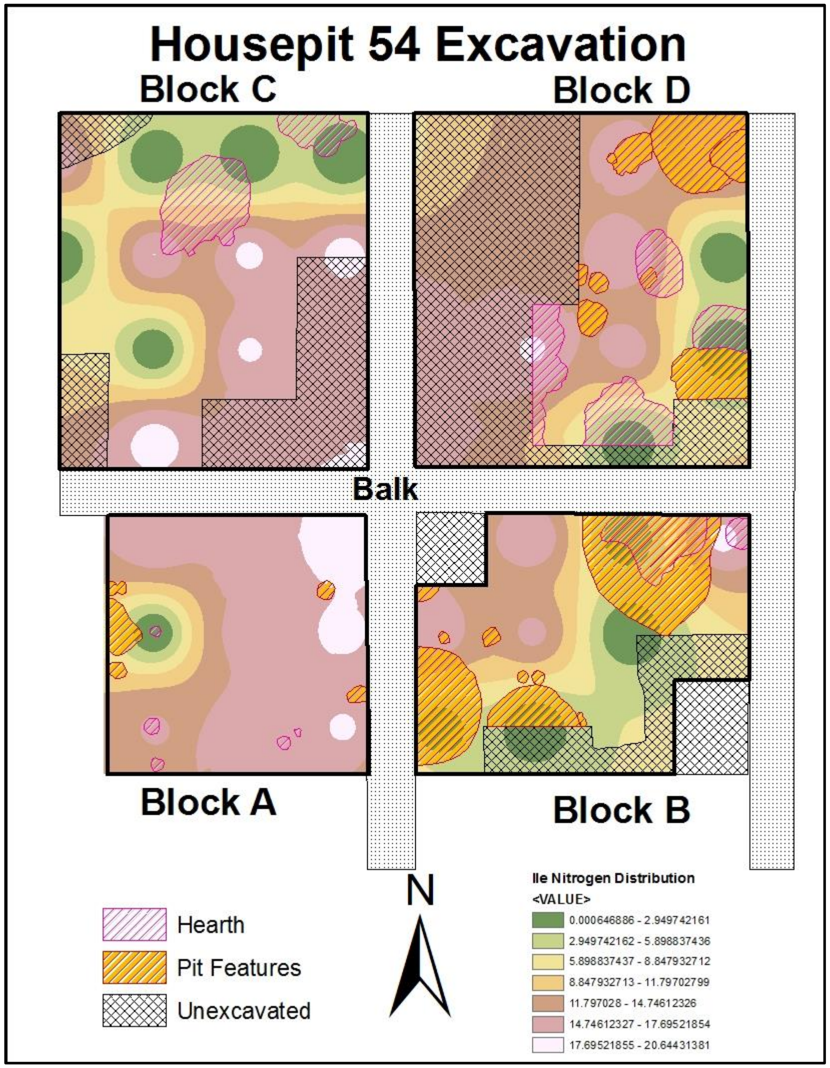


Figure 28. Strat IIe nitrogen [δ15N (‰)] chemical signature distribution.

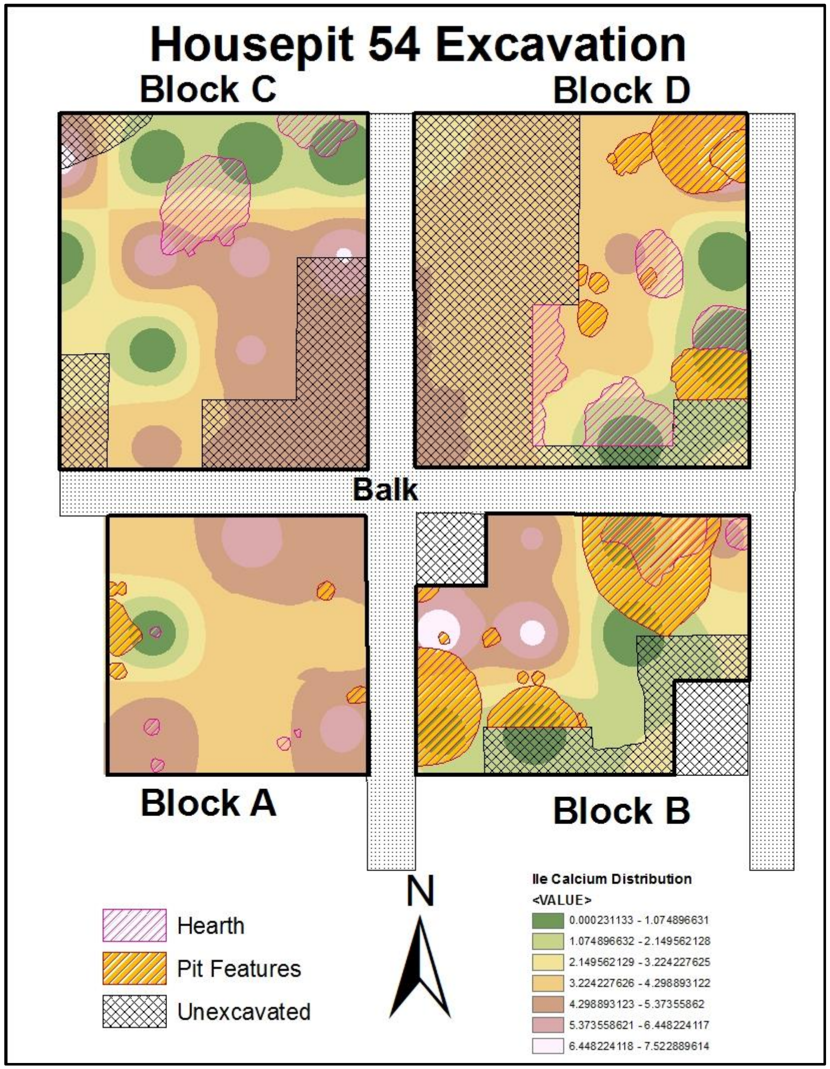


Figure 29. Strat IIe Calcium (wt.%) chemical signature distribution.

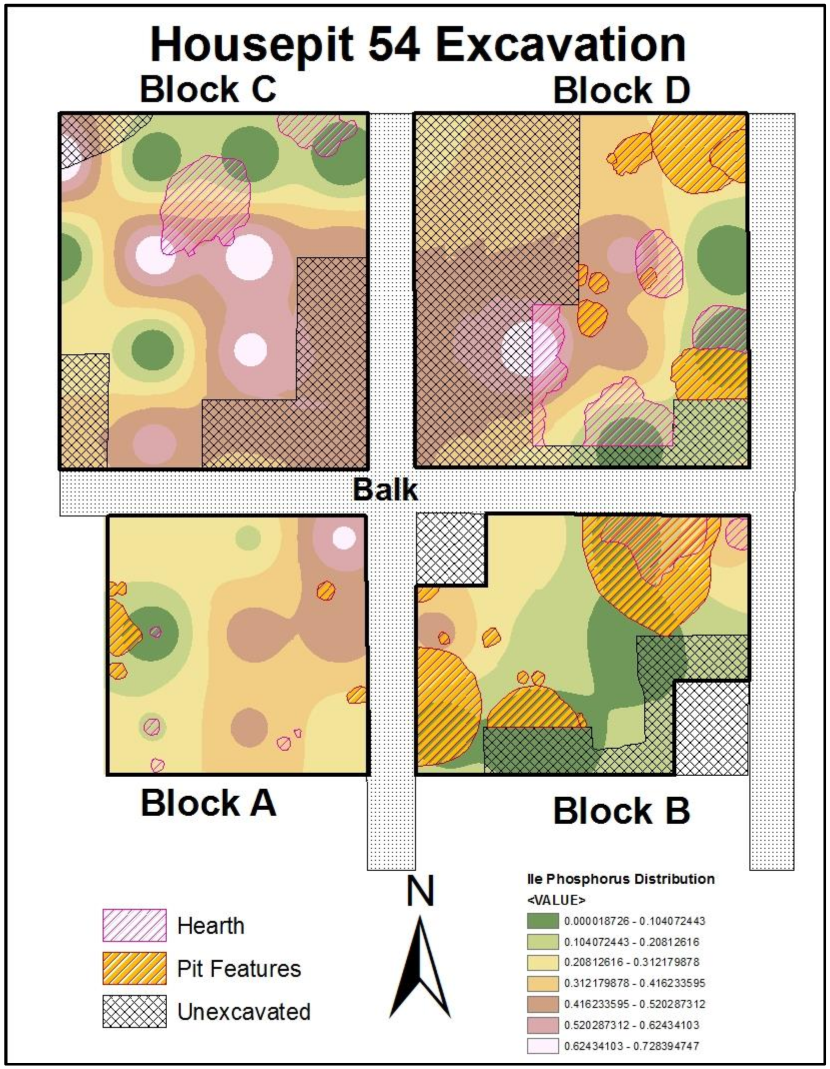


Figure 30. Strat IIe phosphorus (wt.%) chemical signature distribution.

### *Floor IIf*

Stratum IIf is the final floor of the seven-floor sequence associated with the small rectangular variant of Housepit 54 (Figure 31). Stratum IIf sediments are clay dominated in the 35-40% range followed by silt at 20-30%, and subsequent lower percentages of sand, gravel, and pebbles (Prentiss et al. 2020). IIf is entirely buried by IIe sediments with no evidence of roof deposits within the excavation. There are three hearth features associated with IIf, a large shallow hearth in the northeast corner of Block C and another large shallow feature in north-central Block A (Prentiss et al. 2020).

## **Faunal Remains (Fish and Mammal)**

A large number of fauna remains were recovered from the IId strata. In all, 632 fish bones (Figure 32) and 433 mammal bones or fragments (Figure 33) were recovered. These remains were either found in situ or when screening soil. Only Block A and C are present within strata IIf, Block B and D were not part of the house during this time period. Block C had a higher concentration of both fish and mammal bone than Block A.

## **Elemental Analyzer Isotope Ratio Mass Spectrometry (EA IRMS)**

Seventeen samples were prepared for IRMS analysis for δ13C and δ15N. Both of the δ13C and δ15N samples produced reliable δ13C signatures and δ15N signatures, and both produced sufficient quantities that could be measured for the use of interoperation estimation (Table 4). The range of δ13C (Figure 34) is between -26.371‰ to -20.269‰, and the average level of δ13C being -24.309‰. The range of δ15N (Figure 35) is between 14.351‰ to 31.964‰, and the average δ15N ratios was 18.010‰. The highest ratios of δ13C for floor IIf are concentrated throughout the whole of Block A and C of the Housepit. The distribution of δ13C is almost identical with that of δ15N with just a few areas that deviate from the distribution pattern.

## Energy-Dispersive X-Ray Fluorescence (EDXRF)

The geochemical data observed revealed distinct patterns in the elemental composition of floor sediments in Housepit 54. These findings suggest that different functional areas display characteristic geochemical signatures (**Error! Reference source not found.**). The range for Ca (Figure 36) is between 3.929 and 7.297 with an average of 4.500. High concentrations of Ca occur throughout the whole floors of Block A and C of the Housepit. The range for P (Figure 37) is 0.167 to 0.635 and has an average of 0.410. As with Ca, high concentrations of P are located throughout Block A and C of the Housepit. Both Ca and P have a similar distribution pattern but there are some areas of variation between the two elements.

**Table 4. Strat IIf faunal and geochemical results.**

| Block | Unit | Strat | FishCountN | MammalCountN | δ13C (‰) | δ15N (‰) | CaO (wt.%) | P2O5 (wt.%) |
|---|---|---|---|---|---|---|---|---|
| a | 6 | IIf | 85 | 40 | -21.315 | 21.96 | 4.10 | 0.28 |
| a | 7 | IIf | 4 | 1 | -24.1 | 18.7 | 4.47 | 0.29 |
| a | 8 | IIf | 0 | 3 | -23.1 | 17.2 | 7.30 | 0.38 |
| a | 10 | IIf | 16 | 1 | -21.809 | 20.44 | 3.97 | 0.28 |
| a | 12 | IIf | 0 | 20 | 0 | 0 | 0 | 0 |
| a | 14 | IIf | 4 | 22 | -20.924 | 14.35 | 4.05 | 0.25 |
| a | 15 | IIf | 0 | 2 | -20.269 | 20.67 | 4.00 | 0.35 |
| a | 16 | IIf | 0 | 2 | -20.270 | 20.65 | 4.07 | 0.37 |
| c | 2 | IIf | 71 | 26 | -26.2 | 18.1 | 4.07 | 0.32 |
| c | 6 | IIf | 45 | 26 | -26.2 | 17.5 | 4.03 | 0.56 |
| c | 7 | IIf | 0 | 60 | -25.9 | 17.7 | 4.15 | 0.56 |
| c | 9 | IIf | 20 | 25 | 0 | 0 | 0 | 0 |
| c | 10 | IIf | 2 | 6 | -26.3 | 16.8 | 5.36 | 0.53 |
| c | 11 | IIf | 125 | 61 | -26.2 | 17.9 | 4.45 | 0.63 |
| c | 12 | IIf | 2 | 11 | -26.2 | 17.3 | 4.14 | 0.59 |
| c | 13 | IIf | 24 | 20 | -26.0 | 14.6 | 4.61 | 0.60 |

| Block | Unit | Strat | FishCountN | MammalCountN | δ13C (‰) | δ15N (‰) | CaO (wt.%) | P2O5 (wt.%) |
|---|---|---|---|---|---|---|---|---|
| c | 14 | IIf | 77 | 35 | -25.9 | 16.7 | 3.93 | 0.55 |
| c | 15 | IIf | 117 | 45 | -26.1 | 17.1 | 4.00 | 0.27 |
| c | 16 | IIf | 40 | 25 | -26.4 | 18.4 | 5.90 | 0.17 |
| d | 12 | IIf | 0 | 2 | 0 | 0 | 0 | 0 |

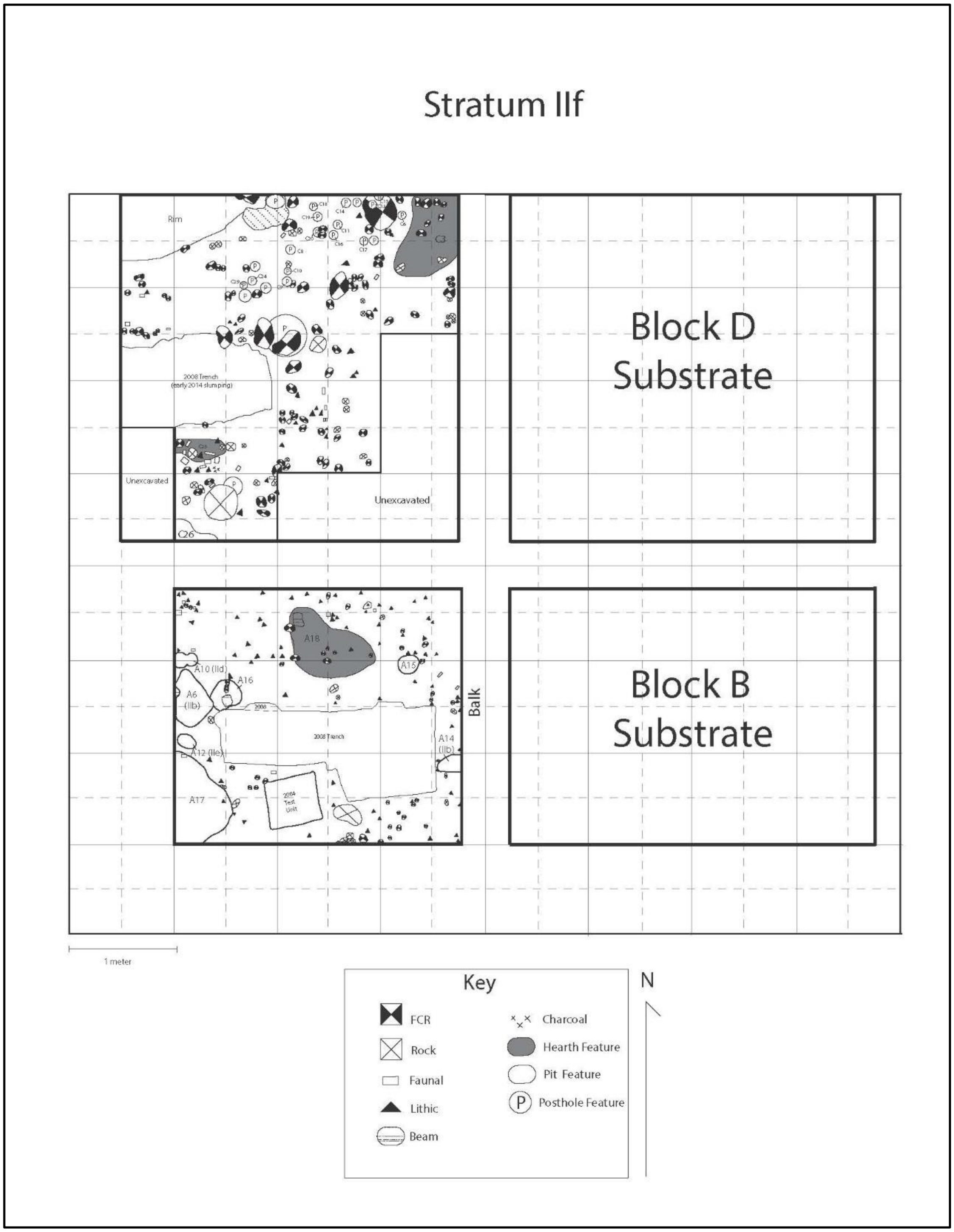


Figure 31. Map of stratum IIf with provenienced artifacts, faunal, FCR, features and prior excavated areas.

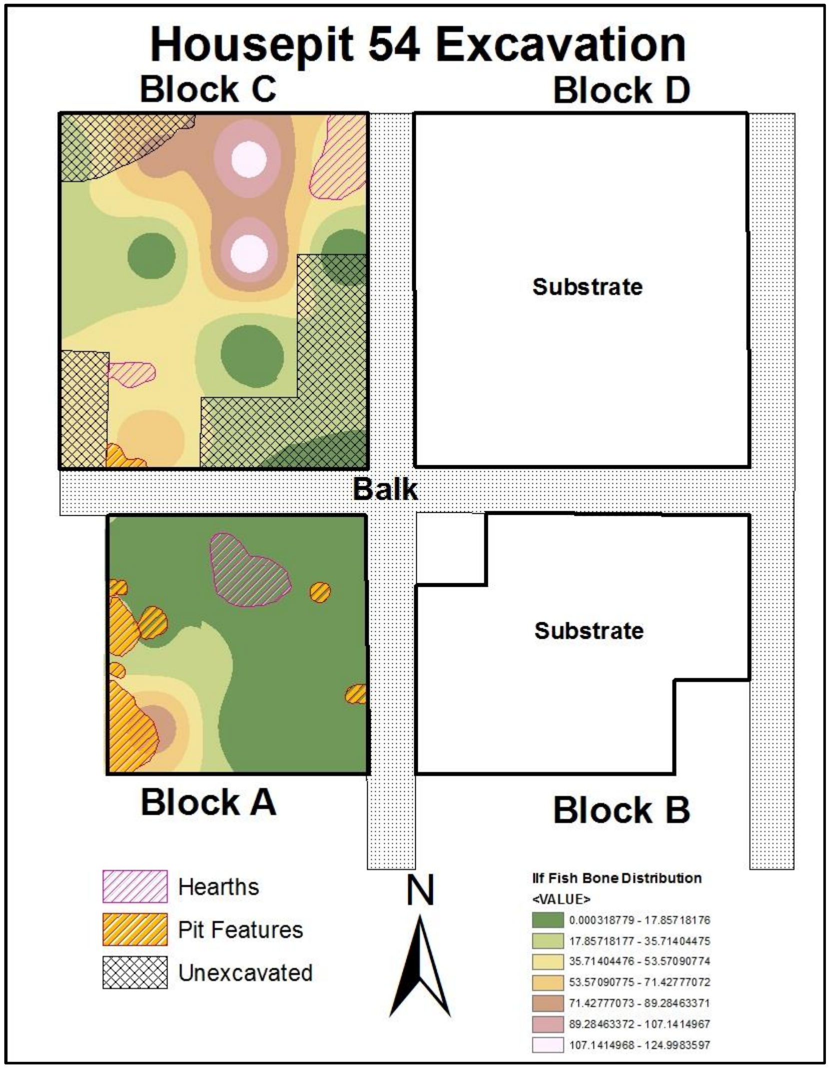


Figure 32. Strat IIf fish bone density counts.

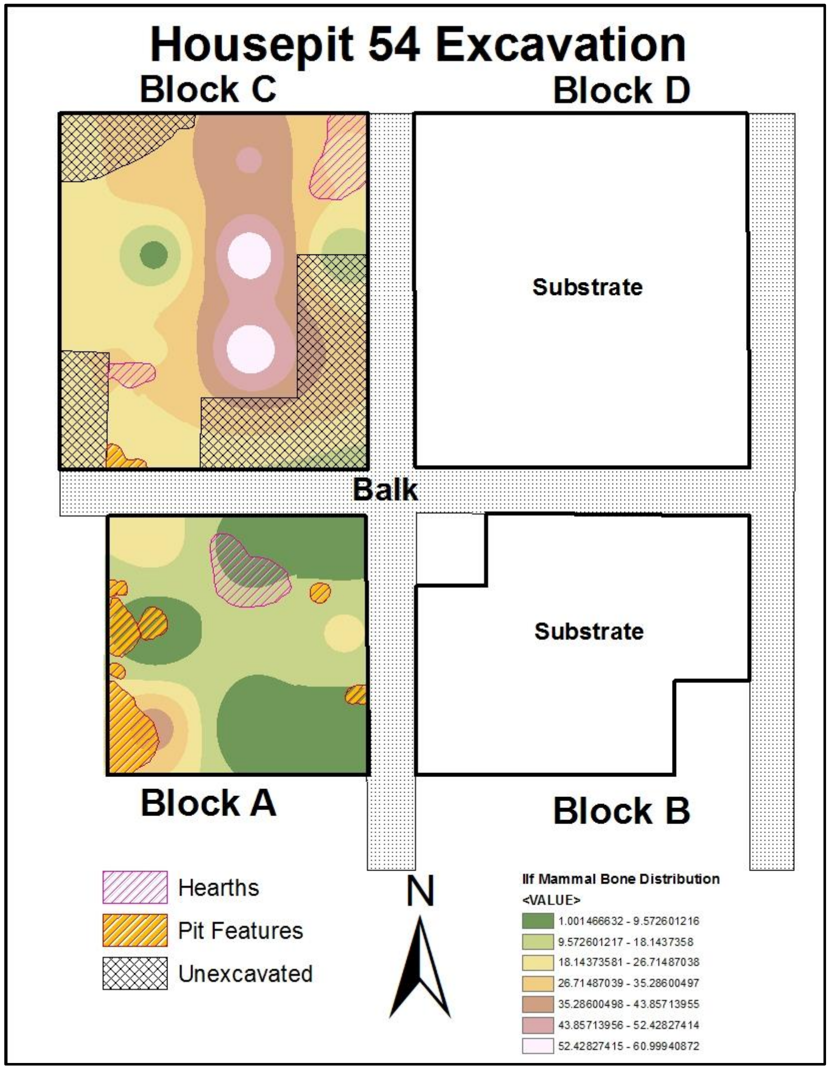


Figure 33. Strat IIf mammal bone density counts.

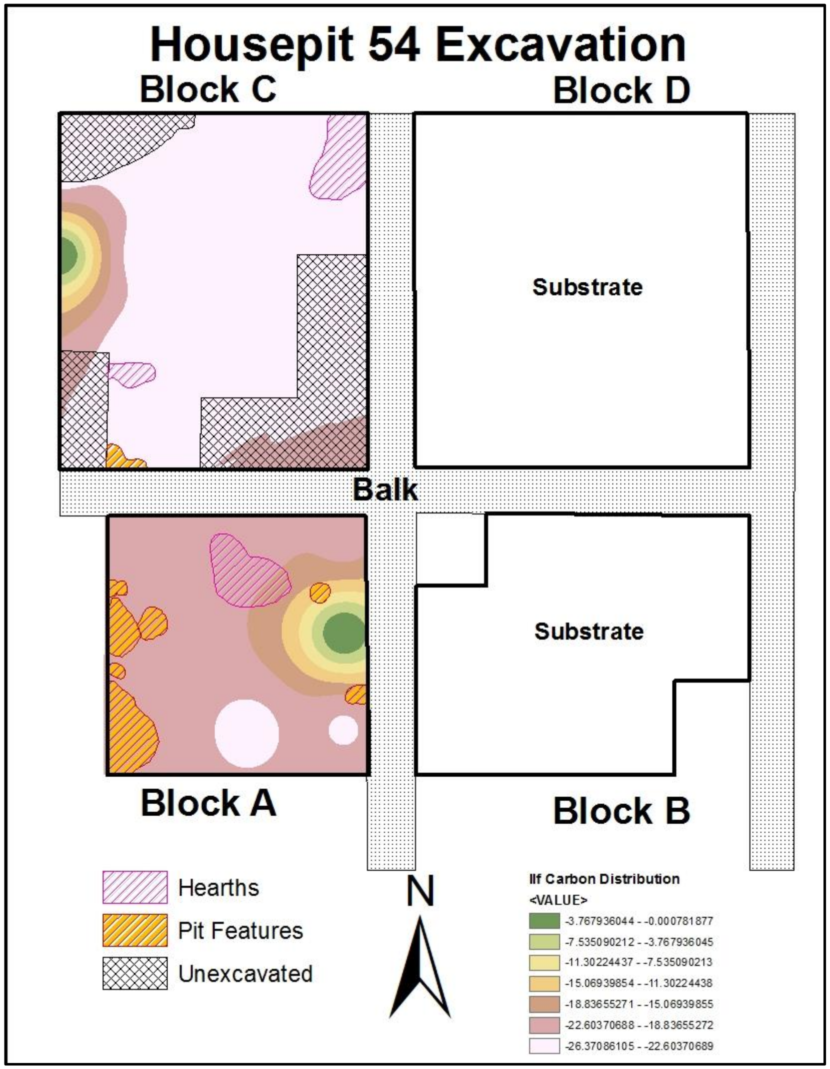


Figure 34. Strat IIf carbon [δ13C (‰)] chemical signature distribution.

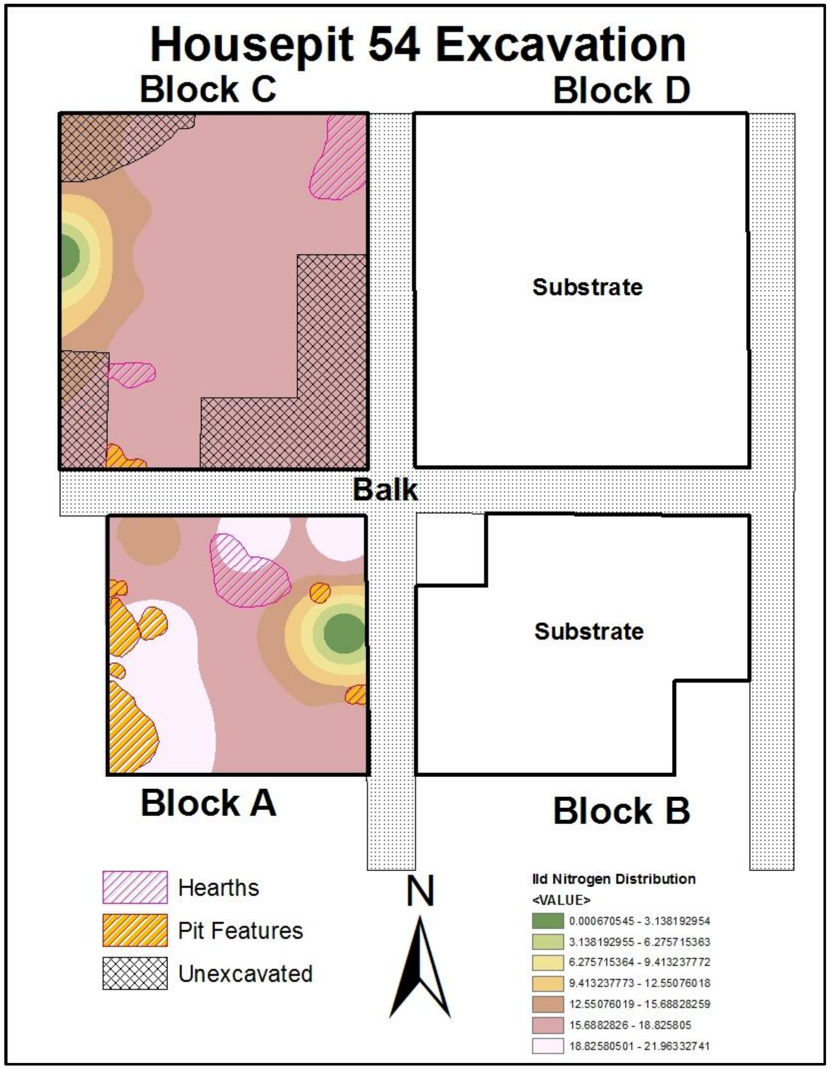


Figure 35. Strat IIf nitrogen [δ15N (‰)] chemical signature distribution.

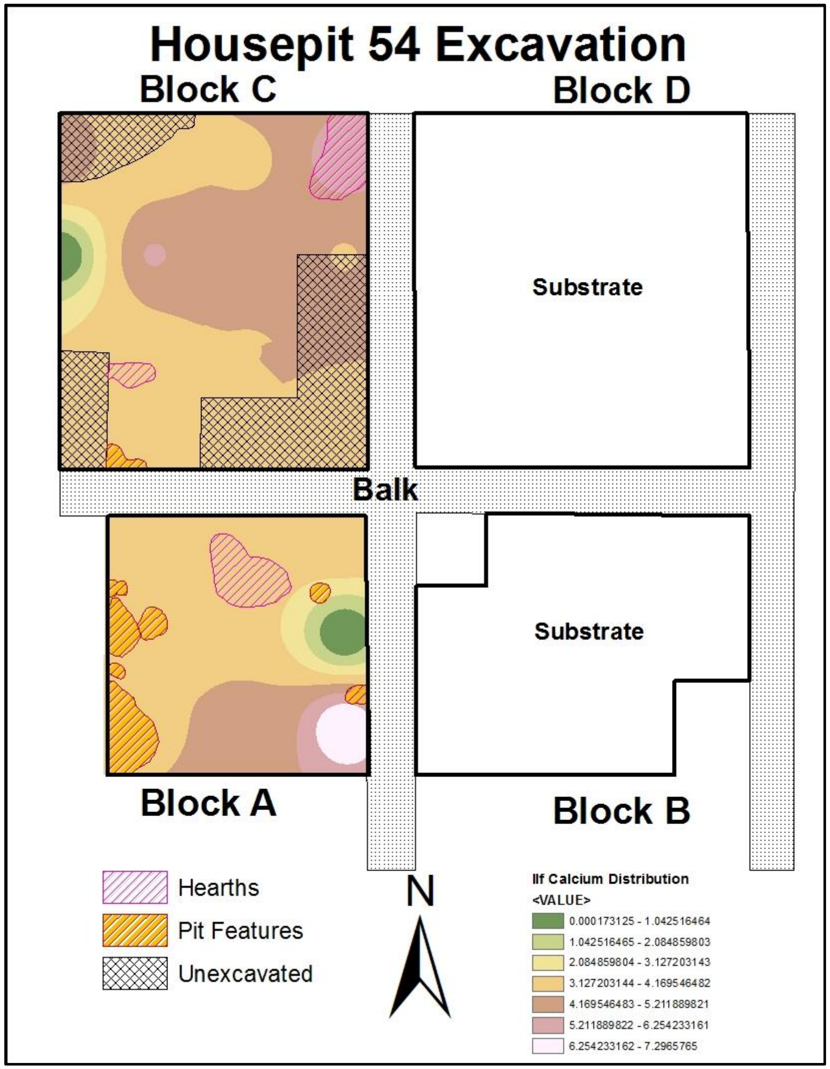


Figure 36. Strat IIf Carbon (wt.%) chemical signature distribution.

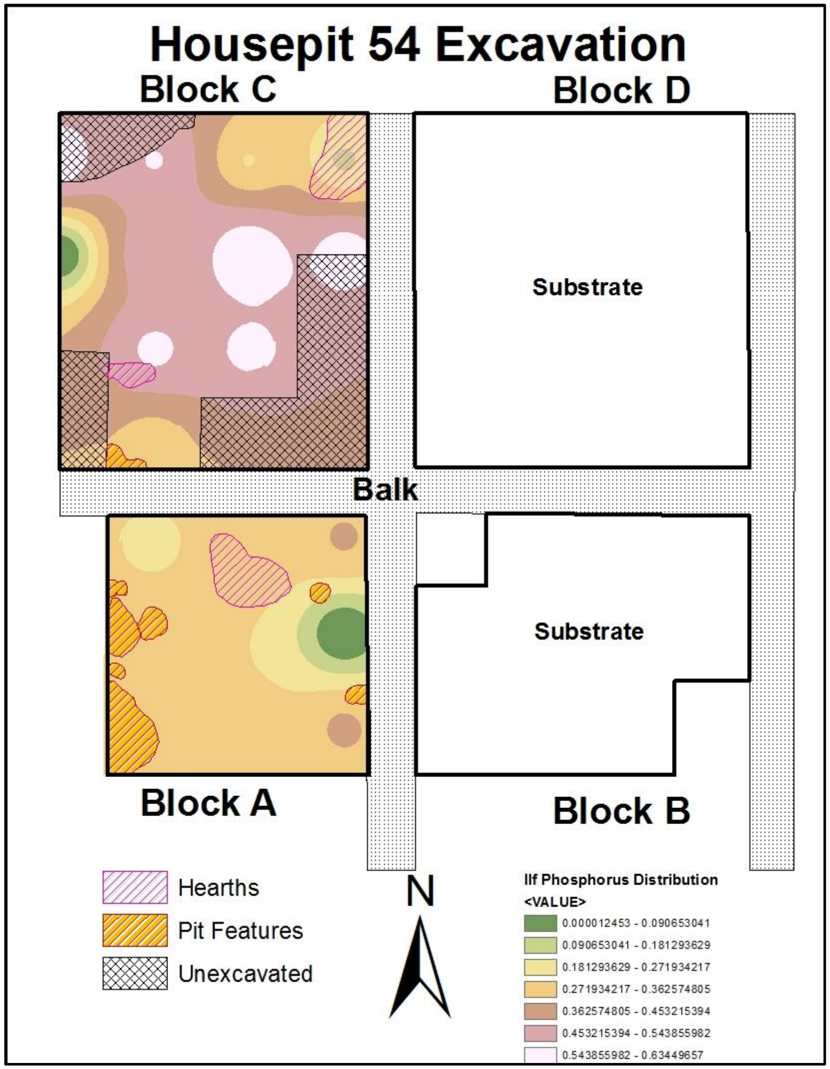


Figure 37. Strat IIf phosphorus (wt.%) chemical signature distribution.

# *Discussion*

Not all activities performed within a Housepit will leave distinct chemical signatures while others will leave signatures that are indistinguishable between others. A concentration of FCR or faunal remains does not mean the area was used for cooking or food preparation. The geochemical concentration patterns presented follow closely but not fully with the spatial distribution of features and ecofacts observed on each floor. There are some discrepancies between chemical signatures and the distribution of features and artifacts.

## *Fish and Mammal Bones*

Similarities in the spatial distribution of fish and mammal bone are evident from the floor surfaces. Between IId, IIe, and IIf the concentrations of both fish and mammal bones are generally found in one area usually near the outer edge of the block. Block A and Block B specifically for IId and IIe floor shows very low evidence of fish and mammal bone. Blocks C and D are the only blocks to consistently have large concentrations of fish and mammal bone present. These concentration areas present on each floor could be evidence of designated food processing activity areas.

## *Carbon and Nitrogen*

$\delta^{13}C$ values represent the relative depletion of a body tissue in $^{13}C$ to the standards of caffeine, fish meal, and JGC Plant and animal values are thus displayed in negative figures, with C3 eating herbivores and their consumers averaging in around –22‰ and lower (Diaz 2019). C3 plants almost exclusively habituate the Mid-Fraser Canyon with an abundance of fresh-water, marine and brackish water resources which dominate the landscape. The complex aquatic isoscape can be differentiated by $\delta^{13}C$ ratios to compare the abundances of terrestrial and marine remains.

Marine and terrestrial remains δ$^{13}$C values can vary depending on certain factors, such as what it originally consumed and/or environmental factors. Higher concentrations of δ$^{13}$C in areas could mean that the area was used for the processing or storage of plant materials.

δ$^{15}$N values reflect the amount of animal protein present relative to the standards of caffeine, USGS 40, and USGS 41 (Ambrose 1993; DeNiro and Epstein 1981; Diaz 2019). The differences in δ$^{15}$N ratios can be used to distinguish marine and terrestrial food sources and therefore examine the ratios of piscivory within the Housepit. The composition of N isotopes within a source reflects the sources of N at the base of the food chain, which are affected by the environment. An area with a high concentration of δ$^{15}$N could mean that the area was used for the processing, cooking, or storage of marine animals.

The C ratios present on Floor IId has an average of -22.286‰. IIe has an average of -21.50‰ and IIf averages -24.309‰ (Table 5), which falls in line with the accepted average values for C3 plants with the range being δ$^{13}$C of -35‰ to -22 ‰ (Jones 2014; Tykot et al. 2006). There is considerable variation in the δ13C of plants, wild plants are generally lower in δ$^{13}$C than domesticated forms such as maize (avg. δ$^{13}$C of -26.5‰) versus domesticated corn (avg δ$^{13}$C of -12.5‰) (Goodale et al. 2017; McCaffery et al. 2014; Tykot et al. 2006). These results are not unexpected for Bridge River, where it would be expected that δ13C signatures would fall in line with a C3 plant environment and the influence of C4 plants in the Mid Fraser Canyon would not likely be through locally available plant resources. The N ratios present on Floor IId has an average of 18.5‰, IIe has an average of 17.39‰, and IIf having an average of 18.01‰ (Table 5), which fall in line with the accepted average values for marine mammals and fish with the range being δ$^{15}$N of 12 to 18‰ (Tykot et al. 2006).

**Table 5. Average ratios of elements and fauna counts.**

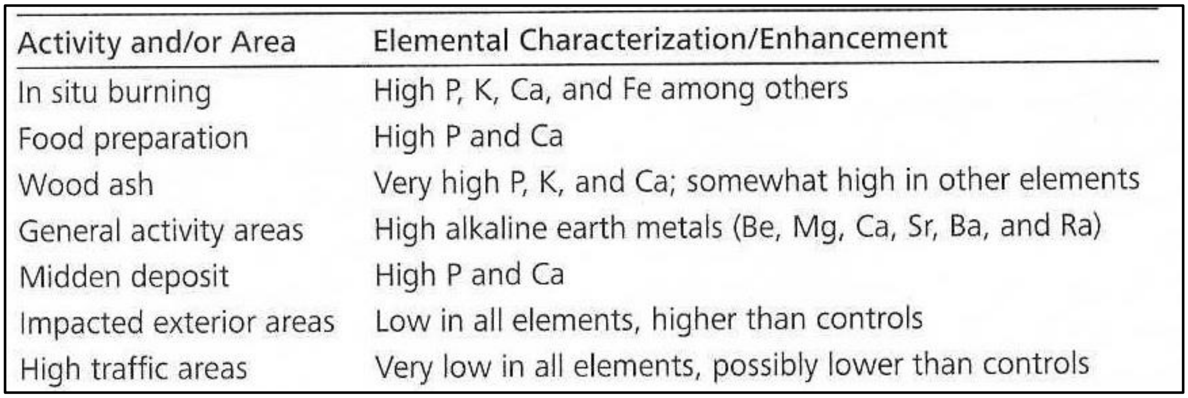
| Strat | **δ13C (‰)** | **δ15N (‰)** | **CaO** | **P2O5** | **FishCountN** | **MammalCountN** |
|---|---|---|---|---|---|---|
| IId | -22.286 | 18.5 | 4.78 | 0.37 | 574 | 325 |
| IIe | -21.5 | 17.39 | 4.77 | 0.44 | 1078 | 993 |
| IIf | -24.309 | 18.01 | 4.5 | 0.41 | 632 | 433 |

The IRMS data of the $\delta^{13}C$ and $\delta^{15}N$ signatures provide a number of potential avenues to explore in the future. First, we were able to achieve solid and accurate results from the Housepit 54 sediments for the $\delta^{13}C$ and $\delta^{15}N$ ratios. The results coincided with the expectations for a C3 plant environment of the Pacific Northwest and activity areas chemical signatures that are left behind. The results also coincide with the expectations of the presence of marine fish, such as salmon. This is evident within the presence of fish bones found on the floor surface. The exceptional stratigraphy and preservation of Housepit 54, future studies of $\delta^{13}C$ and $\delta^{15}N$ could result in a better understanding of the daily life of the inhabitants for Housepit 54. The C and N ratios present within each floor match up with the standard C and N ratio for certain fauna and plants.

### *Calcium and Phosphorus*

The geochemical data presented in this study was examined in relation to the spatial distributions of the faunal remains and features observed on each floor. The concentrations of Ca and P within the sediment of floors IId, IIe, and IIf give a good indication of the spatial distribution of activities within the Housepit. P is typically associated with wood ash and burning (Middleton 2000) (Figure 38). Therefore, we can expect to see elevated ratios of it associated with the hearth areas (Goodale et al. 2017). P and Ca chemical signatures are in abundance in Housepit 54. High ratios of P and Ca are also found in areas of food preparation areas (Figure 38). The high concentrations of Phosphorous and Ca do not fully correspond with high concentration areas of faunal remains. The distribution of P and Ca is concentrated towards the periphery within floor IId. Within floor IIe the concentration of P and Ca is concentrated to the center of the housepit. While P and Ca concentrations on IIf are distributed throughout the housepit.

Areas that were heavy in FCR and hearth features exhibited high concentrations of each element this is most evident within Block D of floor IId, IIe, and IIf. P and Ca were found in high concentrations on each floor within the pithouse. The distribution of it was broad and covered almost every surface. On floors IId and IIe the concentrations of phosphorous and Ca on each floor were almost identical. This was not true for IIf where there were subtle differences between the P and Ca ratios of concentration. The potential that could come from a more in-depth study of each floors elemental ratios could drastically help in fully understanding the lives of the previous inhabitants. The results of this study are promising and could potentially be very valuable in the future, but there are still areas that could be improved on. I think believe the best way to get complete coverage is to sample from each quad in each unit of each block. This would give us complete coverage of each floor, so we wouldn’t have to extrapolate the data in areas with no data available. This would give us a definite picture of the chemical signatures throughout the floor.



| Activity and/or Area | Elemental Characterization/Enhancement |
|---|---|
| In situ burning | High P, K, Ca, and Fe among others |
| Food preparation | High P and Ca |
| Wood ash | Very high P, K, and Ca; somewhat high in other elements |
| General activity areas | High alkaline earth metals (Be, Mg, Ca, Sr, Ba, and Ra) |
| Midden deposit | High P and Ca |
| Impacted exterior areas | Low in all elements, higher than controls |
| High traffic areas | Very low in all elements, possibly lower than controls |

**Figure 38. Elemental concentrations from activities (Goodale et al. 2017).**

# Chapter 5: Conclusions

## *Conclusions*

The goal of this study was to create, analyze, identify, and interpret the distribution of elements and fauna remains across three living floors in Housepit 54. The data presented in this study revealed that there is some correlation between certain elements and faunal remains and features. The results of this study did offer a partial glimpse into the elemental makeup across space and through time in Housepit 54. This study is only the start of a wider project and is the first preliminary look at the elemental distribution within some floors in Housepit 54.

Geochemical analysis coupled with spatial analysis can be a strong tool in helping to understand the distribution of activity areas and features. This study provides meaningful data about how the variations of chemical signatures are distributed across the floors and around features. This study provides the distributions of geochemical signatures as a preliminary examination of Housepit 54's spatial organization. There were several questions put forward to help understand the distribution of activity areas and if they can be identified through a geochemical analysis. The data used for this study was not entirely sufficient. There were missing samples within the floors from areas that contained a feature from a previous floor or areas that were unexcavated. Even with the missing samples, patterns could be extrapolated from the data to give us an estimate of the elemental ratios were throughout the floors as the general analysis used was an interpolation analysis that predicts values for areas that have no data available. This also helped overcome challenges from the large blank areas within each floor from previous trenches and other features, I was able to interpret the spatial distribution of activity areas based on their chemical signatures and spatial data of features and artifacts, but not everything is certain as fauna, lithic, and feature distribution could change drastically in areas.

When taking into consideration the collective use EA IRMS and EDXRF the data revealed an interesting correlation between some elements. Ca and P have almost identical patterns on IId and IIe, but on IIf they are drastically different. Ca and P have been linked in numerous studies to middens and food preparation areas (Goodale et al. 2017; Middleton 2000; Tykot et al 2006). *In situ* burning has likewise been shown to produce high ratios of Ca and P (Middleton 2004). The correlations between two elements on different floors could mean that the same family could have been occupying the same area in the pithouse over a number of floors. Block A and C seem to have a relatively consistent pattern of elemental distribution throughout different floors, while Block B and D fluctuate. The correlation between data using two different analytical techniques is promising, as it suggests there is a correlation between the variation of elements present on the floors of Housepit 54.

The correlations between fauna remains and the elements found in the soil are present within the study but not as prevalent as hoped for. There is a mild correlation between the elements present and the quantity of fauna remains observed. The correlations are not perfect, but the information they present is useable and adds to the discussion. The chemical distributions presented for each floor show a pattern consistent pattern throughout each floor.

There have been several studies within the Mid-Fraser region that used chemical signatures to try and understand the daily life and activity areas within a Housepit. One study is Goodale et al. 2017, which reported on geochemical characterization of the sediments from the fur trade period of Housepit 54. The other study was Middleton 2000, which used chemical identification to identify activity areas within Keatley Creek Housepits.

Goodale et al. (2017) used EDXRF and EA IRMS to analyze ratios of Aluminum (Al), P (P), Potassium (K), Ca (Ca), Titanium (Ti), Iron (Fe), Zinc (Zi), C (C), and N). The Goodale et al study looked at all four elements that were analyzed for this study. As in the Goodale et al study, P was found in high concentrations around the outside of the blocks close to the rim and pit features. The distribution of Ca is similar in pattern to Goodale et al. as it is generally distributed throughout each floor surface. C and N ratios were analyzed using EA-IRMS, but only C produced results in the Goodale et al. study. Goodale et al. had a range of -18.459 to -21.916‰ (Goodale et al 2017), while for this study the range IId was -20.032 to -23.997‰, IIe -14.728 to -25.968‰, and IIf -20.269 to -25.968‰ which all fall within the similar range as the Goodale et al. study, but not completely as the range for this study was larger. These differences are the result of different protocols and machines used, such as Goodale et al. used a portable EDXRF while this study used a Thermo ARL Perform'X EDXRF spectrometer which gives more accurate results.

Middleton (2000) used a multi-element characterization by inductively coupled plasma-atomic emission spectroscopy (ICP/AES) to analyze 12 elements, Aluminum (AL), Barium (Ba), Ca (Ca), Iron (Fe), Potassium (K), Magnesium (Mg), Manganese (Mn), Sodium (Na), P (P), Strontium (Sr), Titanium (Ti), and Zinc (Zn). Only the elements Ca (Ca), P (P) were analyzed in both this study and Middleton's study. Middleton's study looked at 4 different Housepits at Keatly Creek. Concentrations of P were located in areas that contained a hearth and storage or was used as a food preparation area. This also coincides with concentrations of Ca. This holds true for this study as concentrations of both P and Ca were found in areas that contained hearths or storage features.

This present study brought to light a number of problems that can arise from doing a study like this. Complete coverage of the study area is a problem that was encountered as in some blocks there was little or no data or it covers a small portion of the block. This can be a problem when most of the block has been bisected with previous features and trenches. This problem can be abated by using an interpolation analysis that fills the gaps in the data giving a more of a complete coverage of Housepit 54's floors, at the cost of losing a detailed picture of chemical variation.

## *Further Research*

The results of this study are encouraging but the need for further work is a must. It would be advantageous to continue this study and analyze the elemental distribution of every floor in Housepit 54 to gain and understand how the house has changed over its lifespan. It would informative to see if the elemental signatures had the same distribution pattern throughout the corresponding floors. The ability to look at all data for every floor would give a good chronology of the activities that took place in Housepit 54. Further studies would need to included tool types, their inferred use, and their correlation between element signatures. Additional data points within each block on each floor would help to explicate the observed trends. An Increased sample size is particularly important for a better understanding of the daily activities throughout the life of the pithouse.

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