Investigating Site Formation Processes at EjTa-4 on Calvert Island, British Columbia: Results from a Microstratigraphic Study of Excavation Units 12 and 10/15

by
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Declaration of Committee

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Abstract

Accurate interpretation of the archaeological record depends largely on detailed reconstruction of site formation processes. The microscopic and chemical study of archaeological deposits (i.e., the microstratigraphic approach) is effective at reconstructing cultural and natural processes that occurred at any archaeological site. The major focus of my thesis is to test the effectiveness of soil micromorphology and FTIR, two methodological pillars of the microstratigraphic approach, to study site formation processes at EjTa-4, a large shell-matrix site on the central coast of British Columbia. Results indicate well-preserved evidence for activities dating back to 3300 years ago, including built environments, and food processing in the forest. These findings contribute important new information to our knowledge of pre-contact Northwest Coast societies, and to deciphering large shell-matrix sites such as EjTa-4.

Keywords: Site Formation Processes; Microstratigraphy; Microarchaeology; Soil Micromorphology; FTIR; Shell Matrix; EjTa-4; Calvert Island; Shell Midden
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<td>Cal BP</td>
<td>Calibrated Before Present</td>
</tr>
<tr>
<td>FTIR</td>
<td>Fourier Transform Infrared Spectroscopy</td>
</tr>
<tr>
<td>PPL</td>
<td>Plane Polarized Light</td>
</tr>
<tr>
<td>SFU</td>
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<td>XPL</td>
<td>Cross Polarized Light</td>
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Chapter 1. Introduction

Understanding the archaeology of any given site requires the detailed reconstruction of the site formation processes. These processes, as described by Schiffer (1987), fall under two categories: C-transforms (cultural transforms) are human related and, N-transforms (non-cultural transforms) result from natural or environmental processes. Geoarchaeology focusses on the N-transform processes and is well suited to characterizing the spatial and stratigraphic knowledge of archaeological sites (Shahack-Gross, 2017).

Recently, a microstratigraphic and microarchaeological approach, studying deposits at the centimeter to millimeter scale, has proven highly effective at determining site formation processes through precise detailing of depositional and contextual relationships between archaeological components (Matthews et al., 1997; Goldberg & Macphail, 2006; Goldberg & Berna, 2010; Weiner, 2010; Macphail & Goldberg, 2017; Karkanas & Goldberg 2019). The techniques used in the microstratigraphic and microarchaeological approach are soil micromorphology and Fourier Transform Infrared Spectroscopy (FTIR). For this thesis I tested the efficacy of the microstratigraphic approach to study site formation processes at EjTa-4, a large archaeological site on the Pacific coast of British Columbia.

Site EjTa-4 is located on Calvert Island on the central coast of British Columbia. This portion of the British Columbia coastline is rugged with an abundance of fjords and islands (Rahemtulla, 2015:7). Importantly, Calvert Island is located in an area that has been described as a “post-glacial sea level hinge region”, so that its shoreline has essentially remained relatively stable since 14,000 cal BP (McLaren et al., 2014, 2015; Shugar et al., 2014). As result of this peculiar sea level stability, the island was inhabitable since the end of the last ice age (McLaren et al., 2015). EjTa-4, in fact, appears to be one of the sites in BC with the longest human presence, with putative dates up to 13,000 years ago (McLaren et al., 2018).

In 2015 I visited EjTa-4 with Dr. Francesco Berna and Dr. Farid Rahemtulla to collect both intact block and loose samples from excavation Units 12 and 10/15. The intact blocks were resampled in the lab using a micro-excavation protocol developed by
myself, Dr. Francesco Berna, and Dr. Dongya Yang specifically for aDNA and residue analysis. The intact blocks were then impregnated with polyester resin. Once the resin was cured, the blocks were slabbed, sectioned into chips, and sent for petrographic thin section mounting on slides. These slides were examined using a petrographic microscope and micro-FTIR. The loose samples collected in the field and in the lab during micro-excavation of the blocks were analyzed by FTIR. Subsamples have been stored for future analysis.

In this thesis I present the results by illustrating the salient soil micromorphology and FTIR observation found in each lithostratigraphic layer observed in the field. I first describe the finds from excavation Unit 12 followed by results from excavation Unit 10/15. The detailed results of these analyses can be found in the appendixes.

Finally, I discuss the specific and broader significance of my finds. I highlight the effectiveness of the microstratigraphic approach for the study of site formation at EjTa-4. In both excavation units I found evidence for creating built environments, intense use of location (e.g. creation of floors), food processing, and relatively little shell “midden”. My finds articulate why a deposit of this nature should not immediately be classified as a refuse heap or “midden”. There were sophisticated activities taking place, which I identified using the microstratigraphic approach in the lab.
Chapter 2. Background

In this chapter I briefly introduce the archaeology of the central coast of British Columbia, including Calvert Island, and its uniquely stable post ice age coastal shorelines, and its potential for early Holocene and long-use archaeological sites. I then introduce the cultural and archaeological background of site, EjTa-4, the subject of my study. Next, I concisely review the concept of site formation, the microstratigraphic approach, the efficacy of soil micromorphology and Fourier transform infrared spectroscopy (FTIR) analyses for reconstructing natural and anthropogenic formation processes. I present a review of microstratigraphic studies of shell-matrix sites, as EjTa-4 would be currently classified. Finally, I lay out the broader and specific aims of my thesis.

2.1. The Archaeology of Coastal British Columbia

Much of the archaeology of the coastal British Columbia is related directly or indirectly to Fladmark’s 1979 hypothesis of a coastal migration route as an alternative to the Ice-Free Corridor hypothesis for human migration into the Americas. The earliest evidence of human presence in British Columbia dates back putatively to at least 14,000 cal BP in Haida Gwaii (Ramsey et al., 2004) and 14,000 to 13,000 cal BP from archaeological sites on Triquet and Calvert Islands (McLaren et al., 2018). These dates are in line with Fladmark’s 1979 coastal hypothesis, which is further supported by Braje et al. (2019) in their literature review. The latter also suggests that stone tool evidence found around the Pacific Rim indicates that the Fluted Point Tradition was introduced from south to north within the ice-free corridor, and not the other way around as would be expected if the ice free corridor was the original route.

A considerable amount of investigation has gone into determining relative sea level histories along the Pacific coast of North America, and towards locating potential ice-free refugia (areas where terrestrial plants, insects and animals could survive). Fladmark (1979) hypothesised, that these refugia existed during the time that ice covered the continent and he argued that relative sea levels would have been very different during that time (Hetherington et al., 2003; Ward et al., 2003; Letham et al., 2016, 2018; McLaren et al., 2019; Mathewes et al., 2020). Determining relative sea level
histories is therefore integral for locating possible archaeological sites, which may now either be deeply submerged, stranded up to a hundred meters above sea level, or close to current shorelines, as can be found in the Hakai region on the coast of British Columbia (Letham et al., 2016, 2018; McLaren et al. 2014, 2015, 2019). Calvert Island is located in the Hakai region where the sea levels have not fluctuated substantially in the last 15,000 years.

2.2. Study Area: Calvert Island and EjTa-4

Calvert Island and the surrounding region of the central coast of British Columbia are characterized by a rugged coastline with an abundance of fiords and islands (Rahemtulla, 2015:7). There are three zones from west to east: The Outer Mountain Zone, the Coastal Trough, and the Coast Mountain Zone (Fladmark, 1975). To the east of the Outer Mountain Zone the edge of the continental shelf is submerged at approximately 100 meters, and the islands’ elevations are in the range of tens of meters, which is much lower than the mountains of Haida Gwaii or Vancouver Island (Rahemtulla, 2015:7).

Site EjTa-4, is located on the North Eastern part of the island and faces a N-S channel. The beaches around EjTa-4 range from gentle sandy, steep and rocky, to no beach at all due to sharply rising landforms (Rahemtulla, 1995, 2015). Calvert Island is situated in the present day Coastal Western Hemlock (CWH) zone and receives a relatively higher amount of precipitation than other areas along the coast (Rahemtulla, 2015: 10). Common large mammals found throughout the coast are black-tailed deer, black bear, grizzly bear, and wolf (Rahemtulla 2015: 10). Other smaller terrestrial mammals including beaver are also present (Rahemtulla 2015: 10). Marine mammals are abundant including sea otter, Stellar Sea Lion, and northern fur seal (Rahemtulla 2015: 10).
Figure 2.2-1 Study location (Calvert Island) on the British Columbia coast
Regional sea level histories for this area of the central coast have recently been refined (McLaren et al., 2014, 2015; Shugar et al., 2014) (Figure 2.2-3). These studies show that this region has seen remarkably stable sea levels since the last glacial maximum, unlike other areas of the British Columbia coast. This stability is attributed to a hypothesized sea level hinge between the inner and outer coastal extremes, on the post-glacial forebulge complex. As a result, the sea levels at Calvert Island have varied only a few meters since 13,000 BP. This is an important factor with regards to archaeological sites on the central coast since people tend to follow or live close to the shore, sites in this region will be located nearby current shorelines. These sites can also potentially have great accumulation if they have been used for long periods of time (see Figure 2.2-3).
2.3. Archaeology of EjTa-4

The site EjTa-4 is located within the Traditional Territories claimed by the Heiltsuk and Wuikinuxv Nations, both speak languages that are part of the Northern Wakashan Language Family (Black, 1997; Hilton, 1990). The Heiltsuk are descended from a larger group of five known tribes, of which the ‘Wuyalitxv occupied the southern most portion of their territory (White, 2006). The Wuikinuxv had the majority of their winter villages in more inland locations. But they generally had access to both terrestrial and marine resources (Hilton, 1990; Rahemtulla, 2015: 11).
The site EjTa-4 was first identified in 1971 by Pomeroy and Knowlton and has cultural material extending 200 meters horizontally, and at least 4.7 meters below the surface, with radiocarbon dates ranging from 1258-1192 Cal BP to 6180-6018 Cal BP (Rahemtulla, 2015). EjTa-4 was finally abandoned approximately 300 years ago (Rahemtulla, 2015). Within the EjTa-4 intertidal zone, human footprints were found in a buried palaeosol putatively dated to 13,000 years ago and argued to support the long history of human occupation at the site (McLaren et al., 2018). EjTa-4 is in the same region of the coast as Namu on the mainland coast, which to date is the only known site on the central coast of British Columbia that has an archaeological sequence spanning the entire Holocene (Cannon, 1996, 1991; Carlson, 1996, 1991; Rahemtulla, 2006). On the other hand, EjTa-4 is on one of the outer islands, which have had less archaeological investigation and had no historic period construction or major disturbances. Due to the deep cultural deposits and age ranges, EjTa-4 has the potential to provide a spectacular archaeological record similar to that at Namu.

Between 2010-2015 the UNBC field schools recovered fishing and hunting implements and decorative items made from bone, antler, and shell during their excavations but little in the way of chipped stone tools (Rahemtulla, 2015). The stone tools were identified based on the classification system developed for chipped stone tools at Namu (Rahemtulla, 2006) and included projectile points, cores, retouched and unretouched flakes, ground adzes, abraders, and stone beads for example (Rahemtulla, 2015: 28). Worked bone was the largest category of artifact despite little focus in archaeological literature (Rahemtulla, 2015). Other bone, antler, and shell artifacts included: bone points, barbs, harpoons (Figure 2.3-1), awls, combs, beads, and pendants (Figure 2.3-2); shell beads, and worked antler tines (Rahemtulla, 2015: 33). There have also been human remains found at various places within the site (Rahemtulla, 2015: 25).
Figure 2.3-1  Unilaterally barbed harpoon, Artifact 245 (Rahemtulla, 2015)

Figure 2.3-2  Sea Lion tooth pendant, Artifact 236 (Rahemtulla, 2015)
EjTa-4 was likely a winter village which would be consistent with the huge size and depth of the deposits. Evidence from sclerochronological analyses done by Dr. M. Burchell of Memorial University showed that the shells were predominantly collected during the winter season (M. Burchell, personal communication). There is also a large volume of faunal remains, including salmon and herring, which are normally available in the fall and early spring respectively (Rahemtulla, F. personal communication). Approximately 300 years ago the site was abandoned for unknown reasons, but culturally modified trees indicate the site continued to be used in other ways (Rahemtulla, 2014). This abandonment does not appear to have been due a natural disaster (e.g. tsunami) and was before European contact, and the diseases that came with them, had reached the indigenous population and drastically reduced their numbers.

2.4. Site Formation and the Microstratigraphic Approach

Reconstructing site formation is paramount to understand the archaeology of any given site. The processes that form an archaeological site are divided into two general groups: C-transforms, or cultural transforms, are processes related to human activities, and N-transforms, or non-cultural transforms, are environmental processes that affect the archaeological record (Schiffer, 1987). Geoarchaeologists typically elucidate processes that are classified as N-transforms and in doing so, they contribute to the spatial and stratigraphic understanding of any given archaeological site (Shahack-Gross, 2017). Since geoarchaeology is based on the scientific laws of general chemistry, biology, and physics it is applicable globally and can greatly enhance general archaeological studies (Shahack-Gross, 2017). So, for example evidence of human activity (ash, charcoal, bone, shell, etc.) will transform with time following the laws of chemistry, biology, and physics. Knowing how this material transforms in the depositional environments allows for identification of phantom surfaces or areas of altered deposits that are not visible to the naked eye, but that can be seen through the microscope or the geochemical fingerprint.

In recent times it has been shown that site formation studies can be greatly enhanced by adopting a micro-archaeology and micro-stratigraphic approach. This approach entails the study of archaeological deposits at the millimeter to centimeter scale to obtain high resolution and accurate information on the archaeological
components and their contextual relationships (Matthews et al., 1997; Goldberg & Berna, 2010; Weiner, 2010; Macphail & Goldberg, 2017; Karkanas & Goldberg, 2019). These techniques include the use of soil micromorphology and Fourier Transform Infrared Spectroscopy (FTIR). These two techniques can investigate microscopic faunal remains that have routinely been overlooked (Estévez et al., 2013), and identify microscopic evidence of in-situ fire such as in the Acheulean strata of Wonderwerk cave in South Africa for example (Berna et al., 2012).

2.4.1. Fourier Transform Infrared Spectroscopy (FTIR)

Fourier Transform Infrared Spectroscopy (FTIR) is an analytical method “used to identify the functional groups present in organic and inorganic compounds by measuring their absorption of infrared radiation over a range of wavelengths” (Berna, 2017: 411). Archaeological applications of FTIR demonstrate that it is a useful tool to determine archaeological material transformation due to diagenesis (i.e., chemical and physical transformation), state of preservation of artifacts, and presence of heated materials such as fired clay minerals, calcined bone and shells, and pyrogenic calcite (Berna, 2017; Weiner, 2010). Specific to my investigation is the ability of FTIR to identify geogenic, biogenic (e.g. shells), and pyrogenic calcite and aragonite (Regev et al., 2010, Weiner, 2010; Berna, 2017). Pyrogenic calcites commonly found in archaeological contexts include wood ash and lime plaster or mortar, and they are each created via different formation pathways (Regev et al., 2010). Identification of calcite as pyrogenic in origin, and at what temperature the pyrogenic calcite was formed, is done by calculating the ratio of the $\nu_3 = \nu_2$ absorption with pyrogenic calcite having a ratio significantly higher than geogenic or biogenic calcites (Chu et al., 2007; Regev et al., 2010; Berna, 2017). Similarly, using FTIR, it is possible to identify bone heated above 550°C due to characteristic high temperature related transformations of the bone carbonate hydroxyapatite (Berna, 2010).

2.4.2. Soil Micromorphology

At the base of the microstratigraphic approach is soil micromorphology. Soil micromorphology is the microscopic analysis of intact soil, archaeological deposits and features processed in petrographic thin sections (Stoops, 2003: 3; Courty et al., 1989). This technique allows the microscopic observation of the samples while preserving the
context of the archaeological record intact. Micromorphology also allows for the identification and characterization of diagnostic microscopic features related to human activities and natural processes that are otherwise invisible through conventional stratigraphic techniques (Goldberg & Byrd, 1999; Courty, 2001; Goldberg & Berna, 2010; Karkanas & Goldberg, 2019). In particular, this fine-grained analysis allows for the identification of microscopic features such as erosional or aggradation episodes, stable surfaces, anthropogenically prepared surfaces (e.g., floors), surface disturbance, bioturbation, pedogenesis, and geochemical alterations that relate to periods of anthropogenic occupation and/or abandonment (Goldberg & Berna, 2010: 56-57). In addition to this, one can fully integrate micromorphology and FTIR using FTIR microspectrometry (micro-FTIR). Micro-FTIR combines an optical microscope to an FTIR spectrophotometer allowing FTIR analysis directly on particles included in a petrographic thin section (Berna, 2017).

2.5. Microstratigraphic Studies of Shell-Matrix Sites

Due to the large scatter of shells associated with EjTa-4, the site has been classified by convention as a shell midden site (Carlson, 1991; Stein, 1992; Rahemtulla, 2015). Recent scientific practice suggests using the more generic term of shell-matrix site for EjTa-4 and others similar sites (Claassen, 1998; Villagran, 2019). Although there is not a standard definition for shell-matrix site, the term is widely used in recent studies (Villagran, 2019). I thus use shell-matrix site throughout my thesis to refer to EjTa-4.

Soil micromorphology has been extensively used in archaeological contexts to identify site formation processes, post-depositional changes, and diagenesis (Goldberg & Berna, 2010; Estevez, 2014; Canti & Huisman, 2015; Karkanas & Goldberg 2018). However, there are fewer studies utilizing soil micromorphology in shell matrix sites. The majority of the studies on shell matrix sites have been conducted in Tierra del Fuego, Argentina (Vila et al., 2006; Balbo et al., 2010, 2011; Briz Godino et al., 2011; Villagran et al., 2011, 2011; Estevez, 2014). These studies were ethnoarchaeological in nature and conducted on small, circular shell-matrix deposits that do not exactly compare to the nature and dimension of EjTa-4. Thus, the Tierra del Fuego studies are useful for describing a methodology for using micromorphology in shell-matrix deposits, but direct use of their results to make inferences for sites like EjTa-4 are limited. However, they do
set a precedent for utilization of the same techniques to investigate various aspects of site formation and preservation of shell-matrix sites.

Other sites where soil micromorphology of shell matrixes were conducted are located in Japan (Habu et al., 2011), Western Amazonia (Lombardo et al., 2013), Brazil (Estevez et al., 2014), Scotland (Simpson & Barrett, 1996), Catalonia (Estevez, 2014), and California (Goldberg & Byrd, 1999). These sites are pre-contact and they are deeper than the sites investigated in Tierra del Fuego, and therefore, of more relevance to EjTa-4. In Portugal, Duarte et al. (2019) investigated a Mesolithic shell-matrix site that was determined to be laterally constructed instead of being built up by superposition. While not as deep as the excavation units that I studied for this thesis, it does appear to be similar to the entirety of the site EjTa-4, which is also large laterally. Aldeias et al. (2019) performed an experimental archaeology study on what potential microarchaeological evidence could be found from shellfish cooking in the archaeological record. They found, using several roasting procedures, that the microstratigraphic evidence of this roasting activity will appear reworked and disconnected from the actual hearth location. The global work by all these researchers shows that soil micromorphology can be successfully utilized to characterize the sediments and tease out depositional and post-depositional processes, leading to better understanding on the formation of the shell-matrix sites. Research from two groups further informed me on investigations that I would like to perform on the samples I collected; the residue analysis which Lombardo et al. (2013) performed on the samples from Brazil; and different heat source analysis as done by Aldeias et al. (2019).

Common to all the studies performed on shell-matrix sites, including EjTa-4, is the revelation that they have an extremely complex stratigraphy. Despite this complexity, valuable information can be gathered using a microstratigraphic approach as Villagran (2019) demonstrated in comparing several studies on shell deposits in South America. Villagran (2019) shows how this approach can identify pre- and post-depositional alteration and site use. More importantly, Villagran (2019) highlights and defines different classifications for shell-matrix sites (middens, mounds, or general shell bearing sites) that cannot necessarily be identified by size alone but require a microstratigraphic approach.
2.6. Aim of This Study

The broader aim of my Master’s degree research is to contribute to and enhance the study of site formation processes in large coastal shell-matrix sites on the central coast of British Columbia. The formation of deep shell matrixes has been the cause of some debate in British Columbia, particularly the lowest layers. The dark, “greasy” and shell free bottommost layers (a.k.a., shell-less layers) have been alternatively attributed to house floors or decay and leaching of shell material by ground water (Stein 1992), or to the acidic decay of organic material prior to the creation of large shell-matrix sites (and better preservation) by people (Carlson 1991). Being able to contribute to this debate was one of the motivations to test the effectiveness of the microstratigraphic approach at the deep shell-matrix site of EjTa-4 which has several of these layers.

The specific aim of my Master’s thesis is to describe the cultural and the natural processes that occurred through time in two areas of the site EjTa-4 on Calvert Island, British Columbia by using a microstratigraphic approach. In particular, I intend to test the potential of the integrated use of soil micromorphological and FTIR analysis to identify in-situ human activities, natural depositional events, and diagenetic processes. This will enable me to accurately describe a sample of the complex stratigraphy of shell-matrix site at EjTa-4.
Chapter 3. Methods

This chapter starts with a detailed description of the site, excavation areas, and field methods carried out at EjTa-4. Next, I detail the micro-excavation protocol that I developed in the lab with Dr. Berna and Dr. Yang. Finally, I illustrate the specific procedures and equipment used to prepare and analyze the petrographic thin sections and to conduct the FTIR analysis.

3.1. EjTa-4

EjTa-4 (latitude 51° 39’ 53” and longitude 128° 5’ 54”) is on the east coast of Calvert Island. It consists of approximately 2,400 m$^2$ of scatter of archaeological materials possibly reaching depths of 8-9 meters asl (Figure 3.2-1). In total fifteen excavation units were operationalized over five years, and it appears that the oldest archaeological material is found in the northern reaches of the archaeological scatter (Fig 3.2-1). There is no clear correlation between the stratigraphy of the many units and therefore with the exception of the connected Units 10 and 15, each excavation unit has been attributed its own stratigraphic sequence (Rahemtulla, 2015:19). In my thesis I focus on Unit 12 and Units 10 and 15, located in the Northern part of the site. Unit 12 is a 2x2 meter unit that at the time of sampling, was excavated to a depth of 1.8 meters in one area of the unit, thereby exposing the longest continual stratigraphic profile. Units 10 and 15 are two 1x1 meter connected units (1x2m total) excavated to a depth of 4.8 meters at the time of sampling. Following the UNBC project designation I treat these two units as one single unit throughout my thesis, labelled as Unit 10/15. Radiocarbon dating of layers in Unit 10/15 range from 1258-1192 to 6180-6018 Cal BP while in Unit 12 they range from 1293-1302 to 3283-3357 Cal BP (Rahemtulla, 2015: 21). In Unit 12, 8 stone artifacts and 49 made from organic materials were found, while 91 stone artifacts and 155 made from organic materials were found in Unit 10/15 (Rahemtulla, 2015: 28 and 33)
3.2. Field Methods

3.2.1. Sampling and Materials

In May of 2015 I visited the UNBC Archaeology Field School at EjTa-4 along with Dr. Francesco Berna and project director Dr. Farid Rahemtulla, to collect intact sediment block samples from the entire stratigraphic profiles exposed in two excavation units (Units 12, 10/15) (Figure 3.2-1).

Figure 3.2-1 EjTa-4 site boundary with Units 12, 10/15 circled in red inside the yellow box (Rahemtulla, 2015)

The intact sediment blocks were collected so that contacts between each stratigraphic layer identified in the field was sampled by the block (Figure 3.2-3). The blocks were carved out of the wall of the unit using a trowel and/or knife and either had plaster of Paris jacketed around them (Figure 3.2-2) and left to dry before removal or, if moist enough to remain intact, were removed and carefully wrapped in paper towel. All the blocks regardless of plaster jacket or paper towel wrappings, were securely
rewrapped in several layers of packing tape and marked with orientation and sample number before transportation back to camp, where they were stored prior to being delivered to Simon Fraser University later the same summer.

Figure 3.2-2  EjTa-4, Unit 10/15, East Profile. Close up photo of thin beds and intact sediment block jacketed with plaster of Paris being sampled for soil micromorphological analysis.

At the same time loose sediment samples were collected for Fourier Transform Infrared Spectrometry (FTIR) analysis from each field identified stratigraphic layer and were placed in plastic bags and stored with the sample blocks.
Figure 3.2-3  EjTa-4, Unit 12, North Profile. Field scale stratigraphic layers and location of intact blocks sampled for soil micromorphology analysis.
3.3. Lab Methods

3.3.1. Micro-excavation

The samples (jacketed, intact blocks and loose samples) were shipped to the SFU Geoarchaeology Lab. In the lab, samples were partially opened for several days to remove moisture. Once the sample blocks were dried each block underwent a careful micro-excavation the protocol for which was especially developed for aDNA and residue analysis with Dr. Francesco Berna and Dr. Dongya Yang. Metal spatulas were sterilized to avoid cross contamination with the following protocol:

- Immerse in drain cleaner (e.g. Drano™) for 5 minutes
- Wipe with Kimberly-Clark Kimtech™ Science Wipers
- Back into drain cleaner for 5 minutes
- Rinse with distilled water
- In 5% sodium hypochlorite solution (bleach) for 5 minutes
- Rinse with distilled water
- Rinse with 95% acetone.

Photos of the exposed face of each block to be micro-excavated were taken as shown in Figure 3.3-1.
For each block, micro-layers were identified, described, and hand drawn into a sketch of the profile of the block. In addition to the samples for DNA analysis, two samples from each micro-layer were collected for FTIR analysis, if the micro-layer was large enough to be sampled with a spatula. These samples were placed in aluminum foil packets and weighed. The visible components of each microfabric unit were recorded as well as their location if any slight differences were noticed within the micro-layer.

### 3.3.2. Soil Micromorphology

After the micro-excavation was complete the blocks placed in a drying oven at 50°C and then were embedded with styrene polyester resin under vacuum. Once the resin was cured, the embedded blocks were slabbbed, and the areas to be processed into petrographic thin sections were marked on the slabs (Figure 3.3-2). The chips from each block were then cut and sent for mounting into thin sections to Quality Thin Sections, Tucson, Arizona.
Upon return, the petrographic thin section slides were polished with 1μm diamond lapping film on Buehler EcoMet® 250 grinder-polisher system. They were then scanned with both plane- and cross-polarized light (PPL and XPL) with an Epson Perfection V750 Pro high-resolution transmitted light scanner. The analysis of the slides was conducted utilizing an Olympus BX41 Petrographic Microscope System equipped with a Lumenera Infinity 2 CCD camera with which microphotographs in plane- and cross-polarized light were taken. The petrographic thin sections were described for soil micromorphology according to Stoops (2003).

In particular, I identified the microfabric units (see Stoops, 2003) initially by naked eye observation of the slides using obvious colour or compositional differences as can be seen in Figure 3.3-3 or in Appendix A. I then followed a template for each microfabric unit describing the colour, texture, porosity, coarse material components and their relative abundance, and then any notes of particular interest relating to that microfabric unit or between those on the same slide. This information is available in Appendix A. For material components I focused on identification and state of preservation of shells,
barnacle, sea urchin spine, bones, charcoal, ashy material, and any unique components that are summarized in the tables in Appendix B.

Figure 3.3-3 EjTA-4. 50x75 mm petrographic thin section slide (CAI33c-C). Plane Polarized Light scan. Note 5 distinguishable micro-fabric units

3.3.3. FTIR Analysis

The loose sediment samples collected in the field as well as the samples collected from the micro-excavation were analyzed by FTIR using a Thermo-Nicolet iS5 spectrometer. A few micrograms of well-crushed sample was suspended in 5mg of IR grade potassium bromide (KBr), pressed into a 7mm die and placed in the spectrometer. FTIR was performed in transmission mode between the 400 to 4000 cm\(^{-1}\) wavenumbers spectral range. For each spectrum, 32 scans were collected with a resolution of 4 cm\(^{-1}\) wavenumbers. The sediments sampled during the micro-excavation were all run in bulk. Any identified bone, shell, rock, or plant fragment was also run individually. Every
The spectrum was analyzed using the reference spectral libraries available to the SFU Geoarchaeology Lab (Figure 3.3-4).

**Figure 3.3-4 Example of FTIR spectra.**
Top spectrum (purple): Fresh aragonite shell; note the FTIR absorptions at 700 and 859 cm⁻¹ typical of aragonite. Middle spectrum (blue): Aragonite shell heated to 600°C; note the FTIR absorptions at 713 and 875 cm⁻¹ typical of calcite; Bottom spectrum (red) CAI 33c archaeological shell fragment. The latter show FTIR pattern similar to the one of the aragonite shell heated to 600 °C.

Particular attention was devoted to the analysis of shell fragments. In fact, most bivalve shells, and clams among them, are made of aragonite (Lowenstam & Weiner, 1989: 103). Due to diagenetic processes (e.g., dissolution and reprecipitation) and upon heating to temperature of 200°C aragonite transforms into calcite (Weiner, 2010). Upon being heated to temperature of 600°C or more aragonite transforms into calcium oxide (CaO) and then into pyrogenic calcite via hydration and carbonation. Calculation of the FTIR CO₃ v₂/v₄ spectral ratio of the calcite spectra was performed according to Chu *et al.* (2007) to determine if the calcite was biogenic, geogenic, pedogenic, or pyrogenic in origin. Some particles and areas included in the petrographic thin sections were
analyzed by FTIR microspectroscopy using a Thermo-Nicolet iN10 MX FTIR mapping microscope.
Chapter 4. Results

This chapter begins with general stratigraphic observations and descriptions of layers in each excavation unit sampled (12 and 10/15), with the approximate locations of each sampled intact block. Both Unit 12 and 10/15 have several associated carbon-14 dates as seen in their profiles (Figures 4.1-3 and 4.2-3). The micromorphology and FTIR results are presented lithostratigraphically layer by layer (with the exception of Layer 3f), beginning with Unit 12. Layers in each excavation unit are described from top to bottom. The microstratigraphic characteristics for each lithostratigraphic layer are properties that distinguish observed microfabric units that compose them (e.g., colour, microstructure, coarse components, fine components, and pedofeatures). FTIR results are presented as complementary to the micromorphological description. For each layer I summarize the most salient information and provide a tentative interpretation. The detailed micromorphological descriptions are provided in Appendix A and complete FTIR data are summarized in tables of Appendix C.

4.1. Excavation Unit 12

Unit 12 is located in the older area of the site close to the rock face (Figure 3.2-1). The area is heavily wooded and there is a steep slope towards the shoreline. Samples were collected from the wall that continues into the trench dug within the larger unit (Figure 4.1-1 and 4.1-2).

Figure 4.1-1 EjTa-4. Excavation Unit 12. 2015. East profile and deep sounding before being refreshed and sampled for microstratigraphic description and analysis.
4.1.1. Field Stratigraphic Observations

Four major lithostratigraphic layers were identified in the field with the last one being subdivided into eight sublayers (Figure 4.1.-2 and 4.1-3). All the layers slope gently Eastward towards the shore. Layer 0 is leaf litter and is 3-4 centimeters deep. Layer 1, approximately 30 centimeters deep, is brown, silty to clay texture, with abundant roots, small plants, and twigs. Layer 2 is 60 centimeters deep and is coarser than the top layer, blackish brown in colour and has pockets of silty, coarser blackish grey material that contains off white flecks 0.5 millimeters in diameter. Layer 3 is 110 centimeters deep and has sublayers a to h. This layer is composed of a matrix that is blackish brown silty clay. Layers 2, 3b, 3d, and 3h could be interpreted as shell-less house floors.

Figure 4.1-2 EjTa-4. Excavtion Unit 12. East profile. Right: Close up photo of the entire profile with marking of the layers and sublayers. Left: Blow-up of layer 3 with marking of sublayers 3a to 3h.
The Layer 3’s sublayers contain 1 millimeter to 50 millimeter large off-yellowish to white angular fragments and sub-layers of degraded rock. There is a lens of cemented gray silt at approximately 130 centimeters below the surface of the unit.

**Figure 4.1-3**
EJTa-4. Excavation Unit 12, East profile. Lithostratigraphy sketch with approximate block locations (Dates and stratigraphic profiles interpolated from Rahemtulla, 2015)
4.1.2. Soil Micromorphology and FTIR

Below I present soil micromorphology descriptions and FTIR analyses for each lithostratigraphic layer observed in the field. In particular, I describe the general characteristics of the microfabric units constituting each specific lithostratigraphic layer. A total of 28 thin sections were analyzed for Unit 12. For the detailed soil micromorphology analysis of each thin section please refer to Appendix A. For the FTIR analysis of bulk sediments and micromorphologically identified single particles, please refer to Appendix B. Refer to Appendix C for FTIR component analysis and pyrogenic calcite calculations.

Lithostratigraphic Layer 0

In Unit 12, the top Lithostratigraphic Layer (Layer 0) appears to be a few cm thick dispersal of fresh and partially decayed plant parts. Layer 0 was analyzed in the top portion of thin section CAI 21B (Appendix A). Soil micromorphology analysis shows that Layer 0 is composed of microfabric unit 21B-1 containing mainly partially decayed plant tissues aggregated in crumbly peds and dispersed plant organs (e.g., grass rootlets, pine needles, etc.). See Figure 4.1-4. For a detailed soil micromorphology description see Appendix A

Figure 4.1-4 EjTa-4. Excavation Unit 12 – Layer 0. Thin section CAI-21B, PPL scan. Microfabric unit 1: partially decayed plant tissues and plant organs (Field of view: approx. 1.2 x 1.2 cm)
The field and lab observations suggest that the top of Unit 12 (Layer 0) is indeed compatible with a natural forest top-soil horizon (e.g., L/F) composed of fresh and decaying litter with only traces of mineralization of the organic matter. No silt or find sand are observable.

**Lithostratigraphic Layer 1**

The fine matrix of Layer 1 is a dark reddish-brown sediment composed of finely decayed organic material and burrowed by numerous roots and rootlets. Layer 1 was analyzed in several thin sections (i.e., CAI-21B, -22A, -23A + B). Soil micromorphological analyses show that this layer is composed of a microfabric unit resulting from the decay of wood and other plant tissues such as grass roots, needles, and leaves (Figure 4.1-5). Virtually no silt or sand are observed in Layer 1. Field and lab observations, thus, suggest that Layer 1 in Unit 12 is compatible with being a thick F horizon containing a few pebbles and decayed wood fragments.

Figure 4.1-5  EjTa-4. Excavation Unit 12 – Layer 1. Thin section CAI-22A, XPL scan. Microfabric unit 1. Decayed plant tissues (Field of view: approx. 2.4 x 2.4 cm)
Lithostratigraphic Layer 2

The fine matrix of Layer 2 is a black organic rich sediment supporting coarse and very coarse sand. Layer 2 was analyzed in two thin sections (i.e., CAI-23B and -24B). Soil micromorphological analyses show that this layer is composed of two interlayered microfabric sub-units constituted by a fine component composed mainly of black partially decomposed charcoal and plant material. The coarse component is composed of rounded coarse and medium quartz sand and of rounded granite fragments (Figure 4.1-6). The two microfabric subunits are distinguishable by different proportions of black organic matrix and coarse mineral components. These two microfabrics form superimposed darker and lighter cm thick beds.

Figure 4.1-6  EjTa-4. Excavation Unit 12 – Layer 2. Thin section CAI-23B, XPL scan. Microfabric unit 2 (top) Micro-fabric unit 3 (bottom) – Rounded granite granules and sand, decomposed plant material and charcoal (Field of view: approx. 4.5 x 3.0 cm)

FTIR analysis shows that the black fine material contains charcoal and other organic compounds, possibly decayed cellulose and/or fatty acids. A weathered and rounded “exotic” rock (i.e., other than local granite or granodiorite) pebble was observed
in thin section CAI 23B (i.e., microfabric unit 4). This pebble appears to be discoloured by fire and thus is considered as a manuport (Figure 4.1-7).

Figure 4.1-7  EjTa-4. Excavation Unit 12 – Layer 2. Thin section CAI-23B, XPL scan. Microfabric unit 4 - Rounded rock pebble discoloured by fire (Field of view: approx. 1.8 x 1.1 cm)

The dominant sub horizontal porosity suggests that Layer 2 was trampled during and after deposition. The abundance of rounded unsorted sand, gravel, and cobbles contrasts the absence of sand in the natural top-soil horizons forming after abandonment of the site (i.e., Layers 0 and 1). It thus appears that the unsorted and rounded coarse mineral fraction may have been brought in by people, possibly as construction material for a well drained surface. This hypothesis is supported by the presence of charcoal, decayed plant material, and amorphous organic matter of potential anthropogenic origin. Based on this, I hypothesize that layer 2 reflects the remains of living surfaces or house floors.

Lithostratigraphic Layer 3a

Layer 3a is composed of a dark gray organic rich sedimentary matrix, and of white and off-white coarse and very coarse angular speckles. Layer 3a was analyzed in several thin sections (i.e., CAI-8B, -8C, -24B, -25B, and -25D). Soil micromorphological analyses shows that the fine components of the microfabric of Layer 3a are micro charcoal, decayed plant tissues, amorphous organic matter, and micritic calcite grains
The coarse component includes a few sand grain; granite gravel; large pieces of fresh and calcined clam and barnacle shell; fresh and charred bone; fish bone in clusters (Figure 4.1-9); as well as isolated sea urchin spine; and abundant micritic calcite (Figure 4.1-8).

The FTIR analysis show that Layer 3a contains fresh clam shells composed of aragonite, clam shell composed of calcite (thus being heated to 200-300°C), clam shell composed of pyrogenic calcite (heated above 600°C), fresh and charred bone, charcoal, and other organic compounds. These observations suggest that the material is derived from different stages of food processing (e.g., shell cleaning, fire making, smoking, cooking) but were accumulated together most probably in containers (e.g., baskets, skins) during cleaning activities of different domestic spaces.
In the lowest elevations of Layer 3a (e.g., CAI-25B mF2) the gravel size fraction (e.g., shell and charcoal fragments) is chaotically distributed (Figure 4.1-10). This observation suggests that this material was dumped here and did not derived from in-situ sensu stricto activities.

Figure 4.1-9 EjTa-4. Excavation Unit 12 – Layer 3a. Thin section CAI-25B. Microfabric Fishbone in PPL (left) and XPL (right) at 100x magnification

Figure 4.1-10 EjTa-4. Excavation Unit 12 – Layer 3a. Thin section CAI-25B, XPL scan. Microfabric unit 2. Charcoal, granite, and shell fragments gravel chaotically distributed (Field of view: approx. 4.2 x 4.0 cm)
But for the most, the orientation of the coarse components of Layer 3a, appears to be parallel or subparallel to the surface, indicating post depositional compaction (Figure 4.1-8). One of the causes of compaction is trampling of the dumped material as evidenced by the presence of long shell fragments cracked in-situ and still in anatomical connection (Figure 4.1-11).

![Figure 4.1-11 EjTa-4. Excavation Unit 12 – Layer 3a. Thin section CAI-8C, PPL scan. Shell fragment cracked in-situ (Field of view: approx. 2.9 x 1.0 cm)](image)

As for post depositional diagenetic processes occurring in Layer 3a, soil micromorphology revealed the etching of aragonite shells at the contact with Layer 2 (Figure 4.1-12).

![Figure 4.1-12 EjTa-4. Excavation Unit 12 – Layer 3a. Thin section CAI-24B. Etched shell in PPL (left) and XPL (right) at 100x magnification](image)

Interestingly, the integration of soil micromorphology and FTIR analysis revealed the phosphatization of some barnacle and clam shell and the formation of secondary phosphates nodules of apatite often adhering to fragments of charcoal (Figure 4.1-13).
For the details of soil micromorphology and FTIR analysis of Layer 3a please refer to Appendix A and C.

Figure 4.1-13 EjTa-4. Excavation Unit 12 – Layer 3a. Thin section CAI-25B. Phosphate nodules of carbonate hydroxyapatite in PPL (left) and XPL (right). Magnification 100x

It appears that Layer 3a originated as a dump of mixed refuse collected from different food preparation activities that resulted in the burning and crushing of clam and barnacle shells, sea urchin spines, and fish bone. Subsequently this area of EjTa-4 underwent post depositional compaction due to trampling action.

**Lithostratigraphic Layer 3b**

Layer 3b is a 4-5 cm thick dark gray organic rich deposit that contains a few lighter gray speckles. Layer 3b was analyzed in thin sections CAI 25D and CAI 26A. Soil micromorphological analyses shows that the fine components of the microfabric of Layer 3b is composed of microscopically fragmented charred plant material and amorphous organic matter (Figure 4.1-14).
The coarse component includes coarse and very coarse quartz and feldspar sand. The gravel is composed of rounded granite granules and pebbles, charcoal, unheated and heated clam-shell fragments, and fish bone in clusters as well as isolated by themselves (Figure 4.1-15). Micromorphological analysis shows the presence of nodules of apatite, and that clam-shell fragments are etched and/or phosphatized, indicating that soil solution was slightly acidic and rich in phosphate. FTIR analysis shows that Layer 3b contains calcite, heated and not heated carbonate hydroxyapatite, charcoal, and other organic compounds. The absence of aragonite and pyrogenic calcite indicate that the shells have been transformed by geochemical processes and contact to
temperature lower than 500°C. In contrast the presence of heated hydroxyapatite suggests that some of the bone reached temperatures above 500°C.

![Image of fishbone in PPL](image)

*Figure 4.1-15 EjTa-4. Excavation Unit 12 – Layer 3b. Thin section CAI-25D. Fishbone in PPL. Magnification: 100x*

Fish bone at top of Layer 3b as well as other elongated components such as phosphatized shells, appear to be oriented parallel to the surface. This observation suggests that in this location there was a trampled surface. The occurrence of rounded granite gravel and coarse sand suggest that the base of layer 3b layer may have been prepared by people to serve as a surface to conduct activities that produced large quantity of organic compounds (e.g., smoking clams and/or fish).

**Lithostratigraphic Layer 3c**

Layer 3c is a 5-6 cm thick light gray deposit that contains a few whitish gray large pockets and abundant whitish gray speckles. Layer 3c was sampled in thin sections CAI-25E, -26A, and -26C. Soil micromorphological analysis shows that the fine components of the microfabric constituting Layer 3c is composed of microscopically fragmented charred plant material, amorphous organic matter, and micritic calcite (Figure 4.1-16).
Figure 4.1-16 EjTa-4. Excavation Unit 12 – Layer 3c. Thin section CAI-25E, XPL scan. Fragments of charcoal, granite, clam and barnacle shell, bone, and sea urchin spine chaotically dispersed (Field of view: approx. 1.9 x 1.8 cm)

The coarse fraction is composed of charcoal, charred plant tissue, quartz and felspar sand, granite granules, clam and barnacle shell fragments, bone fragments, and sea urchin spine. The particles roundness varies from angular to round and the fabric appears chaotic and unsorted. Large portions of Layer 3c are composed of chunks of cemented micritic calcite containing quartz sand, fire-altered and unaltered fragments of barnacle and clam shell, sea urchin spine, and bone (Figure 4.1-17).
Figure 4.1-17 EjTa-4. Excavation Unit 12 – Layer 3c. Thin section CAI-25E, XPL scan. Cemented micritic calcite with embedded sand and fragments of heated and unheated clam and, barnacle shell, sea urchin spine, and bone (Field of view: approx. 3.6 x 1.9 cm)

The low order birefringence color of domains of calcite and the presence of aggregates of ashed plant remains (Figure 4.1-18) indicate that the dispersed and aggregate calcite is recemented wood ash (Canti, 2003).

Figure 4.1-18 EjTa-4. Excavation Unit 12 – Layer 3c. Thin section CAI-26A. Ashed plant material and calcium oxalate pseudomorph calcite rhombs in PPL (left) and XPL (right) – Magnification: check (100x blow-up)

This hypothesis is confirmed by the presence of heated bone in some of these large chunks (Figure 4.1-19). FTIR analysis shows the presence of heated carbonate hydroxylapatite and that the shell fragments are composed of calcite instead of
aragonite. Also present are the absorptions of pyrogenic calcite. The integration of micromorphology and FTIR analyses suggests that the material found in Layer 3c was originated from dumping of fire ashes and byproduct of shell processing.

Figure 4.1-19 EjTa-4. Excavation Unit 12 – Layer 3c. Thin section CAI-26A. Burnt bone in PPL (left) and XPL (left) at 200x magnification

It appears that layer 3c consists of well-preserved remains from dumped material following the cleaning of a hearth or a brazier and other food wastes, but did not undergo major compaction or trampling.

**Lithostratigraphic Layer 3d**

Layer 3d is a 10-12 cm thick dark gray organic rich deposit that contains a few lighter gray speckles. For these characteristics it resembles Layer 3b. Layer 3d was analyzed in thin sections CAI-26A, -28A, and -28B. Soil micromorphological analyses show that the fine components of the microfabric of Layer 3d is composed of microscopic, fragmented charred plant material and amorphous organic matter (Figure 4.1-20). The coarse component is composed of coarse quartz sand and medium feldspar sand. The gravel is composed of subrounded and subangular granite granules and pebbles, charcoal, unheated and heated clam-shell fragments, sea urchin spine, charcoal, and altered and charred bone (Figure 4.1-20). Worth noting is the presence of a non-local pebble and thus considered to be an “exotic” manuport (Figure 4.1-20).
Micromorphological analysis shows that some shell fragments are partially etched, and, in some cases, the etched area is partially filled with secondary calcite. Phosphatization of some of the shell is also evident as well as the precipitation of carbonate hydroxyapatite nodules (Figure 4.1-20). A pebble-size carbonate hydroxyapatite nodule may be the remains of a carnivore coprolite fragment.

FTIR analysis reveals that Layer 3d shows the absorptions of carbonate hydroxyapatite, calcite, pyrogenic calcite, and charcoal. The absence of aragonite and the presence of calcite and pyrogenic calcite indicate that the shells have been transformed by chemical diagenesis (acid soil solution) and exposure to high temperature. The absence of heated hydroxyapatite suggests that bone and possibly the shell were not heated above ca. 500°C.

It is important to note that Layer 3d rests on Layer 3e with a sharp boundary (Figure 4.1-20), suggesting that its constituents were deposited abruptly on an existing
surface. It also appears that the material in contact with Layer 3e is dominated by organic matrix and sand and gravel while the top of Layer 3d is richer in shell fragments. The elongated particles are generally oriented parallel to the surface, but no evidence of compaction is observed. It thus appears, that the components of Layer 3d originate from activities that produced large quantity of organic compounds (e.g., smoking clams). Subsequently they were covered with highly fragmented shell residues.

**Lithostratigraphic Layer 3e**

Layer 3e is a 9-12 cm thick light gray deposit containing tightly packed white discontinuous laminae. This layer was sampled in thin sections CAI28-A, -B, -C and -D. Soil micromorphology shows that Layer 3e is composed of several superimposed sublayers. It appears that these sublayers are composed of two main alternating microfabric types (Figure 4.1-21).

![Figure 4.1-21 EjTa-4. Excavation Unit 12 - Layer 3e. Thin section CAI-28C. XPL scan. Overlain microfabric units types: Some microfabric units are supported by microscopically fragmented charred plant material, amorphous organic matter, silt, and micritic calcite; Other microfabric units are constituted by self-supporting gravel-size angular shell fragments with a few charcoal fragments (Field of view: approx. 3.8 x 6.3 cm)](image)
One of the two main types of microfabric is constituted by self-supporting gravel size angular shell fragments with a few charcoal fragments. Some of these sublayers are composed of cm-thick fragments while other are composed of mm-thick fragments (Figure 4.1-21). The second microfabric type is similar to ones described in Layers 3a and 3c. Namely, the fine components of this microfabric are composed of microscopically fragmented charred plant material, amorphous organic matter, silt, and micritic calcite. The coarse fraction is mainly composed of charcoal, charred plant tissue, quartz and felspar sand, granite granules, and clam and barnacle shell fragments.

Wood ash clumps and sea urchin are observed only in the top sub layers of Layer 3e. Some of the shell appears heated and degrading in situ with some re-crystallization, while others appear to be acid etched with microsparitic calcite surrounding them. Bone is rare and appears charred and/or partially dissolved. Overall, the entire layer appears heavily compacted with clear evidence of trampling (i.e., presence of *in-situ* fractures of elongated shell fragments). The surface of Layer 3e appears to be a well-preserved compacted surface, as it was compacted and/or trampled without being mixed (Figure 4.1-22).

Figure 4.1-22 Excavation Unit 12 – Boundary between Layer 3d and 3e. Thin section CAI-28B, XPL scan. Note microfabric unit in Layer 3e characterized by compressed and in situ cracked elongated shell fragments suggesting the presence of a trampled surface (Field of view: approx. 4.2 x 3.5 cm)
FTIR analysis shows consistently in all the sublayers the presence of pyrogenic calcite, carbonate hydroxyapatite, and charcoal. It thus appears that the constituents of Layer 3e originated from pyrotechnological activities that resulted in calcination of shells, but not of bone.

In summary, it seems that Layer 3e reflects an area where different materials were dumped in alternation. Some of these materials were mainly calcined coarser and thinner shell fragments. Other materials include wood ash or swept up dirt containing organic compounds, dispersed wood ash, sand, and gravel. Subsequently this location must have undergone strong compression. It is interesting to note that the compressive forces did not cause mixing of the material deposited in different events. It is thus possible that these sediments were buried soon after deposition under a protective surface (e.g., planks, thick mats, etc.) that allowed the preservation of the original spatial organization of the dumped materials.

**Lithostratigraphic Layer 3f**

Lithostratigraphic layer 3f was not sampled for micromorphology. Thus, no description is available.

**Lithostratigraphic Layer 3g**

Layer 3g is a 7-8 cm thick dark gray deposit containing a few off-white speckles. This layer was sampled in thin sections CAI29-A.
Soil micromorphological analyses show that the fine components of the microfabric of Layer 3g is composed of microscopically fragmented charred plant material and amorphous organic matter (Figure 4.1-23). The coarse component includes coarse and medium sand. The gravel is composed of subrounded and subangular granite granules, unheated and heated clam and barnacle shell fragments (Figure 4.1-24). This layer does not seem to be particularly compacted and overall, it appears to be similar to Layer 3d and therefore is interpreted as consisting of dumped refuse, from a location in which large quantity of shell fragments, and charred and uncharred organic compounds were produced.

**Lithostratigraphic Layer 3h**

Layer 3h is at least 18 cm + thick. It is a dark gray organic matter rich layer with common white and off-white angular and subangular speckles. It notably includes a thin black bed close to its base. Layer 3h was sampled in thin sections CAI29-A, -B and -C. Soil micromorphological analyses shows that the fine fraction of Layer 3h is composed by micro charcoal, amorphous organic matter, silt, and micritic calcite grains. The coarse components include a few sand grains and granite gravel. (Figure 4.1-24).
Figure 4.1-24 EjTa-4. Excavation Unit 12 – Layer 3h. Thin section CAI-29C, XPL scan. Microfabric unit constituted by a fine matrix made of micro charcoal, amorphous organic matter, silt and micritic calcite supporting gravel and sand made of granite, quartzite, shell (clam and barnacle), sea urchin spine, charcoal, and bone. (Field of view: approx. 3.5 x 2.3 cm)

It also includes gravel size charcoal, fresh and thermally altered clam shell fragments, thermally altered barnacle shells and sea urchin spine (Figure 4.1-24). Clumps of wood ash, and a few bone fragments are also observed (Figure 4.1-25).

Figure 4.1-25 EjTa-4. Excavation Unit 12- Layer 3h. Thin section CAI-29A. Spongy bone fragment in PPL (left) and XPL (right) at 200x magnification.

The fine and coarse components are organized in several sublayers distinguishable by their different relative proportions of the coarse and fine components. Some of these sublayers are mainly composed of crushed shells. In some of these shell
sublayers, the elongated shell fragments have a random orientation (Figure 4.1-26), suggesting that the material originated as an anthropogenic dump and has kept its original colluvial fabric.

Figure 4.1-26 EjTa-4. Excavation Unit 12 – Layer 3h. Thin section CAI-29C, XPL scan. Elongated shell fragments with random orientation (Field of view: approx. 4.2 x 2.8 cm)

In other shell sub-layers, the elongated particles are oriented parallel to the surface and show signs of being cracked in situ (Figure 3.1.2-27). These micromorphological characteristics suggest that the dumped material underwent periods of compressive forces (e.g., trampling) that packed and reoriented the elongated particles horizontally (Figure 4.1-27).
The top of Layer 3h appears particularly compressed and well-preserved indicating that the top of this layer must have been an exposed surface on top of which trampling and other activities took place. The integrity and the pristine state of preservation of this surface suggests that it either was buried soon after formation or was formed under a protective surface (e.g., plank, thick mats, skin etc.). This type of surface was also observed at top of Layer 3e.

FTIR analysis shows the absorption of charcoal, pyrogenic calcite, carbonate hydroxyapatite. FTIR thus support the hypothesis that part of the components of Layer 3h are food processing residues such as calcined shell, wood ash, and bone. Worth noting in these samples, it is the extensive thermal alteration of the barnacle shells. I hypothesize that barnacles were introduced in the fire because attached to driftwood used as fuel.
In summary, it seems that Layer 3h originated in an area where residues deriving from food processing were dumped regularly. Intermittently between these dumping episodes the area was used in situ or extensively walked upon, possibly covered by a protective surface (e.g., planks, thick mats, etc.) that allowed the formation and the preservation of an undisturbed surface.

4.1.3. Unit 12 Results Summary

Here below (Figure 4.1-28) I summarize the sequence of site formation events hypothesized based on the microstratigraphic observations in excavation Unit 12. It appears that large part of the sedimentary column in this area of EjTa-4 is of anthropogenic origin.
The surface layer of Unit 12 is comprised of forest litter. The cultural deposit layers further down that have been previously identified as hearths and ash lenses (Rahemtulla, 2015) have a complicated depositional and formational history. These stratigraphic layers are comprised of similar components: shell – clam and mussel, barnacle, sea urchin spine, bone, fish bone, charcoal, pyrogenic calcite, re-precipitated calcite, sand, and granite. There are a few unusual components such as a manuport of exotic rock and an obsidian micro flake in layer 3b (Block CAI-26). These layers however appear not to contain any properly in-situ hearths.

The material deposited is mixed, likely collected in baskets from several different locations, contains both heated and unheated material, and forms an anthropogenic

Figure 4.1-28 EjTa-4. Excavation Unit 12. Sketch of the litho- and chrono-stratigraphy with hypothesized site formation processes (Dates and stratigraphic profiles interpolated from Rahemtulla, 2015)
colluvium. If this was due to raking out a hearth in the same area, we would not expect to find unheated material mixed in. There is evidence for trampled surfaces indicating that this was an activity area and not just a midden. These trampled surfaces overlaid compacted ones followed by subsequent deposition. This indicates that multiple activities took place at the same location over time, or that there is a potentially larger picture (deliberate construction) that we cannot see from such a small sample area. The base of the sequence reflects floors built on shell deposits. The area also shows some in-situ activity such as smoking clams and then it was probably the location of a large and long-lasting domestic space.

It is not possible to determine where in the main site the deposited material comes from, it could be a couple of meters away or much farther. At the time of sampling Unit 12 was still undergoing excavation and sterile layers had not been reached, so the information presented here only reflect the data available at that time. But the reconstruction here reveals that the immediate area around Unit 12 was eventually abandoned after at least 2000 years of use, as indicated by the forest litter soil layer above the cultural layers. Following that, human activities continued in other parts of the site, as revealed in the main excavations.

4.2. Excavation Unit 10/15

Unit 10/15 is located near Unit 12 in the older area of EjTa-4, however, it is closer to the shore and further from the rock outcrop than Unit 12. The area is heavily wooded and has a distinct slope Eastward towards the shore as did Unit 12. Samples were collected from two wall areas where shoring was not in place (East and North walls) and where the stratigraphy is accessible. The topmost layers were not sampled due to inaccessibility.
4.2.1. Field Stratigraphic Observations

Thirteen layers were identified in the field with Layer 2 subdivided into two sublayers and Layer 5 subdivided into three sublayers (Figure 4.2-2). The first four layers were described and sampled in the North profile of the excavation Unit and Layers 5 through 13 in the East profile. Layer 1 is the bottommost layer starting approximately at a depth of 458 cm depth below surface and continuing to a depth of 480 cm into the unexcavated. Layer 1 is saturated with water and consists of super compact red clay with black and red mottles and rounded and sub-rounded gravel 5-10 cm in diameter. Layer 2a, approximately from 458 cm to 438 cm depth below surface, is black clay with white to off-white flecks, some stones, and it is plastic in consistency. Layer 2b depth extends from approximately 438 cm to 418 cm and is similar to Layer 2a but with more shell consisting of flakes from 2-5 cm. Layer 3 is a wood plank from approximately 418 cm to 405 cm depth. Layer 4 is laminated shell fragments from an approximate depth of 405 cm to 385 cm. Layer 5a, extends from approximately 385 cm to 365 cm, and it is colluvium similar to Layer 2, however it has more shell and no stone.
Layer 5b extends from approximately 365cm to 345cm and it is a stone layer. Layer 5c is a layer of black to brownish sand at an approximate depth of 345cm to 325cm. Layer 6 is only 2cm thick and consists of laminated ashes and a tan matrix. Layer 7 is also very thin, only 0.5 to 1cm thick, and is crushed charcoal. Layer 8 is a little thicker than the previous two layers, appears laminated, and consists of crushed shells in parallel orientation to the ashes. Layer 9 is very thick from approximately 320cm to 140cm and is like Layer 2b, with more and better-preserved shells. Layer 10 is a shell layer that is at least 35cm thick. Layer 11 is from a depth of approximately 90cm to 20cm and consists of whole and crushed shell, with dark organic silt and clay. Layer 12 is a thin dark organic silt with little shell. Layer 13 is humic layer about 10cm thick.

4.2.2. Soil Micromorphology and FTIR

Below I present the soil micromorphology descriptions and report on FTIR analyses of each lithostratigraphic layer analyzed in the field in Unit 10/15. In particular, I describe the general characteristics of the microfabric units constituting each specific lithostratigraphic layer observed. The top 3 layers of this excavation unit (layer 13, 12, and 11) were not sampled for soil micromorphology. Nevertheless, a total of 17 thin sections were analyzed for Unit 10/15. For the detailed soil micromorphology analysis of each thin section please refer to Appendix A. For the FTIR analysis of bulk sediments and micromorphologically identified single particles please refer to Appendix B. Refer to Appendix C for FTIR component analysis and pyrogenic calcite calculations.
Figure 4.2-2
Unit 10/15 Lithostratigraphy with approximate block locations (Dates and stratigraphic profiles interpolated from Rahemtulla, 2015)
Lithostratigraphic Layer 10

Unit 10/15 Lithostratigraphic Layer 10 is at least 35 cm thick. It is mainly composed of whole and fragmented bivalve shells either sparse or organized in cm thick sub-layers interlayered by bands of dark sediment (Figure 4.2-3).

Layer 10 was analyzed in thin sections CAI37A, B, C, D and E. Soil micromorphological analyses shows that this layer is composed of loosely packed whole shells and large fragments of them. It appears that the shells are dominated by clam species and also contained a few acorn barnacle plates. The shell material appears both fresh and calcined. Dispersed amidst the shell fragments the fine fraction is composed of amorphous organic matter, silt, quartz fine sand, coarse sand size shell, and charcoal fragments (Figure 4.2-4).
Figure 4.2-4  EjTa-4. Excavation Unit 10/15 – Layer 10. Thin section CAI-37D, XPL scan. Chaotically oriented fragments of clam and barnacle shell. The barnacle shell fragments appear particular calcined. Note in between the shell fragments amorphous organic matter, silt, fine and coarse sand, and charcoal fragments (Field of view: approx. 4.5 x 4.5 cm)

Two major types of sublayer have been observed in the slabs of intact block sampled from Layer 10 (Figure 4.2-5): (1) Sub-layers composed mainly of whole shells and partially fragmented shells randomly oriented. These layers represent dumping episodes and the deepest layers of the discard material; (2) Sub-layers composed mainly of extensively fragmented and packed shell fragments oriented parallel to each other. These layers represent the stable and possibly trampled surfaces of the discarded shell heap (Figure 4.2-5).
Figure 4.2-5  EjTa-4. Excavation Unit 10/15 – Layer 10. Intact sediment block CAI-37. Closeup photograph of resin-cured block slab. Note the two shell-matrix sublayers. Top: Whole shells loosely packed; Bottom: The shells are extensively crushed, tightly packed and oriented parallel to each other. (Scale Bar = 5 cm)

A large sub-rounded mudstone cobble was found in one of these shell discard material surfaces (Figure 4.2-5). Micromorphology shows that there are also a few secondary phosphatic nodules, mussel shells, chemically altered bone, and sea urchin spines. Some of the shells have calcite re-precipitation on their edges and show etching that makes them appear scalloped (Figure 4.2-6).
Lithostratigraphic Layer 9

Lithostratigraphic Layer 9 is about 180 cm thick. It appears in the field as organic rich silt with lenses and pockets of shell fragments. For this study, it was sampled at its bottom at the contact with Layer 8 (Figure 4.2-7).
Layer 9 was analyzed in thin sections CAI33c-B and -C. Soil micromorphology shows that the fine matrix is composed of silt, sand (quartz, charred plant material, shell fragments), amorphous organic matter, and it is locally impregnated with micritic calcite. The coarse components include gravel-size fragments of granite, clam, mussel and barnacle shells, sea urchin spine, bone (fish vertebra), and charcoal. The majority of the shell fragments appear to be altered by exposure to heat (calcined) or by the soil solution (etched). See Figure 4.2-8. FTIR analysis shows the absorptions of pyrogenic calcite, carbonate hydroxyapatite, and charcoal suggesting that the majority of the shell was indeed heated above calcination. So, it appears that the components of Layer 9 originated principally as by-product of hearths and shell-fish processing.
Soil micromorphology also shows that the orientation of the elongated shell fragments in Layer 9 is random, suggesting that the shell fragments were dumped in-situ, but that the deposit did not subsequently undergo mechanical or chemical processes that caused a major re-orientation of the fragments. The five bottom most centimeters of Layer 9 are an exception to this. Micromorphology, in fact, shows that at the contact with the underlying Layer 8, the elongated shell fragments are compacted.
and oriented parallel to the surface (Figure 4.2-8). Some of these fragments also show evidence of being cracked in-situ. It thus appears, that during the early stages of the deposition of this deposit, the area was also affected by intense foot traffic.

**Lithostratigraphic Layers 8, 7, and 6**

Below layer 9 we observed a series of well-preserved superimposed thin beds resting on Layer 5 (Figure 4.2-9). These are:

- **Layer 8**: A 3-4 cm thick deposit composed of highly fragmented shells;
- **Layer 7**: A 1-2 cm thick black band of fragmented charcoal;
- **Layer 6**: A 3-4 cm thick orange brown silt laminated band with off-white speckles.

**Figure 4.2-9** EjTa-4. Excavation Unit 10/15, East Profile. Left: Closeup photograph of Layers 5c to 9. Right: Closeup photograph of the slab of resin-cured CAI-33c intact sediment block (Field of view: ca. 8.0 x 9.0 cm)

Layers 8, 7 and 6 were analyzed in thin section CAI33c-C (Figure 4.2-11). Soil micromorphology shows that Layer 8 (i.e., microfabric unit 33c-C mF2) appears to be almost exclusively composed of self supporting highly fragmented and packed clam shells. A few shell fragments appear to be calcined while the majority appears unheated and etched. The elongated fragments appear oriented parallel to the surface and a few also appear cracked in-situ (e.g. trampled?). The fine fraction consists of rare granules composed of silt and sand size charred plant material, amorphous organic matter, and quartz grains. FTIR analysis
shows that it consists of pyrogenic calcite, unheated bone, and charcoal. In summary it appears that layer 8 could be the remains of a floor made of shells.

Layer 7 (i.e., microfabric unit 33c-C mF3 in Appendix A) appears to be composed of gravel-size charcoal and calcined clam and barnacle fragments (Figure 4.2-10). The porosity in between the gravel particles is filled with a light brown silt matrix impregnated by micritic calcite and containing sand size quartz and charcoal particles. FTIR analysis shows the absorptions of pyrogenic calcite, unheated bone, and charcoal. It thus appears that Layer 7 is
the remains of combustion event that witnessed fueling a fire with wood and the calcination of shell in direct contact with the fired wood.

Micromorphology shows that Layer 6 is composed of two super imposed sublayers (i.e. microfabric units 33c-C mF4 and 5 in Appendix A). The top sublayer (mF4) appears as a light-brown gravelly sandy silt. The fine components are composed of a matrix constituted of silt, clay, and micritic calcite. The coarse fraction is composed of sand-size quartz, calcite (shell), and charred material grains. Some of the coarser quartz and granite sand is angular. The top sublayer also contains abundant gravel made of calcined clam and barnacle fragments. This sublayer appears compacted (i.e. massive microstructure) with a very few channels and possibly vesicles. FTIR analysis shows that the top sublayer of Layer 6 contains pyrogenic calcite, unheated bone, and charcoal. The bottom sublayer of Layer 6 (mF5) is 0.5 to 1 cm thick, is more porous and is composed of gravel-size charred and calcined clam and barnacle shell fragments. The porosity in between the gravel is filled with micritic calcite, silt, and sand size grains made of shell, quartz, and charcoal (Figure 4.2-10). FTIR analysis shows that it consists of pyrogenic calcite, unheated bone, and charcoal. Layer 6 rests on Layer 5c which shows microfabric characteristics remarkably similar to the bottom sublayer of Layer 9. See above and below.

One possible interpretation of the compresence of the spectacularly well-preserved Layer 6, 7 and 8 is the following: Layer 6 was an anthropogenic surface made by mixing mud, sand, wood ash, and calcined shell fragments. Layer 7 represents the remains of a fire that was lit on top of the anthropogenic surface and was fueled with wood. Some shells were placed on top of the fire in direct contact with the flames and got charred and calcined. Once the fire was done, the hearth was buried under a layer of unheated shells and this surface was compacted possibly by trampling protected under a skin, or mat, or a plank.

**Lithostratigraphic Layers 5a, 5b, and 5c**

Lithostratigraphic Layer 5 is a ca 60 cm thick blackish gray organic rich deposit containing shell fragments. It has been subdivided in 3 layers: 5a, 5b, and 5c. I start my description from the top with Layer 5c. This layer has micromorphological characteristics similar to Layer 9 (see description above). Their components are similar, with the difference that Layer 5c has a higher concentration of shell fragments with respect to Layer 9 (Figures 4.2-9 and 4.2-10). The top of layer 5c, at the contact with Layer 6, has
been analyzed in thin section CAI33c-C and -E. Micromorphology shows that at this level the shell fragments are oriented parallel to the surface, densely packed, and cracked \textit{in-situ} (Figure 4.2-11).

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{figure4.2-11.png}
\caption{EjTa-4, Excavation Unit 10/15 – Layer 5c. Thin section CAI-33cE, PPL scan. Top of layer 5c, shell fragments cracked in-situ and oriented parallel to the surface (Field of view: approx. 5.4 x 3.2cm)}
\end{figure}

Notably, the top of Layer 5c appears particularly rich with bone fragments that do not appear charred or calcined (Figure 4.2-11). On the other hand, the bone material appears to be slightly diagenetically altered and discoloured to an orange tint. FTIR analysis shows the absorptions of pyrogenic calcite, carbonate hydroxyapatite and charcoal. It thus appears that while many of the shells were in contact with temperature of at least 550 °C bone was not.

Layer 5b is defined by a high concentration of cobbles. Layer 5b was analyzed at its base at the contact with layer 5a in thin section CAI39B. The boundary between layer 5b and 5a was demarcated by a well-preserved large wood post/plank laying horizontal (Figure 4.2-12).
Micromorphology shows that the fine matrix of Layer 5b is composed of amorphous organic matter deriving from the decomposition of wood and charcoal (Figure 4.2-13). The coarse fraction contains quartz fine sand and coarse sand size particles of charred plant materials and decayed shells. The gravel is composed of fragments of clam shells, charcoal, bone, and a few grains of granite. Notably the shell fragments are extremely altered, with alteration including discolouring, etching, and most impressively exfoliation with the formation of long filaments of altered calcite (Figure 4.2-13). Some of the shell fragments appear to have been calcined. The charcoal also looks like it tended to exfoliate in this depositional context.
Interestingly FTIR analysis shows that the bottom of layer 5b exhibits the absorptions of aragonite, pedogenic and pyrogenic calcite, charcoal, and carbonate hydroxyapatite. Thus, it appears that despite the obvious chemical and physical alteration, unheated shell and bone material are still preserved in this type of deposit.

In addition, there is a well-preserved portion of the wood at the boundary between Layers 5b and 5a. In fact, the hemicellulose and lignin composing the cell wall in the wood structure preserved a good degree of birefringence (Figure 4.2-14). FTIR analysis also shows that a sample of the wood displays some of the absorptions of cellulose and hemicellulose. This result supports the microscopic observation of the birefringence of the tissue composing the cell wall of the wood structure.
Layer 5a is a 20 cm thick blackish gray organic deposit containing shell fragments. It was analyzed in thin sections CAI39-C and -D. Soil micromorphology shows that the fine matrix, the coarse fraction and the gravel components, and the microstructure of Layer 5a are highly comparable with the ones of Layer 5b. The main difference is that in Layer 5a (Figure 4.2-15) the shell fragments are smaller and do not appear as weathered as in Layer 5b (Figure 4.2-13). FTIR notably shows carbonate hydroxyapatite adhering to charcoal.
Lithostratigraphic Layers 4, 3, and 2

Layer 4, 3 and 2 were observed starting at a depth of ca 410 cm below surface. Layer 4 is a blackish gray organic deposit containing shell fragments that are organized in laminae (Figure 4.2-17). Layer 3 appears to be the remains of a decayed wood feature, a log, post, or a plank (Figure 4.2-17). Layer 2 is blackish brown clay with white and off-white flecks. Sublayer 2b appears to have larger and more abundant amounts of flecks than sublayer 2a, which also contains some stones (Figure 4.2-17).

![Image of layers 2a, 2b, 3, and 4](image)

Figure 4.2-16 EjTa-4. Excavation Unit 10/15, North Profile - Layers 2a, 2b, 3, and 4. Closeup photo

These layers were analyzed in thin sections CAI38-D, -E, -F, and -I. Soil micromorphology revealed that the fine matrix of these layers is composed mainly by decayed charcoal and humified plant tissues. The organic matrix supports silt, quartz fine and medium sand, and coarser shell particles (Figure 4.2-17)
Micromorphology shows that these layers are laminated (Figure 4.2-17). The lamination is defined by the compaction and the parallel orientation of the gravel-size shell fragments. Some laminae contain mainly charcoal fragments (i.e., 38D-mF2), other mainly shell fragments (i.e., 38D-mF3). Notably, some laminae contain bone fragments with shell and granite particles (i.e., 38D-mF4). Shell fragments appear to originate mainly from clams. Barnacle fragments are rare. Some of the shell fragments appear to
be calcined. Larger shell fragments are exfoliated as observed in Layer 5a. Shell fragments are also stained, etched and, in some cases, appear to be phosphatized. A few sand-size nodules of phosphate are observed adhering to the organic matrix. Wood tissue found in these layers appears extremely weathered to the point that it is impossible to identify any cellular structure, as the wood was completely humified (Figure 4.2-18).

Figure 4.2-18 EjTa-4. Excavation Unit 10/15 – Layer 3. Thin section CAI-38F, XPL scan. Decayed wood (Field of view: approx. 1.9 x 1.6 cm)

The FTIR analysis shows absorptions of aragonite, calcite, pyrogenic calcite, carbonate hydroxyapatite, and charcoal. FTIR results thus support the mixed presence of bone, charcoal, phosphate nodules and the co-presence of fragments of well-preserved shell and bone, calcined shells, diagenetically altered shells, phosphate nodules and charcoal. The likely explanation for microstratigraphic evidence observed in Layer 4, 2a and 2b, is that this sequence reflects periods of different anthropogenic activities occurring intermittently on the forest floor.
Lithostratigraphic Layer 1

Layer 1 is the deepest level reached to date in Unit 10/15. It starts at a depth of ca 450 cm and continues deeper than 480 cm below surface. Layer 1 is a reddish brown very compact clay with black and red mottles. A few rounded and subrounded 5-10 cm in diameter cobbles were also observed at this depth. Layer 1 was analyzed in thin sections CAI-30B and -31B. Soil micromorphology shows very well the boundary between Layer 2a (at top) and Layer 1 (Bottom) (Figure 4.2-19).

Figure 4.2-19 EjTa-4. Excavation Unit 10/15 – Boundary between Layer 1 and 2a. Thin section CAI-30B, XPL scan. Layer 1 (at bottom) is composed mainly of decayed wood and organic matter (Field of view: approx. 4.3 x 6.5 cm)
The bottom of Layer 2a is composed of a blackish and porous granular matrix containing charcoal and granite sand and granules. Layer 1, on the other hand, is composed of a compact reddish-brown matrix composed of amorphous organic matter with a few fine sand grains (Figure 4.2-19). The coarse fraction appears to be composed of fragment of decayed wood almost completely humified. No shells or bone have been observed, in Layer 1 nor coarser sand. A rounded intrusive igneous rock pebble was observed in thin section CAI 30B. It thus appears that Layer 1 is composed of decaying wood and may represent a period when this part of the island was not being used by people.

4.2.3. Unit 10/15 Results Summary

Here (Figure 4.2-20) I summarize the hypothesized sequence of site formation events based on the microstratigraphic observations in excavation Unit 10/15. It appears that large part of the sedimentary column in this area of EjTa-4 was influenced by in-situ human activities in a landscape dominated by a forest environment. Around 3,500 years cal BP the area was used for some very specialized activities that involved the preparation of surfaces made by mixing mud, sand, and crushed shell to light a fire on top of it. Everything was then covered with crushed shells. The area was used less intensively than Unit 12 until 1,300-1,400 cal BP when it was used to dump large amounts of whole and fragmented shells. Unit 15 was eventually abandoned after at least 6,000 years of use.
Figure 4.2-20 EjTa-4. Excavation Unit 10/15. Sketch of the litho- and chrono-stratigraphy with hypothesized site formation processes (Dates and stratigraphic profiles interpolated from Rahemtulla, 2015)
Chapter 5. Discussion

5.1. General Considerations

The principal objective of my thesis was to test the potential of the microstratigraphic approach (Matthews et al., 1997; Goldberg & Berna, 2010; Weiner, 2010; Macphail & Goldberg, 2017; Karkanas & Goldberg, 2019) to study the site formation processes at EjTa-4, an exceptionally large and old shell-matrix site in the central coast of British Columbia. Few sites in the Pacific North West Coast compare to it. My results were beyond expectations and I was able to identify significant sedimentological differences among the many layers analyzed and pinpoint evidence of natural and cultural processes that took place at EjTa-4 for the last 6,000 years.

In particular, the integration of micromorphology and FTIR analysis allowed me to observe the make-up of some spectacularly preserved anthropogenic surfaces dating to 3,516-3,316 Cal BP (Figure 5.1-1). Some of these stratigraphic sequences (see Figure 5.1-1) are revealing the existence of highly specialized food processing activities (e.g., smoking) or even rituals (i.e., smudging ceremonies).
I also noted potential evidence for the employment of planks, mats, or skins to create living and activities surfaces and evidence for the utilisation of containers for handling refuse. These observations have enormous potential to shed new and fundamental light on the behaviour and ancient knowledge of the ancestral people of British Columbia. Information about different types of human ecological interactions at EjTa-4 was also revealed. For instance, I observed that in the area of Unit 12 human presence and activities significantly contributed to a built environment. In fact, large portions of the sedimentary column of Unit 12 are composed of materials introduced by
people such as wood ash, shells, sand, and gravel from the beach. In contrast, Unit 10/15 reveals that for long periods of time people conducted activities in the forest environment and contributed materials such as shells, bone, and charcoal to the forest litter horizons. One wonders if these may be also evidence of the ancestors managing the forest by performing these activities in it and/or bringing organic materials from elsewhere.

Micromorphological characteristics and chemical fingerprints of each layer, were identified and I hypothesized a sequence of formation processes for each of the excavation units (Figure 5.1-2). I can then correlate the litho- and chrono-stratigraphy of two or more excavation units and hypothesize what was going on a cross of different areas of EjTa-4 at a specific time. For instance, by looking at the correlation illustrated in Figure 5.2-2, it appears that ca 2,000 years cal BP there was a domestic environment in proximity of Unit 12, while food processing and other activities took place in the forest environment in the area of Unit 10/15. About 1,300 cal BP the situation seems to be reversed and the area of Unit 12 is abandoned while intensive clam harvesting and processing activities were taking place in proximity of Unit10/15 that was used to dump large quantities of shells.

My finds contribute importantly to the debate on how to decipher a shell “midden” site, the term that has been used conventionally in Canada to classify EjTa-4 and other similar archaeological sites in the central coast of British Columbia (Carlson, 1991; Stein, 1992; Rahemtulla, 2006). I believe my finds show that at EjTa-4, of the many layers analyzed, only a few preserve the characteristics of refuse heaps and could be appropriately classified as “shell midden” deposits (as the term midden means “refuse accumulation” in old Danish). My results are more in line with classifying EjTa-4 with the more generic term of “shell-matrix site” (Villagran, 2019). In fact, despite their external jumbled appearance, under the microscope the majority of the layers look like remains of in-situ activities while others are the remains of shells that were “recycled and re-engineered” into living surfaces. The latter observation feeds into the hypothesis that has been around for quite some time that shellfish were recycled for engineering or, I would add, landscape management purposes (Blukis-Onat, 1985).

My finds also challenge the common notion among some archaeologists that all compacted black shell-less layers should be considered as the remains of house floors.
From my analysis it appears that some black shell-less layers may have been associated with house floors, but other such layers do not have the microstratigraphic fingerprints of house floors. In fact, each “black layer” that I have analyzed showed significant differences that distinguished it from the others. Of the many “black layers” analyzed, only the bottom most layer of Unit10/15 could be considered shell-less. It appears that this layer is formed by an accumulation of decayed wood. So, my analysis brings up the issue of equifinality in the causations of these shell-less black layers and reinforces the notion that each of these layers needs to be investigated properly and alternate hypotheses must be explored. More importantly, my observations evidenced the existence of activity surfaces (e.g., floors) prepared straight on shell accumulations.

Whole shells, shell fragments, and shell sand are observed in all the layers, with the exception of Layer 1 in Unit 10/15 and the modern soil at top of Unit 12. To my surprise, I documented the presence of shells in extremely organic rich matrixes. Aragonite shells are found calcined (transformed to pyrogenic calcite), etched but reprecipitated into secondary calcite, and mechanically exfoliated. Calcitic sea urchin spine were also observed in organic matrixes. These observations contribute important information on the diagenetic processes occurring in these types of archaeological deposits of the central coast of BC. It appears that despite the acidity of the soil solution, buffer mechanisms are activated by the presence of the carbonate of the shells that allow for the preservation of shell material and bone even in deposits with high content of organic matter. Bone fragments appear rarely and slightly altered. Given what was just said and that I also documented the presence of phosphate nodules, I would attribute the scarcity of bone to an original low input rather than to taphonomic or diagenetic processes.
Figure 5.1-2 EjTa-4/ Tentative litho-, micro-, chrono-stratigraphic correlation between Unit 10/15 and Unit 12 (Dates and stratigraphic profiles interpolated from Rahemtulla, 2015)
Another important outcome of my work is that the micro-excavation protocol and the use of magnification and good lighting turned out to be very effective for several reasons. First, it allowed for the accurate description and photographic documentation of the intact stratigraphy within the lab. Thus, some nuances of the stratigraphy that could have been missed in the field were identified in the lab. Second, I was able to identify exceedingly small artifacts that would have been missed in the field screening process. An example of this was the finding of one mm-size pressure flake of obsidian in the block CAI 26 from Unit 12. Micro-excavation allowed for the exact attribution of these tiny artifacts to the proper stratigraphic layer. Third, I was able to accomplish a detailed description of the nature of the sediment and the appearance of the cultural material (burnt, stained, etc.). Finally, I was able to collect highly contextualized sub-samples for FTIR samples that I analyzed and for aDNA and residue analysis that are stored for future analysis.

In conclusion, I restate that as with other microstratigraphic studies of shell deposits around the world (Simpson & Barrett, 1996; Goldberg & Byrd, 1999; Vila et al., 2006; Balbo et al., 2010, 2011; Godino et al., 2011; Habu et al., 2011; Villagran et al., 2011, 2011; Lombardo et al., 2013) my work was very effective in determining the depositional processes within the two deep profiles analyzed. I was, in fact, able to observe that the pre-contact inhabitants of Calvert Island were moving the remains of hearths and food processing and depositing them in a mix in another location. Unique to my study, I was able to do so across several meters apart in a site that has an extension of 2,400 m². Many similar shell-matrix sites studied were significantly smaller than EjTa-4 (e.g. at Tierra del Fuego they are only cm’s deep). Finally, I want to stress that to my knowledge, this is the first that a microstratigraphic investigation of deposits from a shell-matrix site was performed on the coast of British Columbia, making this study unique.

5.2. Future Directions

The work I presented here showcases the fundamental importance of analyzing the sedimentary column at the molecular and microscopic scale when studying site formation processes. I believe I demonstrate that from a thin section one can scale up and infer implications not only on landscape transformations, but also on traditional knowledge and human eco-dynamics. In light of this, it would be worth expanding
To learn more about deep-time extension of traditional practices, I should engage a middle range theory approach to improve the accuracy of the cultural significance of my microstratigraphic findings. For instance, I could start creating a reference petrographic thin section library of well-preserved, and unequivocally identified archaeological features (i.e., floors, hearths, etc.) from coastal British Columbia, and ethnographic or experimentally made floors and shell surfaces. This research endeavour will improve the ability to accurately recognize anthropogenic surfaces observed microscopically, and the traditional knowledge behind them. I would commence by trying to experimentally reproduce the sequence of well-preserved surfaces (Layers 6, 7, and 8) observed in Unit 10/15 (Figures 4.2-8, 4.2-10, and 5.1-1). I probably would start with mixing beach mud from Calvert Island with wood ash and finely crushed shells to see if I could reproduce the microfabric observed in Layer 6 (Figures 4.2-10 and 5.1-1).

Moreover, my thin sections can be used to further investigate the stratigraphic distribution of different species of clams, mussels, barnacles, sea urchins, and fish and mammal bone to gain insights into the changes of subsistence at EjTa-4 through time. My thin section collection can also be used to identify and source “exotic” lithic raw materials and explore the ancient social networks connecting EjTa4 to the rest of the coast and the interior (Reimer, 2018). Even more exciting, is the opportunity for the archaeological community to use the thin sections and the loose sediment sub-samples to test the effectiveness of a plethora of innovative environmental and archaeologica proxies. Britton and Richards (2019) recently offered an extensive and updated review of the most advanced analytical techniques that could be used in Archaeology. I would recommend beginning with:

1) Micro FTIR on existing thin sections to assess combustion conditions of shells and bone.
2) Residue analysis (e.g. lipids, steroids) to learn about plants and animal groups that were processed, smoked, and/or cooked at the site.
3) Soil DNA, aDNA, and proteomics to identify species introduced at the site.
4) Phytoliths, diatoms, and sponges to estimate vegetation, humidity, and water salinity changes through time.
5) Leaf wax isotopes to estimate (micro)climate changes.
Chapter 6. Conclusions

The principal objective of my thesis is to assess the potential for integrating soil micromorphology and FTIR analyses to study site formation processes at EjTa-4, a large and long-lived archaeological site on the central coast of British Columbia. Few sites on the Pacific North West Coast compare to EjTa-4. Site EjTa-4 consists of approximately 2,400 m$^2$ of scatter of archaeological materials possibly reaching depths of 9 meters asl. These materials date back to 7,000 years ago, but there is some evidence that people were at the site as early as 13,000 years ago. EjTa-4 is thus one of very few sites on coastal British Columbia that are in an area of relatively stable sea levels since the end of the last glaciation, and this it may have been in the path of the earliest coastal migrations by humans into the continent.

EjTa-4 is classified and listed as a shell midden site by researchers, Cultural Resource Managers, and government agencies, but there are issues with the term. It does not accurately reflect the complexity of its stratigraphy nor the potential differences in meaning when comparing to other regions of the world. Midden is also a word laden with negative and colonial connotations and, while it is still widely used, I believe its use should be limited to classify only specific deposit. EjTa-4 and similar sites should be classified with the more scientifically appropriate term of “shell-matrix” site.

Accurate interpretation of the archaeological record of EjTa-4 or of any archaeological site with such a complex stratigraphy, depends largely on detailed reconstruction of site formation processes. Part of this process entails deciphering cultural processes (in-situ human activities that result in anthropogenic deposits) and natural processes (e.g., sedimentation, erosion, soil formation, diagenesis, taphonomy) that may have occurred through time at a specific location within an archaeological site. Microscopic and chemical analyses of archaeological stratigraphy (a.k.a., the microstratigraphic approach) has been most effective for reconstructions of shell-matrix sites in California, South America, Europe, and Asia.

Soil micromorphology (the microscopic analysis of intact soils and archaeological deposits, features, and materials processed in petrographic thin section) is the pillar of the microstratigraphic approach to study site formation processes. As seen in this study it can provide contextualized descriptions of the sedimentological components, assess
their natural or anthropogenic origin, their transport and deposition mechanisms, and their transformation due to physical, geochemical, and soil formation processes. FTIR is a powerful complementary analytical tool that provides molecular information beyond optical microscopy.

The integration of micromorphology and FTIR analysis of the stratigraphic columns of two excavation Units at EjTa-4 allowed me to identify significant sedimentological differences among the many layers analyzed, and pinpoint evidence of natural and cultural processes that took place at EjTa-4 over the last 6,000 years. Specifically, I was able observe the make-up of some spectacularly preserved anthropogenic cm-thick surfaces that most probably related to highly specialized food processing activities (e.g., smoking clams and fish). Moreover, I was able to pinpoint potential evidence for the use of containers for handling refuse, and the use of planks, mats, or skins to create living and activity surfaces. Finally, I observed clear evidence of human-built environments and activities conducted habitually in forested areas.

To conclude, the explorative work I present here showcases the fundamental effectiveness of the microstratigraphic approach in archaeology. I believe that my work at EjTa-4 illustrates that from a thin section, one can scale up and infer implications not only on landscape transformations, but also on traditional knowledge and human eco-dynamics. I therefore recommend further application of this approach to samples from other areas at EjTa-4, and to other archaeological sites on Calvert Island and on the Pacific Northwest Coast.
References


Appendix A.

Thin Section Descriptions

Thin Section ID: CAI 1A

- **Stratigraphic Unit(s):** Soil forming on paleo dune on northwest shore
- **Thin Section Size:** 7.5 X 5.0 cm
- **Number of micro-Fabric Units (µFU):** 2
- **Boundaries between µFU:** Clear wavy

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Figure A1. CAI 1A Thin Section in PPL and XPL with marking of micro-Fabric Units (µFU) 1 and 2

**micro-Fabric Unit # 1**

- **Relative depth** (from top): 0.0 - 2.5 cm
- **Color** (naked eye): medium brown, grey
- **Texture** (including sorting): fibrous organic
- **Microstructure** (including development): Spongy, moderately developed
- **Coarse Material** [roundness, size range, abundance (% of total coarse material)]:
  - Single Mineral Grains: quartz – subangular, fine sand 10% of coarse material
  - Compound Mineral Grains and Rock Fragments: n.o.
  - Inorganic Residues of Biological Origin: n.o.
  - Anthropogenic Artifacts: n.o.
  - Organic: roots – organ residue, tissue residues, 90% of coarse material
- **Micromass:** amorphous organic material
- **Pedofeatures:** n.o.
- **Notes:** Forest floor leaf litter.
**micro-Fabric Unit # 2**

- **Relative depth** (from top): 2.5 – 5.0 cm
- **Color** (naked eye): dark brown, grey
- **Texture** (including sorting): well sorted; sand, organics
- **Microstructure** (including development): spongy, moderately developed

**Coarse Material** [roundness, size range, abundance (% of total coarse material)]:
  - Single Mineral Grains: quartz – very fine sand, subangular 29% of coarse material (frequent), Feldspars 1%
  - Compound Mineral Grains and Rock Fragments: n.o.
  - Inorganic Residues of Biological Origin: n.o.
  - Anthropogenic Artifacts: n.o.
  - Organic: organ residues – roots, tissue residues 70%

**Micromass**: amorphous organic material

**Pedofeatures**: n.o.

**Notes**: More sand than in unit 1 with areas where the sand is closely packed in an organic matrix of partially decomposed leaf litter on top of a sand dune.

**Summary**: In CAI-1A I observed the forest floor and organic rich A horizon forming on the surface of reworked beach sand.
Thin Section ID: CAI 8B

Stratigraphic Unit(s): Layer 3a, Excavation Unit 12
Thin Section Size: 7.5 X 5.0 cm
Number of micro-Fabric Units (µFU): 2
Boundaries between µFU: Clear irregular

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Figure A2. CAI 8B Thin Section in PPL and XPL with marking of micro-Fabric Units (µFU) 1 and 2

**Micro-Fabric Unit # 1**

Relative depth (from top): 0.0 – 4.0 cm
Color (naked eye): grey, white, black, medium brown
Texture (including sorting): unsorted, gravelly clay loam
Microstructure (including development): Spongy, moderately developed
Coarse Material [roundness, size range, abundance (% of total coarse material)]:
  - Single Mineral Grains: quartz – fine sand, few; feldspar, very few
  - Compound Mineral Grains and Rock Fragments: granite – several pieces up to ~1cm
Inorganic Residues of Biological Origin: Shell – clam, bone, fish bone (clusters as well as individually), sea urchin spine
Anthropogenic Artifacts: n.o.
Organic: plant material (charcoal?); amorphous organic material
Micromass: amorphous organic material (~40% of surface area), lots of micritic calcite, clump of ash
**Pedofeatures:** n.o.
**Notes:** N.A.

**micro-Fabric Unit # 2**

**Relative depth** (from top): 4.0 – 7.0 cm

**Color** (naked eye): grey, white, black, brown

**Texture** (including sorting): gravelly, sandy loam

**Microstructure** (including development): complex

**Coarse Material** [roundness, size range, abundance (% of total coarse material)]:
- **Single Mineral Grains:** quartz - fine sand, few; feldspar, very few
- **Compound Mineral Grains and Rock Fragments:** granite – several pieces up to ~1 cm
- **Inorganic Residues of Biological Origin:** calcite – many shells and bone – a vertebrae can be seen, sea urchin spine, barnacle
- **Anthropogenic Artifacts:** n.o.
- **Organic:** abundant charcoal – with obvious parenchyma, few plant material

**Micromass:** N.A.

**Pedofeatures:** n.o.

**Notes:** Micritic calcite but some sparry calcite near the shells due to etching (?)

**Summary:** N.A.
Thin Section ID: CAI 8C

Stratigraphic Unit(s): Layer 3a, Excavation Unit 12  
Thin Section Size: 7.5 X 5.0 cm  
Number of micro-Fabric Units (µFU): 3  
Boundaries between µFU: 1-2 = gradual smooth; 2-3 = gradual smooth

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Figure A3. CAI 8C Thin Section in PPL and XPL with marking of micro-Fabric Units (µFU) 1 to 3

**micro-Fabric Unit # 1**

Relative depth (from top): 0.0 – 1.5 cm top left half  
Color (naked eye): Brown, black, grey, white  
Texture (including sorting): unsorted, gravelly sandy loam  
Microstructure (including development): complex (spongy, granular)  
Coarse Material [roundness, size range, abundance (% of total coarse material)]:  
  - Single Mineral Grains: quartz, fine sand, few  
  - Compound Mineral Grains and Rock Fragments: granite  
  - Inorganic Residues of Biological Origin: calcite – shell; bone – many, some are gravel sized; fishbone; sea urchin spine; micritic calcite – crushed shell?  
  - Reprecipitate? Ash? Some is sparry close to etched shells  
  - Anthropogenic Artifacts: n.o.  
  - Organic: charcoal? – very few: tissue residue; amorphous organic  
Micromass: clay, micrite  
Pedofeatures: phosphate nodules

Notes:
- Bone ~ 1cm length, edges rounded  
- Rock – granite 30 div at 50um div – rounded  
- Large open spaces, some areas more compact

**micro-Fabric Unit # 2**

Relative depth (from top): 1.5 – 3.0 cm bottom right half
**Color** (naked eye): Brown, black, grey, white
**Texture** (including sorting): unsorted – gravel to silt
**Microstructure** (including development): complex (intergrain microaggregate, spongy)

**Coarse Material** [roundness, size range, abundance (% of total coarse material)]:
  - Single Mineral Grains: quartz – fine sand, few
  - Compound Mineral Grains and Rock Fragments: granite – gravel sized, very few
  - Inorganic Residues of Biological Origin: bone, fishbone, shell - many

**Anthropogenic Artifacts**:
  - Organic: charcoal? – few, tissue residues, amorphous organic material

**Micromass**: clay, micrite, amorphous organic matter

**Pedofeatures**: n.o.

**Notes**:
- Shell fracture – large piece broken in situ, vertical fractures as well as horizontal
- Clay coating? Or barnacle that has its cavity filled?
- Ash rhombs?

---

**micro-Fabric Unit # 3**

**Relative depth** (from top): 3.0 – 4.5 cm
**Color** (naked eye): Brown, black, grey, white
**Texture** (including sorting): gravelly sandy loam
**Microstructure** (including development): complex (intergrain microaggregate, granular, spongy)

**Coarse Material** [roundness, size range, abundance (% of total coarse material)]:
  - Single Mineral Grains: quartz – fine sand, few
  - Compound Mineral Grains and Rock Fragments: granite – gravel sized, very few
  - Inorganic Residues of Biological Origin: bone, fishbone, shell - many

**Anthropogenic Artifacts**: n.o.

**Micromass**: clay, micrite, amorphous organic matter

**Pedofeatures**: n.o.

**Notes**: N.A.

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**Summary**: N.A.
Thin Section ID: CAI 21B

Stratigraphic Unit(s): Layer 0 & 1, Excavation Unit 12
Thin Section Size: 7.5 X 5.0 cm
Number of micro-Fabric Units (µFU): 2
Boundaries between µFU: Clear smooth

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<td><img src="image2.png" alt="XPL Scan" /></td>
</tr>
</tbody>
</table>

Figure A4. CAI 21B Thin Section in PPL and XPL with marking of micro-Fabric Units (µFU) 1 and 2

**micro-Fabric Unit # 1**

Relative depth (from top): 0.0 – 3.0 cm
Color (naked eye): black, brown, grey
Texture (including sorting): fine organic
Microstructure (including development): Complex (granular, crumb)
Coarse Material [roundness, size range, abundance (% of total coarse material)]:
- Single Mineral Grains: quartz – very few
- Compound Mineral Grains and Rock Fragments: n.o.
- Inorganic Residues of Biological Origin: n.o.
- Anthropogenic Artifacts: n.o.
- Organic: amorphous organic material, plant tissue – rootlets ~ 1.5 cm length
Micromass: opaque amorphous organic matter
Pedofeatures: N.A.
Notes: N.A.
micro-Fabric Unit # 2

Relative depth (from top): 3.0 – 7.0 cm
Color (naked eye): black, brown, grey
Texture (including sorting):
Porosity (including accommodation): more closely packed than µUF 1
Microstructure (including development): Spongy

Coarse Material [roundness, size range, abundance (% of total coarse material)]:
  Single Mineral Grains: quartz
  Compound Mineral Grains and Rock Fragments: n.o.
  Inorganic Residues of Biological Origin: n.o.
  Anthropogenic Artifacts: n.o.
  Organic: plant tissues, roots ~ 2 cm length

Micromass: amorphous organic material
Pedofeatures: N.A.
Notes: N.A.

Summary: N.A.
Thin Section ID: CAI 22A

Stratigraphic Unit(s): Mid Layer 1, Excavation Unit 12
Thin Section Size: 7.5 X 5.0 cm
Number of micro-Fabric Units (µFU): 1
Boundaries between µFU: n/a

<table>
<thead>
<tr>
<th>Plane Polarized Light (PPL) Scan</th>
<th>Cross-Polarized Light (XPL) Scan</th>
</tr>
</thead>
</table>

Figure A5. CAI 22A Thin Section in PPL and XPL. Only one micro-Fabric Unit (µFU) has been observed in this thin section.

micro-Fabric Unit # 1

Relative depth (from top): 0.0 to 7.0 cm
Color (naked eye): dark brown to black
Texture (including sorting): unsorted
Porosity (including accommodation): 
Microstructure (including development): spongy

Coarse Material [roundness, size range, abundance (% of total coarse material)]:
- Single Mineral Grains: quartz, feldspar – size 15 div at 50um/div, abundance <1%
- Compound Mineral Grains and Rock Fragments: n.o.
- Inorganic Residues of Biological Origin: n.o.
- Anthropogenic Artifacts: n.o.
- Organic: plant tissue, amorphous organic, root, parenchyma (most likely stained)

Micromass: N.A.
Pedofeatures: N.A.
Notes: N.A.

Summary: N.A.
Thin Section ID: CAI 23A

**Stratigraphic Unit(s):** Layer 1 & 2, Excavation Unit 12  
**Thin Section Size:** 7.5 x 5 cm  
**Number of micro-Fabric Units (µFU):** 2  
**Boundaries between µFU:** Diffuse broken

<table>
<thead>
<tr>
<th>Plane Polarized Light (PPL) Scan</th>
<th>Cross-Polarized Light (XPL) Scan</th>
</tr>
</thead>
<tbody>
<tr>
<td>µFU 1</td>
<td>µFU 2</td>
</tr>
</tbody>
</table>

Figure A6. CAI 23A Thin Section in PPL and XPL with marking of micro-Fabric Units (µFU) 1 to 2

**micro-Fabric Unit # 1**

**Relative depth** (from top): 0.0 to 6.0 cm  
**Color** (naked eye): dark brown to black  
**Texture** (including sorting): unsorted, fibrous organic  
**Microstructure** (including development): complex (platy)  
**Coarse Material** [roundness, size range, abundance (% of total coarse material)]:  
  - Single Mineral Grains: n.o.  
  - Compound Mineral Grains and Rock Fragments: n.o.  
  - Inorganic Residues of Biological Origin: n.o.  
  - Anthropogenic Artifacts: n.o.  
  - Organic: plant tissue, large ~ 1.5cm in diameter  
**Micromass:** amorphous organic material N.A.  
**Pedofeatures:** N.A.  
**Notes:** Layer 1, Possibly F layer (shrinking due to desiccation of the sample)

**micro-Fabric Unit # 2**

**Relative depth** (from top): 6.0 to 7.0 cm  
**Color** (naked eye): dark brown to black  
**Texture** (including sorting): unsorted, sand
Microstructure (including development): intergrain microaggregate

Coarse Material [roundness, size range, abundance (% of total coarse material)]:
  Single Mineral Grains: quartz, plagioclase of feldspar –, angular to sub-rounded
  Compound Mineral Grains and Rock Fragments: granite, sub-rounded, some is crushed
  Inorganic Residues of Biological Origin: n.o.
  Anthropogenic Artifacts: n.o.
  Organic: roots, rootlets

Micromass: black amorphous organic matter.

Pedofeatures: N.A.

Notes: Layer 2: the mineral grains are clumped together in a matrix of black amorphous organic material

Summary: N.A.
Thin Section ID: CAI 23B

**Stratigraphic Unit(s):** Layer 1 & 2, Excavation Unit 12
**Thin Section Size:** 7.5 X 5.0 cm
**Number of micro-Fabric Units (µFU):** 4
**Boundaries between µFU:** 1 & 2 – clear wavy; 2 & 3 – diffuse irregular; 3 & 4 – diffuse irregular

<table>
<thead>
<tr>
<th>Plane Polarized Light (PPL) Scan</th>
<th>Cross-Polarized Light (XPL) Scan</th>
</tr>
</thead>
<tbody>
<tr>
<td>µFU 1</td>
<td></td>
</tr>
<tr>
<td>µFU 2</td>
<td></td>
</tr>
<tr>
<td>µFU 3</td>
<td></td>
</tr>
<tr>
<td>µFU 4</td>
<td></td>
</tr>
</tbody>
</table>

Figure A7. CAI 23B Thin Section in PPL and XPL with marking of micro-Fabric Units (µFU) 1 to 4

**micro-Fabric Unit # 1**

**Relative depth** (from top): 0.0 – 1.3 cm
**Color** (naked eye): black
**Texture** (including sorting): unsorted, sandy clay
**Microstructure:** complex (spongy, crumb, granular)
**Coarse Material** [roundness, size range, abundance (% of total coarse material)]:
- Single Mineral Grains: quartz – rounded and sub-rounded
- Compound Mineral Grains and Rock Fragments: granite
- Inorganic Residues of Biological Origin: n.o.
- Anthropogenic Artifacts: n.o.
- **Organic:** plant tissue, spherical opaque droplets, large root ~cm in diameter
**Micromass:** amorphous organic material
**Pedofeatures:** n.o.
**Notes:** (Layer 1) 30% grains and granite, 70% organic material

**micro-Fabric Unit # 2**

**Relative depth** (from top): 1.3 – 3.0 cm
**Color** (naked eye): dark gray
**Texture** (including sorting): gavelly sand, unsorted
**Microstructure**: complex (spongy, intergrain microaggregate, crumb)

**Coarse Material** [roundness, size range, abundance (% of total coarse material)]:
- **Single Mineral Grains**: quartz – at lot >75% sub-angular to sub-rounded,
- **Compound Mineral Grains and Rock Fragments**: granite piece ~1cm diameter, sub-angular, 2 smaller pieces ~0.5cm
- **Inorganic Residues of Biological Origin**: n.o.
- **Anthropogenic Artifacts**: n.o.
- **Organic**: plant tissue, organs (rootlets)

**Micromass**: amorphous organic

**Pedofeatures**: n.o.

**Notes**: 30% organic, 70% mineral for coarse material

---

**micro-Fabric Unit # 3**

**Relative depth** (from top): 3.0 – 5.6 cm

**Color** (naked eye): speckled black

**Texture** (including sorting): Loamy sand

**Porosity** (including accommodation):

**Microstructure**: complex (vesicular, crack, blocky, crumb)

**Coarse Material** [roundness, size range, abundance (% of total coarse material)]:
- **Single Mineral Grains**: quartz – fine to med sand size, lots of it, angular, sub-angular, sub-rounded
- **Compound Mineral Grains and Rock Fragments**: granite – small pieces –sub-rounded;
- **Inorganic Residues of Biological Origin**: n.o.
- **Anthropogenic Artifacts**: n.o.
- **Organic**: plant tissue, roots,

**Micromass**: amorphous organic material

**Pedofeatures**: n.o.

**Notes**: 60% is organic, 40% mineral

---

**micro-Fabric Unit # 4**

**Relative depth** (from top): 5.6 – 6.7 cm

**Color** (naked eye): light gray, brown

**Texture** (including sorting): gravel

**Microstructure**: complex (bridged grain, intergrain microaggregate)

**Coarse Material** [roundness, size range, abundance (% of total coarse material)]:
- **Single Mineral Grains**: quartz, plagioclase – lots, sub-angular
- **Compound Mineral Grains and Rock Fragments**: granite (degraded?) sub-angular;
- **Inorganic Residues of Biological Origin**: n.o.
- **Anthropogenic Artifacts**: n.o.
- **Organic**: plant tissue, charcoal

**Micromass**: amorphous organic material

**Pedofeatures**: n.o.

**Notes**: 30% organic, 70% mineral

---

**Summary**: Layer 2 is actually a laminated/layered deposit
Thin Section ID: CAI 24B

Stratigraphic Unit(s): Boundary Layer 2 & 3a, Excavation Unit 12
Thin Section Size: 7.5 X 5.0 cm
Number of micro-Fabric Units (µFU): 2
Boundaries between µFU: clear, irregular – largely visible in XPL only

<table>
<thead>
<tr>
<th>µFU</th>
<th>Plane Polarized Light (PPL) Scan</th>
<th>Cross-Polarized Light (XPL) Scan</th>
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<tr>
<td>1</td>
<td><img src="image1.png" alt="Image" /></td>
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<td>2</td>
<td><img src="image3.png" alt="Image" /></td>
<td><img src="image4.png" alt="Image" /></td>
</tr>
</tbody>
</table>

Figure A8. CAI 24B Thin Section in PPL and XPL with marking of micro-Fabric Units (µFU) 1 and 2

micro-Fabric Unit # 1

Relative depth (from top): 0.0 – 2.0/5.5 cm
Color (naked eye): brownish black, speckled
Texture (including sorting): sandy clay loam
Microstructure (including development): spongy
Coarse Material [roundness, size range, abundance (% of total coarse material)]:
- Single Mineral Grains: quartz – sub-angular 35%
- Compound Mineral Grains and Rock Fragments: granite, unknown rock 5%
- Inorganic Residues of Biological Origin: bone and/or phosphatized barnacle?
- Anthropogenic Artifacts: n.o.
- Organic: charcoal, plant organs and tissues, loosely packed – 60%
Micromass: amorphous organic,
Pedofeatures: phosphatized shell?
Notes: µFU 1 (bottom of Layer 2) has essentially no shells

micro-Fabric Unit # 2

Relative depth (from top): 2.0/5.5 – 7.0 cm
Color (naked eye): brownish black, speckled
Texture (including sorting): Gravelly loamy sand
Microstructure (including development): vughy

Coarse Material [roundness, size range, abundance (% of total coarse material)]:
   Single Mineral Grains: quartz, plagioclase – sub-angular
   Compound Mineral Grains and Rock Fragments: granite
   Inorganic Residues of Biological Origin: angular gravel and sand size bivalve, sea urchin and barnacle shell fragments – very degraded (exfoliated, etched, phosphatized, calcined), fish bone.
   Anthropogenic Artifacts: n.o.
   Organic: plant tissue

Micromass: micrite, clay, amorphous organic material

Pedofeatures: dissolving shells

Notes: µFU 2 (top of Layer 3a) is characterized by the presence of shells.

Summary: µFU 1 has essentially no shells, while µFU 2 is characterized by the presence of shells.
Thin Section ID: CAI 25B

Stratigraphic Unit(s): Bottom of layer 3a, Excavation Unit 12
Thin Section Size: 7.5 X 5.0 cm
Number of micro-Fabric Units (µFU): 2
Boundaries between µFU: Clear wavy

<table>
<thead>
<tr>
<th>µFU</th>
<th>Plane Polarized Light (PPL) Scan</th>
<th>Cross-Polarized Light (XPL) Scan</th>
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<tbody>
<tr>
<td>1</td>
<td><img src="image1.png" alt="PPL Scan" /></td>
<td><img src="image2.png" alt="XPL Scan" /></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure A9. CAI 25B Thin Section in PPL and XPL with marking of micro-Fabric Units (µFU) 1 and 2

**Micro-Fabric Unit # 1**

Relative depth (from top): 0.0 – 3.0 cm
Color (naked eye): Yellowish black, brown, white
Texture (including sorting): Gravelly, sandy loam
Microstructure (including development): Spongy
Coarse Material [roundness, size range, abundance (% of total coarse material)]:
- Single Mineral Grains: quartz, plagioclase
- Compound Mineral Grains and Rock Fragments: granite piece 2.3cm length, some smaller pieces approx. 2-3mm, diorite
- Inorganic Residues of Biological Origin: shell – broken in situ, sub angular, crushed shell, etched shell, barnacle, sea urchin, bone
- Anthropogenic Artifacts: n.o.
- Organic: organic tissue (charred, humified)
Micromass: amorphous organic matter, clay, micrite
Pedofeatures: phosphate nodules
Notes: the shell fragments appear slightly parallel to the surface

**Micro-Fabric Unit # 2**

Relative depth (from top): 3.0 – 7.0 cm
Color (naked eye): Yellowish black, brown, white
Texture (including sorting): poorly sorted Gravely, sandy loam.
Microstructure (including development): complex (spongy, platy, vughy)
Coarse Material [roundness, size range, abundance (% of total coarse material)]:
  Single Mineral Grains: quartz, plagioclase
  Compound Mineral Grains and Rock Fragments: Granite 2cm x 1.2cm – appears burnt, smaller pieces of granite
  Inorganic Residues of Biological Origin: Shell, barnacle, sea urchin spine, fish bone, mussel shell, bone – one area where it appears crushed or broken in situ
  Anthropogenic Artifacts: n.o.
  Organic: plant tissue, charcoal,
Micromass: amorphous organic matter, clay, micrite
Pedofeatures: slight phosphatization of the micromass and phosphate nodules
Notes: Unknown burnt something – appears green in PPL and bluey/green/gold in XPL; Phosphatized barnacle; Shell appears etched in some places – sparry; some shell appears pink in PPL.

Summary: N.A.
**Thin Section ID: CAI 25D**

**Stratigraphic Unit(s):** Layer 3a (bottom), 3b, 3c (top), Excavation Unit 12  
**Thin Section Size:** 7.5 X 5.0 cm  
**Number of micro-Fabric Units (µFU):** 3  
**Boundaries between µFU:** 1-2 = Clear wavy; 2-3 = Clear smooth.

<table>
<thead>
<tr>
<th>Plane Polarized Light (PPL) Scan</th>
<th>Cross-Polarized Light (XPL) Scan</th>
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<tr>
<td>µFU 1</td>
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</tr>
<tr>
<td>3</td>
<td><img src="image3" alt="PPL Scan" /></td>
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</tbody>
</table>

Figure A10. CAI 25D Thin Section in PPL and XPL with marking of micro-Fabric Units (µFU) 1 to 3

**Micro-Fabric Unit # 1**

- **Relative depth** (from top): 0.0 - 1.7/2.2 cm  
- **Color** (naked eye): Black, brown, white, grey  
- **Texture** (including sorting): Gravelly loamy sand  
- **Microstructure** (including development): spongy  
- **Coarse Material** [roundness, size range, abundance (% of total coarse material)]:  
  - Single Mineral Grains: quartz, plagioclase 25% of coarse material  
  - Compound Mineral Grains and Rock Fragments: granite  
  - Inorganic Residues of Biological Origin: Shell (75% of coarse material), sea urchin spine; bone?  
  - Anthropogenic Artifacts: n.o.  
  - Organic: charcoal (largest piece ~ 15mm), roots  
- **Micromass:** amorphous organic matter, micrite, clay  
- **Pedofeatures:** phosphatized shells  
- **Notes:** Shell – clam, fragments, some shells broken in situ, angular, largest 10mm to 2mm; Calcite – some micritic and others are larger crystals (sparry?)(crushed shell?), also some are browner, some are lighter grey/yellow; lighter areas are similar to the sample shell heated to 600 degrees C, the darker are more similar to shell heated to 500 degrees C; Phosphatized barnacle or shell – organics decomposing will be phosphatized – apatite; Otoliths?
micro-Fabric Unit # 2

Relative depth (from top): 1.7/2.2 – 6.0 cm
Color (naked eye): Brownish black, white/grey
Texture (including sorting): Gravelly sandy loam
Microstructure (including development): Complex (platy, spongy)

Coarse Material [roundness, size range, abundance (% of total coarse material)]:
  Single Mineral Grains: quartz (subangular), plagioclase
  Compound Mineral Grains and Rock Fragments: granite (fractured)
  Inorganic Residues of Biological Origin: shell (exfoliated and phosphatized), fishbone
  Anthropogenic Artifacts: n.o.
  Organic: charcoal, plant tissues and organs (roots).

Micromass: black amorphous organic material
Pedofeatures: shell phosphatization and phosphate nodules (coprolite?)
Notes: This is Layer 3b. This layer looks like what is expected when acid and phosphate rich solution has phosphatized the sediment.

micro-Fabric Unit # 3

Relative depth (from top): 6.0 – 7.1 cm
Color (naked eye): Brownish black, white, gray
Texture (including sorting): gravelly sandy loam
Microstructure (including development): complex

Coarse Material [roundness, size range, abundance (% of total coarse material)]:
  Single Mineral Grains: quartz, plagioclase – subangular, more abundant in this unit than unit 2
  Compound Mineral Grains and Rock Fragments: granite
  Inorganic Residues of Biological Origin: shell (phosphatized, heated, etched) sea urchin spine, bone
  Anthropogenic Artifacts: n.o.
  Organic: charcoal, plant tissue, roots,

Micromass: amorphous organic, clay, micrite
Pedofeatures: phosphatization
Notes: Top of Layer 3c

Summary: N.A.
Thin Section ID: CAI 25E

**Stratigraphic Unit(s):** Layer 3c, Excavation Unit 12  
**Thin Section Size:** 7.5 x 5.0 cm  
**Number of micro-Fabric Units (µFU):** 4  
**Boundaries between µFU:** 1 to 2 clear irregular; 1 to 3 diffuse broken; 2 to 3 diffuse broken; 2 to 4 clear smooth; 3 to 4 clear wavy.

<table>
<thead>
<tr>
<th>Plane Polarized Light (PPL) Scan</th>
<th>Cross-Polarized Light (XPL) Scan</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1.png" alt="PPL Scan" /></td>
<td><img src="image2.png" alt="XPL Scan" /></td>
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</tbody>
</table>

Figure A11. CAI 25E Thin Section in PPL and XPL with marking of micro-Fabric Units (µFU) 1 to 4

**micro-Fabric Unit # 1**

Relative depth (from top): 0.0 – 2.0 cm  
**Color** (naked eye): grayish black  
**Texture** (including sorting): sandy loam  
**Microstructure** (including development): chambers  
**Coarse Material** [roundness, size range, abundance (% of total coarse material)]:  
- Single Mineral Grains: quartz, plagioclase, subangular – most abundant portion of the inorganic coarse material 70%  
- Compound Mineral Grains and Rock Fragments: granite  
- Inorganic Residues of Biological Origin: shell, sea urchin spine (rare).  
- Anthropogenic Artifacts: n.o.  
- Organic: charcoal, plant tissue (charred humified)  
**Micromass:** amorphous organic material, micrite, clay  
**Pedofeatures:** phosphate nodules  
**Notes:** 30% inorganic: 70% inorganic coarse material; Shell appears to be micritic, degraded calcite; some areas of crushed calcite, mixed with organic matter and quartz; spicules – acid etched; larger pieces have rounded edges.

**micro-Fabric Unit # 2**

Relative depth (from top): 0.0 – 2.0 cm
Color (naked eye): light brown (tan)
Texture (including sorting): gravelly sandy clay
Microstructure (including development): massive
Coarse Material [roundness, size range, abundance (% of total coarse material)]:
  Single Mineral Grains: quartz, plagioclase
  Compound Mineral Grains and Rock Fragments: granite, rhyolite(?)
  Inorganic Residues of Biological Origin: sea urchin spines, shell, barnacle, bone?
  Anthropogenic Artifacts: n.o.
  Organic: amorphous organic matter, plant tissue
Micromass: micrite
Pedofeatures: n.o.
Notes: wood ash rhombs?

micro-Fabric Unit # 3
Relative depth (from top): 2.0 - 4.6 cm
Color (naked eye): black, brown, yellow, grey
Texture (including sorting): gravelly loamy sand
Microstructure (including development): complex (channel, vughy)
Coarse Material [roundness, size range, abundance (% of total coarse material)]:
  Single Mineral Grains: quartz, calcite
  Compound Mineral Grains and Rock Fragments: granite, siltstone, diorite(?)
  Inorganic Residues of Biological Origin: shell, sea urchin spine.
  Anthropogenic Artifacts: n.o.
  Organic: charcoal
Micromass: micrite, clay, amorphous organic matter
Pedofeatures: n.o.
Notes: 65% inorganic : 35% organic coarse material; Shell degraded, some is angular, most is subangular and cracked in place.

micro-Fabric Unit # 4
Relative depth (from top): 2.1 – 4.6 cm
Color (naked eye): black, grey, yellow
Texture (including sorting): gravelly silty sandy loam
Microstructure (including development): channel
Coarse Material [roundness, size range, abundance (% of total coarse material)]:
  Single Mineral Grains: quartz, calcite
  Compound Mineral Grains and Rock Fragments: granite
  Inorganic Residues of Biological Origin: shell, sea urchin spine, bone, barnacle
  Anthropogenic Artifacts: n.o.
  Organic: charcoal,
Micromass: amorphous organic material, micrite
Pedofeatures: n.o.
Notes: 60% inorganic: 40% organic coarse material; shell – degraded, subangular to angular, some crushed areas; region of quartz grains closer together with amorphous organic material in between but not tightly packed.
**Thin Section ID:** CAI 26A  
**Stratigraphic Unit(s):** Boundary Layer 3b-3c, Excavation Unit 12  
**Thin Section Size:** 7.5 x 5.0 cm  
**Number of micro-Fabric Units (µFU):** 3  
**Boundaries between µFU:** 1 to 2 clear wavy; 2 to 3 diffuse broken

<table>
<thead>
<tr>
<th>µFU</th>
<th>Plane Polarized Light (PPL) Scan</th>
<th>Cross-Polarized Light (XPL) Scan</th>
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<tbody>
<tr>
<td>1</td>
<td><img src="image1" alt="PPL Scan of µFU 1" /></td>
<td><img src="image2" alt="XPL Scan of µFU 1" /></td>
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<td>2</td>
<td><img src="image3" alt="PPL Scan of µFU 2" /></td>
<td><img src="image4" alt="XPL Scan of µFU 2" /></td>
</tr>
</tbody>
</table>

Figure A12. CAI 26A Thin Section in PPL and XPL with marking of micro-Fabric Units (µFU) 1 to 3.

**micro-Fabric Unit # 1**

**Relative depth** (from top): 0.0 – 1.0 cm  
**Color** (naked eye): brown, black  
**Texture** (including sorting): sandy clay  
**Microstructure** (including development): vughy  
**Coarse Material** [roundness, size range, abundance (% of total coarse material)]:  
- Single Mineral Grains: quartz  
- Compound Mineral Grains and Rock Fragments: granite  
- Inorganic Residues of Biological Origin: shell (phosphatized and heated)  
- Anthropogenic Artifacts: n.o.  
- Organic: decayed charcoal, plant tissue  
**Micromass:** amorphous organic material  
**Pedofeatures:** n.o.  
**Notes:** N.A.
micro-Fabric Unit # 2

Relative depth (from top): 1.0 – 2.9 cm  
Color (naked eye): brownish black, grey, white  
Texture (including sorting):  
Microstructure (including development):  
Coarse Material [roundness, size range, abundance (% of total coarse material)]:  
  Single Mineral Grains: quartz, k-feldspars  
  Compound Mineral Grains and Rock Fragments: granite  
  Inorganic Residues of Biological Origin: shell, sea urchin spine, barnacle (all heated, some etched)  
  Anthropogenic Artifacts: n.o.  
  Organic: charcoal, plant tissue  
Micromass: black amorphous organic material, micrite  
Pedofeatures: n.o.  
Notes: calcite also appears to have be re-precipitated on the edge of shells, the shells appear serrated; sea urchin spine – degraded – large space between centre and edge, the edge appears to have the holes filled with clay, area where the sea urchin spine appears to have be re-precipitated;

micro-Fabric Unit # 3

Relative depth (from top): 2.9 - 6.6 cm  
Color (naked eye): yellowish gray, dark gray  
Texture (including sorting): gravelly sandy silty clay  
Microstructure (including development): chamber  
Coarse Material [roundness, size range, abundance (% of total coarse material)]:  
  Single Mineral Grains: quartz, calcite, k-feldspar  
  Compound Mineral Grains and Rock Fragments: granite – crushed or broken, some possibly burnt  
  Inorganic Residues of Biological Origin: shell, bone, sea urchin spine, barnacle  
  Anthropogenic Artifacts: n.o.  
  Organic: charcoal  
Micromass: micrite, black amorphous organic matter  
Pedofeatures: oxide staining and nodules  
Notes: Majority is micritic calcite – probably a combination of shell and ashed wood; ash rhombs present; no orientation of any particles in an organized manner; burnt shell that has re-precipitated as spiritic calcite – still in shape of the shell or the urchin spine; burning and then a period of time when saturated with water.

Summary: N.A.
Thin Section ID: CAI 28A

**Stratigraphic Unit(s): Boundary** Layer 3d to 3e, Excavation Unit 12
**Thin Section Size:** 7.5 X 5.0 cm
**Number of micro-Fabric Units (µFU):** 2
**Boundaries between µFU:** Clear smooth

<table>
<thead>
<tr>
<th>Plane Polarized Light (PPL) Scan</th>
<th>Cross-Polarized Light (XPL) Scan</th>
</tr>
</thead>
</table>

Figure A14. CAI 28A Thin Section in PPL and XPL with marking of micro-Fabric Units (µFU) 1 and 2

**micro-Fabric Unit # 1**

- **Relative depth** (from top): 0.0 – 3.4 cm
- **Color** (naked eye): black, grey, brown, orange, white
- **Texture** (including sorting): gravelly sandy clay
- **Microstructure** (including development): chambers
- **Coarse Material** [roundness, size range, abundance (% of total coarse material)]:
  - Single Mineral Grains: quartz, calcite (altered)
  - Compound Mineral Grains and Rock Fragments: granite, exotic
  - Inorganic Residues of Biological Origin: sea urchin spine, shell – subangular to subrounded, bone, barnacle, fish bone
  - Anthropogenic Artifacts: n.o.
  - Organic: plant tissue, charcoal
- **Micromass**: amorphous organic material, micritic calcite
- **Pedofeatures**: coprolite
- **Notes**: Bone appears heated or digested?; shell – etching, crushed, re-precipitated calcite on shell edges?; ash? appear to rhombs present; second piece of silicate that has columnar crystals.
micro-Fabric Unit # 2

Relative depth (from top): 3.4 – 6.5 cm
Color (naked eye): black, brown, grey, white
Texture (including sorting): gravel
Microstructure (including development): channels

Coarse Material [roundness, size range, abundance (% of total coarse material)]:
  - Single Mineral Grains: quartz, calcite (altered shell)
  - Compound Mineral Grains and Rock Fragments: granite
  - Inorganic Residues of Biological Origin: shell (some broken in situ, angular, subangular, etched, heated); barnacle, sea urchin spine, bone
  - Anthropogenic Artifacts: n.o.
  - Organic: charcoal (well preserved and degraded)

Micromass: amorphous organic material,
Pedofeatures: n.o.
Notes: there appears to be a mostly horizontal layer of shell dividing the two units on the slide; this unit appears to have relatively more shell than the upper unit; concentration of black organic (charcoal?) and others with largely ash.

Summary: N.A.
Thin Section ID: CAI 28B

**Stratigraphic Unit(s):** Boundary layers 3d - 3e, Excavation Unit 12  
**Thin Section Size:** 7.5 X 5.0 cm  
**Number of micro-Fabric Units (µFU):** 2  
**Boundaries between µFU:** clear wavy

<table>
<thead>
<tr>
<th>Plane Polarized Light (PPL) Scan</th>
<th>Cross-Polarized Light (XPL) Scan</th>
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<tbody>
<tr>
<td>µFU 1</td>
<td>µFU 2</td>
</tr>
</tbody>
</table>

![Figure A15. CAI 28B Thin Section in PPL and XPL with marking of micro-Fabric Units (µFU) 1 and 2](image)

**micro-Fabric Unit # 1**

- **Relative depth** (from top): 0.0 – 2.8 cm  
- **Color** (naked eye): black, brown, grey, white  
- **Texture** (including sorting):  
- **Porosity** (including accommodation):  
- **Microstructure** (including development):  
- **Coarse Material** [roundness, size range, abundance (% of total coarse material)]:  
  - Single Mineral Grains: quartz, feldspars  
  - Compound Mineral Grains and Rock Fragments: granite  
  - Inorganic Residues of Biological Origin: shell, bone, sea urchin spine  
  - Anthropogenic Artifacts: n.o.  
  - Organic: charcoal, rootlets  
- **Micromass:** black amorphous organic material, micrite, clay  
- **Pedofeatures:** phosphate nodules  
- **Notes:**

**micro-Fabric Unit # 2**
**Relative depth** (from top): 2.8 – 6.4 cm

**Color** (naked eye): black, brown, yellow/orange, white, grey

**Texture** (including sorting): gravelly silt loam

**Microstructure** (including development): chambers

**Coarse Material** [roundness, size range, abundance (% of total coarse material)]:
- Single Mineral Grains: quartz, feldspars
- Compound Mineral Grains and Rock Fragments: n.o.
- Inorganic Residues of Biological Origin: shell (one large one that spans ~5cm across the entire slide, broken in place, exfoliated); barnacle, sea urchin spine, bone (charred)
- Anthropogenic Artifacts: n.o.
- Organic: charcoal,

**Micromass**: amorphous organic material, micrite, clay

**Pedofeatures**:

**Notes**: etched shells; radial calcite filling cracks; fish bone – there may be one; some shells appear to be breaking down in “crumbs” and others appear to be etching and exfoliating into filaments.

**Summary**: N.A.
Thin Section ID: CAI 28C

Stratigraphic Unit(s): Layer 3e, Excavation Unit 12
Thin Section Size: 7.5 X 5.0 cm
Number of micro-Fabric Units (µFU): 3
Boundaries between µFU: 1 - 2 clear wavy; 2-3 gradual wavy

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<tr>
<th>µFU</th>
<th>Plane Polarized Light (PPL) Scan</th>
<th>Cross-Polarized Light (XPL) Scan</th>
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<td><img src="image1.png" alt="PPL Scan" /></td>
<td><img src="image2.png" alt="XPL Scan" /></td>
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<tr>
<td>3</td>
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</tbody>
</table>

Figure A16. CAI 28C Thin Section in PPL and XPL with marking of micro-Fabric Units (µFU) 1 to 3

micro-Fabric Unit # 1

Relative depth (from top): 0.0 – 2.4 cm
Color (naked eye): black, grey, brown, white
Texture (including sorting): gravelly sandy loam
Microstructure (including development): complex
Coarse Material [roundness, size range, abundance (% of total coarse material)]:
  - Single Mineral Grains: quartz, feldspars, calcite
  - Compound Mineral Grains and Rock Fragments: granite, schist
  - Inorganic Residues of Biological Origin: shell, sea urchin spine, barnacle
  - Anthropogenic Artifacts: n.o.
  - Organic: charcoal
Micromass: amorphous organic material, micrite, clay
Pedofeatures: n.o.
Notes: Microsparitic, needle fibre calcite; shell pieces range from ~1.5cm to 1mm fragments; staining around some of degrading shell; some of the shell is “bending” versus breaking.

micro-Fabric Unit # 2

Relative depth (from top): 2.4 – 5.2 cm
Color (naked eye): whitish gray
**Texture** (including sorting): gravel

**Microstructure** (including development): platy

**Coarse Material** [roundness, size range, abundance (% of total coarse material)]:
- Single Mineral Grains: quartz, calcite
- Compound Mineral Grains and Rock Fragments: granite – heated?
- Inorganic Residues of Biological Origin: shell (fresh, heated, etched, dissolving, stained)
- Anthropogenic Artifacts: n.o.
- Organic: charcoal ~ 1cm in size

**Micromass**: micritic calcite, amorphous organic material, clay

**Pedofeatures**:

**Notes**: shell fragments are very large and oriented roughly horizontal; shells exfoliating and reprecipitating in the same place; some recrystallization of the shells.

**micro-Fabric Unit # 3**

**Relative depth** (from top): 5.2 – 6.7 cm

**Color** (naked eye): black, grey, brown, white

**Texture** (including sorting): gravelly sandy loam

**Microstructure** (including development): complex

**Coarse Material** [roundness, size range, abundance (% of total coarse material)]:
- Single Mineral Grains: quartz, feldspars, calcite
- Compound Mineral Grains and Rock Fragments: granite
- Inorganic Residues of Biological Origin: shell, sea urchin spine, barnacle
- Anthropogenic Artifacts: n.o.
- Organic: charcoal

**Micromass**: amorphous organic material, micrite, clay

**Pedofeatures**: n.o.

**Notes**: N.A.

**Summary**: N.A.
**Thin Section ID: CAI 29A**

**Stratigraphic Unit(s):** Layers 3g - 3h, Excavation Unit 12  
**Thin Section Size:** 7.5 X 5.0 cm  
**Number of micro-Fabric Units (µFU):** 2  
**Boundaries between µFU:** diffuse smooth  

<table>
<thead>
<tr>
<th>µFU</th>
<th>Plane Polarized Light (PPL) Scan</th>
<th>Cross-Polarized Light (XPL) Scan</th>
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<td><img src="image3.jpg" alt="Image 3" /></td>
<td><img src="image4.jpg" alt="Image 4" /></td>
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</tbody>
</table>

Figure A18. CAI 29A Thin Section in PPL and XPL with marking of micro-Fabric Units (µFU) 1 and 2

**micro-Fabric Unit # 1**

*Relative depth* (from top): 0.0 to 1.0 cm  
*Color* (naked eye): black  
*Texture* (including sorting): sandy loam  
*Microstructure* (including development): complex  
*Coarse Material* [roundness, size range, abundance (% of total coarse material)]:  
  - Single Mineral Grains: quartz, feldspars, calcite  
  - Compound Mineral Grains and Rock Fragments: n.o.  
  - Inorganic Residues of Biological Origin: shell (fresh, heated, dissolving), barnacle (heated)  
  - Anthropogenic Artifacts: n.o.  
  - Organic: charcoal  
*Micromass:* amorphous organic material, micrite, clay  
*Pedofeatures:* n.o.  
*Notes:* N.A.

**micro-Fabric Unit # 2**

*Relative depth* (from top): 1.0 to 7.0 cm  
*Color* (naked eye): grey
Texture (including sorting): gravelly sandy loam

Microstructure (including development): complex (channels, platy, chambers)

Coarse Material [roundness, size range, abundance (% of total coarse material)]:
  Single Mineral Grains: quartz, feldspars, calcite
  Compound Mineral Grains and Rock Fragments: granite
  Inorganic Residues of Biological Origin: shell, sea urchin spine, bone, barnacle
  Anthropogenic Artifacts: n.o.
  Organic: charcoal

Micromass: amorphous organic material, micrite, clay

Pedofeatures: n.o.

Notes: Micritic calcite mixed with organic material; shell appears to be heated; some of the bone doesn't appear to be heated, some appears digested; much less sea urchin than in most of the previous slides – 28D is the exception with no sea urchin spines; there appears to be small accumulations of ash mixed in.

Summary: N.A.
Thin Section ID: CAI 29B

Stratigraphic Unit(s): Layer 3h, Excavation Unit 12  
Thin Section Size: 7.5 X 5.0 cm  
Number of micro-Fabric Units (µFU): 1  
Boundaries between µFU: N.A.

<table>
<thead>
<tr>
<th>Plane Polarized Light (PPL) Scan</th>
<th>Cross-Polarized Light (XPL) Scan</th>
</tr>
</thead>
<tbody>
<tr>
<td>µFU 1</td>
<td>µFU 1</td>
</tr>
</tbody>
</table>

Figure A19. CAI 29B Thin Section in PPL and XPL with marking of micro-Fabric Units (µFU) 1 and 2

micro-Fabric Unit # 1

Relative depth (from top): 0.0 to 7.0 cm  
Color (naked eye): grey  
Texture (including sorting): gravelly sandy loamy  
Microstructure (including development): complex (channels, platy)  
Coarse Material [roundness, size range, abundance (% of total coarse material)]:  
  Single Mineral Grains: quartz, feldspars, calcite  
  Compound Mineral Grains and Rock Fragments: granite  
Inorganic Residues of Biological Origin: shell, sea urchin spine, bone, barnacle  
Anthropogenic Artifacts: n.o.  
Organic: charcoal  
Micromass: amorphous organic material, micrite, clay  
Pedofeatures: n.o.  
Notes: The very top ~ 0.5cm has less shell, less sparry calcite, possible ash; can see a very degraded sea urchin spine.

Summary: N.A.
Thin Section ID: CAI 29C

Stratigraphic Unit(s): Layer 3 bottom layer, Excavation Unit 12
Thin Section Size: 7.5 X 5.0 cm
Number of micro-Fabric Units (µFU): 2
Boundaries between µFU: diffuse broken

<table>
<thead>
<tr>
<th>Plane Polarized Light (PPL) Scan</th>
<th>Cross-Polarized Light (XPL) Scan</th>
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<tr>
<td>µFU 1</td>
<td>µFU 2</td>
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</tbody>
</table>

Figure A20. CAI 29C Thin Section in PPL and XPL with marking of micro-Fabric Units (µFU) 1 to 3.

**micro-Fabric Unit # 1**

Relative depth (from top): 0.0 – 5.2 cm
Color (naked eye): grey
Texture (including sorting): gravelly sandy loamy
Microstructure (including development): complex (channels, platy)
Coarse Material [roundness, size range, abundance (% of total coarse material)]:
  - Single Mineral Grains: quartz, feldspars, calcite
  - Compound Mineral Grains and Rock Fragments: granite, sandstone
  - Inorganic Residues of Biological Origin: shell, sea urchin spine, bone, barnacle
  - Anthropogenic Artifacts: n.o.
  - Organic: charcoal
Micromass: amorphous organic material, micrite, clay
Pedofeatures: n.o.
Notes: all the shells appear to be altered by heat. some shell appears etched while others appear to have calcite re-precipitated on the edges; calcite needles can be seen easily.

**micro-Fabric Unit # 2**

Relative depth (from top): 5.2 – 7.0 cm
Color (naked eye): black
Texture (including sorting): sandy clay
Microstructure (including development): crack
Coarse Material [roundness, size range, abundance (% of total coarse material)]:
   Single Mineral Grains: quartz, calcite
   Compound Mineral Grains and Rock Fragments: granite
   Inorganic Residues of Biological Origin: shell, bone, barnacle
   Anthropogenic Artifacts: n.o.
   Organic: n.o.
Micromass: amorphous organic material,
Pedofeatures: n.o.
Notes: peat-like thin layer. It could be labelled as layer 3i

Summary: N.A.
Thin Section ID: CAI 30B

Stratigraphic Unit(s): Boundary layer 1 and 2a, Excavation Unit 10/15
Thin Section Size: 7.5 X 5.0 cm
Number of micro-Fabric Units (µFU): 2
Boundaries between µFU: clear wavy

<table>
<thead>
<tr>
<th>µFU</th>
<th>Plane Polarized Light (PPL) Scan</th>
<th>Cross-Polarized Light (XPL) Scan</th>
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<td><img src="image3.jpg" alt="PPL Scan 2" /></td>
<td><img src="image4.jpg" alt="XPL Scan 2" /></td>
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</table>

Figure A21. CAI 30B Thin Section in PPL and XPL with marking of micro-Fabric Units (µFU) 1 and 2

**micro-Fabric Unit # 1**

- **Relative depth** (from top): 0.0 - 2.2 cm
- **Color** (naked eye): black
- **Texture** (including sorting): sandy clay
- **Microstructure** (including development): complex
- **Coarse Material** [roundness, size range, abundance (% of total coarse material)]:
  - Single Mineral Grains: quartz
  - Compound Mineral Grains and Rock Fragments: granite
  - Inorganic Residues of Biological Origin: n.o.
  - Anthropogenic Artifacts: n.o.
  - Organic: charcoal
- **Micromass**: amorphous organic material
- **Pedofeatures**: n.o.
- **Notes**: predominantly decomposed organic matter.

**micro-Fabric Unit # 2**

- **Relative depth** (from top): 2.2 - 6.9 cm
- **Color** (naked eye): dark orangey brown
- **Texture** (including sorting): sandy clay
- **Microstructure** (including development): Crack
**Coarse Material** [roundness, size range, abundance (% of total coarse material)]:
  - **Single Mineral Grains**: quartz – very few
  - **Compound Mineral Grains and Rock Fragments**: granite
  - **Inorganic Residues of Biological Origin**: n.o.
  - **Anthropogenic Artifacts**: n.o.
  - **Organic**: decayed wood

**Micromass**: amorphous organic matter
**Pedofeatures**: n.o.
**Notes**: decayed wood, peat? phosphatized seed coating?

**Summary**: N.A.
Thin Section ID: CAI 31B

Stratigraphic Unit(s): Bottom most of layer 1, Excavation Unit 10/15
Thin Section Size: 7.5 X 5.0 cm
Number of micro-Fabric Units (µFU): 1
Boundaries between µFU: N.A.

<table>
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<tr>
<th>Plane Polarized Light (PPL) Scan</th>
<th>Cross-Polarized Light (XPL) Scan</th>
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</thead>
</table>

Figure A22. CAI 31B Thin Section in PPL and XPL. Only one micro-Fabric Unit (µFU) has been observed in this thin section.

**micro-Fabric Unit # 1**

Relative depth (from top): 0.0 to 7.5 cm
Color (naked eye): dark orangey brown
Texture (including sorting): clay
Microstructure (including development): platy
Coarse Material [roundness, size range, abundance (% of total coarse material)]:
  - Single Mineral Grains: n.o.
  - Compound Mineral Grains and Rock Fragments: n.o.
  - Inorganic Residues of Biological Origin: n.o.
  - Anthropogenic Artifacts: n.o.
  - Organic: decayed wood
Micromass: amorphous organic matter
Pedofeatures: n.o.
Notes: decayed wood, peat? Potentially phosphatized seed coating – same as in the slide 30B.

Summary: N.A.
Thin Section ID: CAI 33c-B

Stratigraphic Unit(s): Layer 9, Excavation Unit 10/15
Thin Section Size: 7.5 X 5.0 cm
Number of micro-Fabric Units (µFU): 1
Boundaries between µFU: N.A.

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<thead>
<tr>
<th>Plane Polarized Light (PPL) Scan</th>
<th>Cross-Polarized Light (XPL) Scan</th>
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<td><img src="image1.png" alt="PPL Scan" /></td>
<td><img src="image2.png" alt="XPL Scan" /></td>
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Figure A23. CAI 33c-B Thin Section in PPL and XPL. Only one micro-Fabric Unit (µFU) has been observed in this thin section.

micro-Fabric Unit # 1

Relative depth (from top): 0.0 to 7.0 cm
Color (naked eye): white, grey, brown, yellow, black
Texture (including sorting): gravel
Microstructure (including development): intergrain microaggregate
Coarse Material [roundness, size range, abundance (% of total coarse material)]:
  - Single Mineral Grains: quartz, feldspars, calcite
  - Compound Mineral Grains and Rock Fragments: granite
  - Inorganic Residues of Biological Origin: bone; shell – clam and possible mussel, etched and exfoliated; sea urchin spine, barnacle
  - Anthropogenic Artifacts: n.o.
  - Organic: charcoal?
Micromass: amorphous organic material, micrite, clay
Pedofeatures: n.o.
Notes: directly below the degraded granite; large pieces of shell broken in situ – up to 3cm in length; only one obvious sea urchin spine; large bone fragments ~ 0.5cm in diameter.

Summary: N.A.
Thin Section ID: CAI 33c-C

Stratigraphic Unit(s): Layers 5c, 6, 7, 8, 9, Excavation Unit 10/15
Thin Section Size: 7.5 X 5.0 cm
Number of micro-Fabric Units (µFU): 6
Boundaries between µFU: 1 to 2 clear wavy; 2 to 3 clear irregular; 3 to 4 clear, smooth; 4 to 5 gradual smooth; 5 to 6 clear wavy

<table>
<thead>
<tr>
<th>µFU</th>
<th>Plane Polarized Light (PPL) Scan</th>
<th>Cross-Polarized Light (XPL) Scan</th>
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<td>6</td>
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Figure A24. CAI 33c-C Thin Section in PPL and XPL with marking of micro-Fabric Units (µFU) 1 through 6

micro-Fabric Unit # 1

Relative depth (from top): 0.0 – 1.7 cm
Color (naked eye): yellowish orangey black
Texture (including sorting): gravelly sandy clay
Microstructure (including development): massive
Coarse Material [roundness, size range, abundance (% of total coarse material)]:
  Single Mineral Grains: quartz, feldspars, calcite
  Compound Mineral Grains and Rock Fragments: granite
Inorganic Residues of Biological Origin: shell – clam, sea urchin spine, barnacle
Anthropogenic Artifacts: n.o.
Organic: charcoal?
Micromass: amorphous organic matter
Pedofeatures: phosphate crusts
Notes: bone? shells etched and phosphatized;
micro-Fabric Unit # 2

**Relative depth** (from top): 1.7 - 3.0 cm
**Color** (naked eye): Pinkish off white
**Texture** (including sorting): gravel
**Microstructure** (including development): compact grain

**Coarse Material** [roundness, size range, abundance (% of total coarse material)]:
- **Single Mineral Grains**: quartz, calcite
- **Compound Mineral Grains and Rock Fragments**: n.o.
- **Inorganic Residues of Biological Origin**: shell (fresh, etched, a few heated at top)
- **Anthropogenic Artifacts**: n.o.
- **Organic**: n.o.

**Micromass**: amorphous organic material

**Pedofeatures**: n.o.

**Notes**: Layer of shells – fragmented in situ – arranged roughly horizontally; bottom has a small amount of mixing with the layer underneath, shells at top of µFU 2 appear calcined in situ.

micro-Fabric Unit # 3

**Relative depth** (from top): 3.0 - 4.1 cm
**Color** (naked eye): black and gray
**Texture** (including sorting): gravelly silt loam
**Microstructure** (including development): complex

**Coarse Material** [roundness, size range, abundance (% of total coarse material)]:
- **Single Mineral Grains**: quartz, calcite
- **Compound Mineral Grains and Rock Fragments**: n.o.
- **Inorganic Residues of Biological Origin**: shell (heated), barnacle (heated)
- **Anthropogenic Artifacts**: n.o.
- **Organic**: charcoal – large pieces ~ 0.5cm

**Micromass**: amorphous organic material, clay, micrite

**Pedofeatures**: n.o.

**Notes**: barnacles and shells of µFU 3 appear burnt/calcined in situ.

micro-Fabric Unit # 4

**Relative depth** (from top): 4.1 - 5.0 cm
**Color** (naked eye): orangey brown with light gray speckles
**Texture** (including sorting): gravelly silty clay
**Microstructure** (including development): massive (with a few vesicles and channels)

**Coarse Material** [roundness, size range, abundance (% of total coarse material)]:
- **Single Mineral Grains**: quartz, calcite
- **Compound Mineral Grains and Rock Fragments**: granite (rare)
- **Inorganic Residues of Biological Origin**: heated barnacle and shell fragments
- **Anthropogenic Artifacts**: n.o.
- **Organic**: n.o.

**Micromass**: clay, micrite

**Pedofeatures**: oxides hypo-coatings

**Notes**: It appears this is a surface made with mixing mud, wood ash, and calcined shells
micro-Fabric Unit # 5

Relative depth (from top): 5.0 - 6.0 cm
Color (naked eye): orangey brown with dark gray speckles
Texture (including sorting): gravelly silty clay
Microstructure (including development): complex
Coarse Material [roundness, size range, abundance (% of total coarse material)]:
  Single Mineral Grains: quartz, feldspars, calcite
  Compound Mineral Grains and Rock Fragments: granite
  Inorganic Residues of Biological Origin: charred and calcined shell, barnacle, sea urchin spine
  Anthropogenic Artifacts: n.o.
  Organic: n.o.
Micromass: clay, micrite
Pedofeatures: n.o.
Notes: Shell fragments – larger than previous unit, more prominent (less degraded), some appear to be “ashed” – they do not change colour when the stage is rotated; the unit has more chambers and spaces than the previous unit; shell appears dark brown in places – charred but not as ashed as the previous unit; the ash appears browner than the ash in the unit above – charring staining; appears to be calcite precipitated on edges of shells and on edges of pores – doesn’t appear sparry like in other units with no ash; degraded shell doesn’t appear sparry like those that are acid etched.

micro-Fabric Unit # 6

Relative depth (from top): 6.0 – 7.0 cm
Color (naked eye): black, grey, brown,
Texture (including sorting): gravelly loamy sand
Microstructure (including development): complex
Coarse Material [roundness, size range, abundance (% of total coarse material)]:
  Single Mineral Grains: quartz, feldspars, calcite
  Compound Mineral Grains and Rock Fragments: granite
  Inorganic Residues of Biological Origin: shell, barnacle, bone?
  Anthropogenic Artifacts: n.o.
  Organic: n.o.
Micromass: clay, micrite, amorphous organic material
Pedofeatures: n.o.
Notes: Shell – large fragments, light staining – arranged largely horizontal (some mixing); micritic calcite mixed with amorphous organic material and throughout the unit, more sparry calcite than previous layer; calcite precipitated on shell edges; no acid etching apparent on the shells – may be a slight amount on one or two shell pieces; one large bone – appears stained or heated.

Summary: It appears that unit µFU 4 was built on top of µFU 6. µFU 3 is the not-combusted charcoal of a fire lit on top of µFU 4. µFU 5 maybe the results of a previous fire lit on top of surface similar to µFU 4. µFU 2 is a layer of fresh and crushed shells.
Thin Section ID: CAI 33c-E

Stratigraphic Unit(s): Layers 5c; Excavation Unit 10/15
Thin Section Size: 7.5 X 5.0 cm
Number of micro-Fabric Units (µFU): 2
Boundaries between µFU: clear smooth

<table>
<thead>
<tr>
<th>µFU</th>
<th>Plane Polarized Light (PPL) Scan</th>
<th>Cross-Polarized Light (XPL) Scan</th>
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**Figure A25. CAI 33c-E Thin Section in PPL and XPL with marking of micro-Fabric Units (µFU) 1 and 2**

**micro-Fabric Unit # 1**

- **Relative depth** (from top): 0.0 - 2.9 cm
- **Color** (naked eye): white, black, brown, grey, orange
- **Texture** (including sorting): gravelly loamy sand
- **Microstructure** (including development): complex (platy, channels)
- **Coarse Material** [roundness, size range, abundance (% of total coarse material)]:
  - Single Mineral Grains: quartz, feldspars, calcite
  - Compound Mineral Grains and Rock Fragments: granite
  - Inorganic Residues of Biological Origin: shell, barnacle (phosphatized), bone (rare), sea urchin spine.
  - Anthropogenic Artifacts: n.o.
  - Organic: charcoal, rootlet?
- **Micromass**: amorphous organic material, clay, micrite (adhering to shell fragments)
- **Pedofeatures**: n.o.
- **Notes**: Shell largely oriented horizontally – broken in situ, some movement away from horizontal; micritic calcite appears throughout the unit – appears more sparry than previous slide (33c);

**micro-Fabric Unit # 2**

- **Relative depth** (from top): 2.9 - 4.5 cm
- **Color** (naked eye): brownish gray, pink, orange, white
- **Texture** (including sorting): gravelly sandy loam
- **Microstructure** (including development): complex
- **Coarse Material** [roundness, size range, abundance (% of total coarse material)]:
Single Mineral Grains: quartz, feldspars, calcite
Compound Mineral Grains and Rock Fragments: granite, basalt (rare)
Inorganic Residues of Biological Origin: shell, barnacle, bone
Anthropogenic Artifacts: n.o.
Organic: charcoal
Micromass: amorphous organic material, clay, micrite
Pedofeatures: n.o.
Notes: Basalt. Much less large shells than above unit; less apparent black matrix – lighter; micritic calcite throughout, appears to be more abundant than previous unit

Summary: N.A.
Thin Section ID: CAI 37D

Stratigraphic Unit(s): Layer 10, Excavation Unit 10/15
Thin Section Size: 7.5 X 5.0 cm
Number of micro-Fabric Units (µFU): 1
Boundaries between µFU: N.A.

<table>
<thead>
<tr>
<th>Plane Polarized Light (PPL) Scan</th>
<th>Cross-Polarized Light (XPL) Scan</th>
</tr>
</thead>
<tbody>
<tr>
<td>![PPL Scan]</td>
<td>![XPL Scan]</td>
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</tbody>
</table>

Figure A29. CAI 37D Thin Section in PPL and XPL. Only one micro-Fabric Unit (µFU) has been observed in this thin section.

micro-Fabric Unit # 1

Relative depth (from top): 0.0 to 7.2 cm
Color (naked eye): white, black, purple, grey
Texture (including sorting): gravel
Microstructure (including development): single grain
Coarse Material [roundness, size range, abundance (% of total coarse material)]:
  Single Mineral Grains: calcite, quartz
  Compound Mineral Grains and Rock Fragments: granite
  Inorganic Residues of Biological Origin: shell – clam and mussel (etched, possibly burnt); barnacle (burnt); bone?
  Anthropogenic Artifacts: n.o.
  Organic: charcoal,
Micromass: amorphous organic material, clay, micrite
Pedofeatures: n.o.
Notes: Shells are whole or in large fragments. They have random orientation. Typical of material being loosely dumped.

Summary:
Thin Section ID: CAI 38D

Stratigraphic Unit(s): Layer 4, Excavation Unit 10/15
Thin Section Size: 7.5 X 5.0 cm
Number of micro-Fabric Units (µFU): 3
Boundaries between µFU: 1 to 2 – clear wavy; 2 to 3 – clear wavy;

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<th>Plane Polarized Light (PPL) Scan</th>
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</table>

Figure A31. CAI 38D Thin Section in PPL and XPL with marking of micro-Fabric Units (µFU) 1 to 3.

micro-Fabric Unit # 1

Relative depth (from top): 0.0 – 2.3 cm
Color (naked eye): black, brown
Texture (including sorting): gravelly fine organic matrix
Microstructure (including development): complex

Coarse Material [roundness, size range, abundance (% of total coarse material)]:
- Single Mineral Grains: quartz, calcite, feldspars
- Compound Mineral Grains and Rock Fragments:
- Inorganic Residues of Biological Origin: shell (etched, stained, phosphatized), bone?
- Anthropogenic Artifacts: n.o.
- Organic: charcoal, plant tissues

Micromass: amorphous organic material

Pedofeatures: n.o.

Notes: Some pieces of shell are very degraded, appears as though in situ;
micro-Fabric Unit # 2

**Relative depth** (from top): 2.3 - 3.8 cm  
**Color** (naked eye): brownish white  
**Texture** (including sorting): gravel  
**Microstructure** (including development): intergrain microaggregate  
**Coarse Material** [roundness, size range, abundance (% of total coarse material)]:  
  - Single Mineral Grains: quartz - few  
  - Compound Mineral Grains and Rock Fragments: n.o.  
  - Inorganic Residues of Biological Origin: shell (etched, stained, phosphatized?).  
  - Anthropogenic Artifacts: n.o.  
  - **Organic**: plant tissues? Charcoal?  
**Micromass**: amorphous organic material  
**Pedofeatures**: n.o.  
**Notes**: N.A.

micro-Fabric Unit # 3

**Relative depth** (from top): 4 - 7 cm  
**Color** (naked eye): black, brown, gray  
**Texture** (including sorting): gravelly fine organic matrix  
**Microstructure** (including development): platy  
**Coarse Material** [roundness, size range, abundance (% of total coarse material)]:  
  - Single Mineral Grains: quartz, feldspars, calcite  
  - Compound Mineral Grains and Rock Fragments: granite  
  - Inorganic Residues of Biological Origin: clam shell, barnacle, bone (fish?).  
  - Anthropogenic Artifacts: n.o.  
  - **Organic**: plant tissue, charcoal  
**Micromass**: black amorphous organic material,  
**Pedofeatures**: n.o.  
**Notes**: Dominated by black amorphous organic matter

**Summary**: Appears these are the remains of activities such as fire making and shell processing on a forest floor
Thin Section ID: CAI 38F

**Stratigraphic Unit(s):** Layer 4 and 3, Excavation Unit 10/15
**Thin Section Size:** 7.5 X 5.0 cm
**Number of micro-Fabric Units (µFU):** 2
**Boundaries between µFU:** Clear smooth

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<th>µFU</th>
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<td>2</td>
<td><img src="image3.png" alt="Image" /></td>
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Figure A33. CAI 38F Thin Section in PPL and XPL with marking of micro- Fabric Units (µFU) 1 and 2

**micro-Fabric Unit # 1**

**Relative depth (from top):** 0.0 - 3.2 cm  
**Color (naked eye):** black,  
**Texture (including sorting):** fine organic matrix  
**Microstructure (including development):** granular  
**Coarse Material [roundness, size range, abundance (% of total coarse material)]:**  
  *Single Mineral Grains*: quartz, calcite  
  *Compound Mineral Grains and Rock Fragments*: large, white granite cobble 4.5 x 2.8cm, rounded  
  *Inorganic Residues of Biological Origin*: shell (etched, stained), bone (charred)  
  *Anthropogenic Artifacts*: n.o.  
  *Organic*: charcoal  
**Micromass**: black amorphous organic material  
**Pedofeatures**: calcite hypocaoting at the bottom of the unit  
**Notes**: sand is accumulating at the contact with decaying wood at the bottom of the unit.

**micro-Fabric Unit # 2**

**Relative depth (from top):** 3.2 – 6.7 cm  
**Color (naked eye):** brownish black
Texture (including sorting): clay
Microstructure (including development): massive (cracks due to shrinking)
Coarse Material [roundness, size range, abundance (% of total coarse material)]:
  Single Mineral Grains: quartz – few
  Compound Mineral Grains and Rock Fragments: n.o.
  Inorganic Residues of Biological Origin: n.o.
  Anthropogenic Artifacts: n.o.
  Organic: decayed wood
Micromass: dark reddish brown amorphous organic matter
Pedofeatures: n.o.
Notes: Remains of a wood feature (e.g. plank, post, log).

Summary: N.A.
**Thin Section ID:** CAI 39B

- **Stratigraphic Unit(s):** Layer 5b, Excavation Unit 10/15
- **Thin Section Size:** 7.5 X 5.0 cm
- **Number of micro-Fabric Units (µFU):** 2
- **Boundaries between µFU:** 1 to 2: clear smooth

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<tr>
<th>µFU</th>
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<th>Cross-Polarized Light (XPL) Scan</th>
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<td><img src="image3.png" alt="PPL Scan" /></td>
<td><img src="image4.png" alt="XPL Scan" /></td>
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</tbody>
</table>

Figure A35. CAI 39B Thin Section in PPL and XPL with marking of micro-Fabric Units (µFU) 1 to 2

**micro-Fabric Unit # 1**

- **Relative depth** (from top): 0.0 – 5.5 cm
- **Color** (naked eye): black, brown, yellow
- **Texture** (including sorting): gravelly sandy clay
- **Microstructure** (including development): complex (tendentially platy)
- **Coarse Material** [roundness, size range, abundance (% of total coarse material)]:
  - Single Mineral Grains: quartz, calcite
  - Compound Mineral Grains and Rock Fragments: granite
  - Inorganic Residues of Biological Origin: clam shell (etched, calcined, stained, exfoliated); barnacle (calcined)
  - Anthropogenic Artifacts: n.o.
  - Organic: charcoal
- **Micromass**: black amorphous organic tissue
- **Pedofeatures**: n.o.
- **Notes**: Laminated layer. Some of the laminae are composed of charcoal and other of shells. The shells are peculiarly exfoliating.
micro-Fabric Unit # 2

**Relative depth** (from top): 5.5 – 7 cm
**Color** (naked eye): brownish black
**Texture** (including sorting): N.A.
**Microstructure** (including development): N.A.

**Coarse Material** [roundness, size range, abundance (% of total coarse material)]:
- Single Mineral Grains: N.A.
- Compound Mineral Grains and Rock Fragments: N.A.
- Inorganic Residues of Biological Origin: N.A.
- Anthropogenic Artifacts: N.A.
- **Organic**: wood

**Micromass**: N.A.

**Pedofeatures**: N.A.

**Notes**: Fairly well-preserved wood; a few pieces of quartz at the top unit that are probably part of the above unit.

**Summary**: laminated anthropogenic surfaces resting on wood remains (e.g., post, plank, log)
**Thin Section ID:** CAI 39D  
**Stratigraphic Unit(s):** Layer 5a, Excavation Unit 10/15  
**Thin Section Size:** 7.5 X 5.0 cm  
**Number of micro-Fabric Units (µFU):** 1  
**Boundaries between µFU:** N.A.

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Figure A36. CAI 39D Thin Section in PPL and XPL. Only one micro-Fabric Unit (µFU) has been observed in this thin section.

**micro-Fabric Unit # 1**

- **Relative depth** (from top): 0.0 – 6.0 cm  
- **Color** (naked eye): black, brown, yellow  
- **Texture** (including sorting): gravelly sandy clay  
- **Microstructure** (including development): complex (tendentially platy)  
- **Coarse Material** [roundness, size range, abundance (% of total coarse material)]:  
  - Single Mineral Grains: quartz, calcite, feldspars  
  - Compound Mineral Grains and Rock Fragments: granite  
  - Inorganic Residues of Biological Origin: clam shell (etched, stained); barnacle (etched, phosphatized), sea urchin (phosphatized, stained), bone  
  - Anthropogenic Artifacts: n.o.  
  - Organic: charcoal  
- **Micromass:** black amorphous organic matter, micrite  
- **Pedofeatures:** n.o.  
- **Notes:** µFU similar to µFU 1 of CAI39B. Laminated layer. The laminae are composed of charcoal and shells. The shells are peculiarly exfoliating.
Appendix B.

Stratigraphic Components Tables
<table>
<thead>
<tr>
<th>Layer</th>
<th>Block and Sub-Layers</th>
<th>Clam Shell</th>
<th>Barnacle</th>
<th>Sea Urchin Spine</th>
<th>Mussel Shell</th>
<th>Bone</th>
<th>Fish Bone</th>
<th>Charcoal</th>
<th>Calcite</th>
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Table B2. Stratigraphic Components Units 10 & 15
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Table C3. Shell Calcite ν2/ν4 Ratios for the identification of burnt shells (Note ν2/ν4 Ratio values ≥ 4.0 are indicative of pyrogenic calcite)

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<th>ν4(^{(\text{CO}_3)})</th>
<th>FTIR Absorption</th>
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