GEOARCHAEOLOGICAL ANALYSIS OF TWO NEW TEST PITS AT THE DMANISI SITE, REPUBLIC OF GEORGIA

Winston S. Zack

Thesis Prepared for the Degree of

MASTER OF SCIENCE

UNIVERSITY OF NORTH TEXAS

May 2013

APPROVED:

C. Reid Ferring, Major Professor
Steve Wolverton, Committee Member
Alexandra Ponette-González, Committee Member
Paul Hudak, Chair of the Department of Geography
Mark Wardell, Dean of the Toulouse Graduate School

Zack, Winston S. *Geoarchaeological Analysis of Two New Test Pits at the Dmanisi Site, Republic of Georgia.* Master of Science (Applied Geography), May 2013, 99 pp., 23 tables, 22 figures, reference list, 48 titles.

This thesis presents the results of geoarchaeological investigations conducted at two new test pits, M11 and M12, at the paleoanthropological site of Dmanisi during the 2012 field season. This research is important for understanding the site formation processes occurring along the north-south axis of the Dmanisi site and how that affects the chronostratigraphic sequence and interpretation of archaeological materials here. With these excavations we can build a stronger interpretation for how broader areas of this site formed and changed both geologically and archaeologically. The geologic results of this study indicate that changes in sediment deposition and development episodes can affect interpretations of how long these sediments accumulated, how likely bones are to preserve, as well as how secondary gravel deposition can influence several archaeological interpretations. The archaeological results suggest that there could have been changes in occupation intensity between the stratum A and B phases although different rates of sediment deposition and surface stability could affect such artifact accumulations. In addition, during the stratum B phase there appears to be little change in artifact procurement behaviors and reduction characteristics by these hominins. The overall results of this research indicate that geologic factors should be addressed and cautions should be taken prior to making interpretations about archaeological assemblages.

ACKNOWLEDGEMENTS

A project such as this would not have been possible without the help and support of my family, friends and colleagues. I thank you all for your assistance and patience with this Dmanisi project. First, to my family especially my parents, Tom and Sherri, and my brother Jason thank you all for the encouragement with this project as this degree is a stepping stone to my future career. Second, I am most grateful to Reid Ferring for taking me under your wing and giving me the chance to work at one of the most important paleoanthropological sites of the last century, Dmanisi. Your direction, guidance, patience and passion with this project has been a source of inspiration and motivation. In addition, to my master's student colleagues, especially Peter Crislip for all the assistance and guidance in completing this project, it is truly appreciated. Finally, thanks goes to the entire Dmanisi team who assisted me with excavations and data collecting during the 2012 season. Thank you all.

TABLE OF CONTENTS

Page

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

This thesis presents the results of geoarchaeological investigations conducted at two new test pits, M11 and M12 (Figure 1.1), at the paleoanthropological site of Dmanisi during the 2012 field season. This research is important for understanding the more extensive site formation processes occurring along the north-south axis of the Dmanisi site and how that affects the chronostratigraphic sequence of archaeological materials. Specifically, this research was conducted in order to resolve objectives involving 1) how did the sediments along the north-south axis of the promontory form and how do these compare with excavations elsewhere on site, along with 2) does hominin occupation intensity and periodicity, and artifact procurement and reduction behaviors appear to change over space and time.

The basis for these investigations began in 2005 with the opening of excavation Block M5 100m west from previous excavations; most of the excavations conducted prior to M5 plotted archaeological materials to an inaccurate chronostratigraphic sequence complicating more extensive archaeological interpretations across the site. The M5 excavations revealed the thickest and most complete stratigraphic sequence yet exposed at Dmanisi along with the earliest stone artifacts (Ferring et al. 2011). This evidence quickly suggested that site formation processes including sediment deposition and development as well as hominin occupations were more active than previously realized here and needed to be investigated further in order to understand how the site formed overall.

The overarching goals of this research are to 1) reconstruct two different portions of the site's geological and sedimentological history in order to understand how the north-south axis of the promontory developed, 2) increase the general understanding of how soils developed at these two test pits, 3) establish a geologic context for several of the archaeological components at Dmanisi, and 4) assess the broader site formation processes taking place on the promontory.

In order to address the above research questions and accomplish these goals it is important to integrate the methods and analyses previously conducted at Dmanisi. First the geologic setting is established including the geomorphology, stratigraphy, and sedimentary environments. Geoarchaeological site formation investigates how different types of sediment were deposited, how they transformed under different environmental conditions and how these conditions may change over space and time (Butzer 1982). These stratigraphic analyses will also provide greater context to the associated archaeological and paleontological materials.

This is followed by the archaeological components of flaked stone artifact analysis and interpreting those artifacts within the greater geologic context. The artifact component of site formation can help determine how different portions of the site were used, the spatial patterning of artifact forms, as well as other descriptive components of artifact reduction which can lead to interpretations of hominin behaviors overall (Schiffer 2002). Tentative geoarchaeological comparisons to contemporary archaeological sites in Africa can also be made to improve understanding of early hominin behaviors in general.

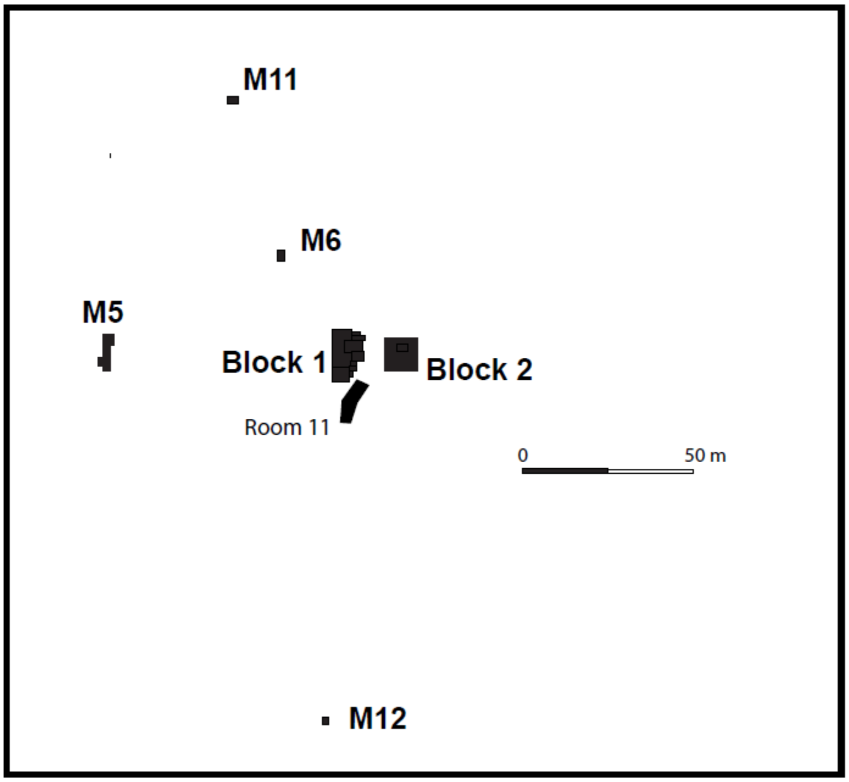


Figure 1.1. Map of Dmanisi excavations including M11 and M12; figure from Reid Ferring.

Field Methods

Test pit M11 is located approximately 60 m north of M6 and 80 m north of the main block excavations within a small grove of trees surrounded by a decaying medieval stone building (Figure 1.1). This location was chosen for being the most northern extent of paleolithic excavations yet conducted on the promontory, thereby expanding the breadth of paleolithic site formation overall. A small 2.5x1.5 m test trench was laid out, and five $0.5m^2$ quads were excavated (Figure 1.2).

Test pit M12 is located approximately 110 m south of the M5 excavations, on the southwestern end of the promontory, within a small grove of trees surrounded by a dilapidated medieval stone building (Figure 1.1). A 1x1m test pit was excavated down to the Masavera basalt.

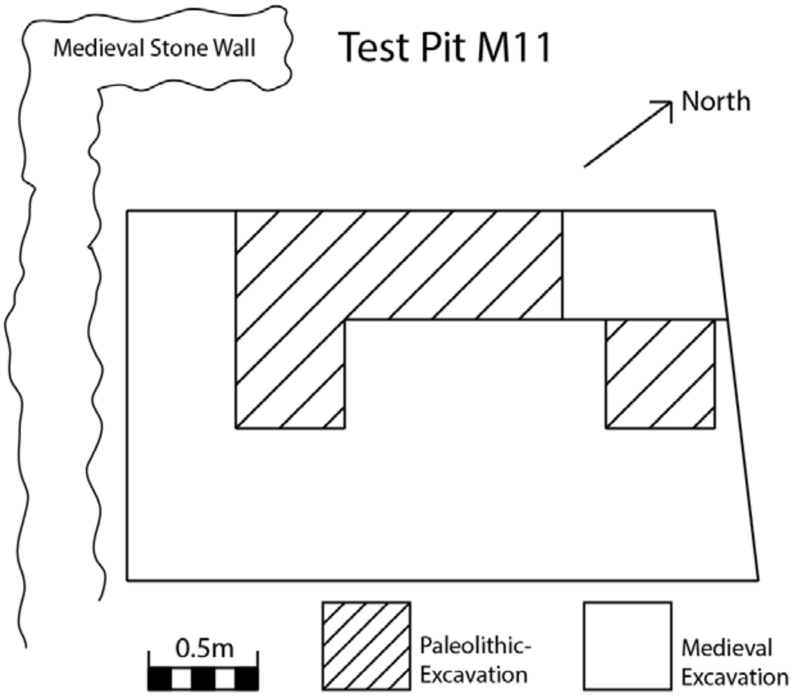


Figure 1.2. Test Pit M11 excavation block.

A primary datum was established next to each test pit. Vertical (z-coordinate) measurements were recorded as measurements above or below an established datum. Elevation reference stakes were set at each test pit with string and line levels attached to measure elevations of artifacts and features. Horizontal (x and y-coordinate) measurements were established from a primary 0/0 grid point from a set corner of each test pit. Excavation units varied for each test pit based on accommodation of space.

All test pit information was recorded on standardized data forms to ensure consistency of information and format. Recovered *in situ* artifacts, bone, and cobbles were measured, mapped, and placed individually in separate collections bags with standardized provenience data tags. All further excavated sediment was dry screened on site through 3 mm mesh. All pebbles, artifacts, bone, or cobbles recovered from the screens were collectively placed in finds bags with separate provenience information. Gravel data was collected in the field and later divided in the following size classes: granules <1 cm, small pebbles 1-2 cm, large pebbles 2-5 cm, cobbles/boulders >5 cm.

Excavation techniques varied based upon the circumstances of the test pit and upon the amount of time left in the field season. Generally troweling, hammering, and brushing of the sediments was employed until significant artifacts, bone or features were encountered; at M12 a jackhammer was used to break through the indurated calcium carbonate layers. Meticulous excavation techniques with finer tools were undertaken when artifacts, bones and features were encountered.

Sediment samples were collected along one profile wall from both M11 and M12. Samples were collected at specific designated points in the profile wall where there were indications of changes in sediment/soil features. Twelve samples were collected from M11 and thirteen samples were collected from M12. Approximately 100-200g of sediment was collected from each location. All the samples were individually weighed, and some samples were split to get their total weight to between 100g and 150g in preparation for shipment. Lab methods are discussed at the beginning of their corresponding chapters below.

CHAPTER 2

STUDY SETTING

The Dmanisi site is located 41.31° N, 44.35° E approximately 85 km southwest of the capital Tbilisi in the rural lower Caucasus Mountains near the border with Armenia (Tappen et al. 2007). This site contains the remnants of several periods of human occupation, including medieval, Bronze Age, and Lower Pleistocene hominin remains and artifacts. Dmanisi is significant to paleoanthropology in that it is currently the earliest definitive evidence for hominins outside of Africa (Gabunia et al. 2000, Lordkipanidze et al. 2007, Ferring et al. 2011) including both their skeletal remains (Lordkipanidze et al. 2007) as well as stone artifacts (Ferring et al. 2011).

During the paleolithic hominin occupation of Dmanisi this region was an active center of volcanism. Approximately 1.85 Ma an 80-100m thick flow of Masavera basalt filled the Dmanisi valley, temporarily building up the level of the Masavera and Pinasauri Rivers, and helping to create the Dmanisi promontory and surrounding geomorphologic landscape features. The Masavera and Pinasauri Rivers appear to have quickly re-incised their valleys by eroding away the Masavera basalt as there is no evidence on the promontory of alluvial sediment deposition (Gabunia et al. 2000). During this period, several volcanic eruptions deposited thick quantities of mafic ash which contain the Dmanisi fossils and artifacts. There is no preserved sedimentological evidence at Dmanisi to suggest that local volcanic eruptions have occurred since the last Upper Matuyama event 1.76 Ma.

Dmanisi was first realized as a location of interest to paleoanthropologists in 1983 with the discovery of extinct fauna and flaked stone artifacts (Mgeladze et al. 2011). Starting in 1989 annual systematic paleolithic excavations occurred at the site, with the first hominin mandible, D211, being discovered just two years later (Gabunia and Vekua 1993, Lordkipanidze et al. 2007). To date more than a dozen excavation blocks and test pits have been excavated across the promontory yielding more than 10,000 fossils of at least 44 extinct species of fauna, which includes more than sixty hominin fossils, as well as more than 3,000 stone artifacts (Lordkipanidze et al. 2007). Despite its extensive record of study, Dmanisi still contains several unresolved issues related to its geoarchaeology and site formation processes.

The archaeology of Dmanisi is currently a rarity in the larger network of contemporaneous Lower Paleolithic, Lower Pleistocene era assemblages most commonly found in Africa. It is well established that the hominin occupants of Dmanisi have their biological roots in Africa (Lordkipanidze et al. 2007). In contrast, the other recovered extinct fauna do not necessarily originate from Africa suggesting that hominin dispersal into Georgia was not necessarily motivated by the migration of African species there (Tappen et al. 2007, Lordkipanidze et al. 2007). In addition, these hominins also appear to have maintained their traditional African simple flaked stone tool technology, termed Mode I, from which thousands of artifacts have been recovered throughout the Dmanisi site assemblage. Therefore it is important to understand the environmental background from which these Dmanisi hominins inhabited in order for stronger archaeological interpretations to be addressed here.

Previous Research

Stratigraphy and Sediments

The first defined stratigraphy at Dmanisi divided sediments into six units starting with

Stratum I at the top and Stratum VI at the bottom. These were used between the years 1989 and 2002 by Dzaparidze et al. (1989) and Mgeladze et al. (2011). During this period several test excavations were dug with artifacts and faunal remains mapped to those stratigraphic specifications. This initial system proved to be quite inaccurate because it only took into account major horizon boundaries but not the lesser sub-horizons and geomorphic features within the stratigraphic sequence. A revised stratigraphic scheme was formally established in 2000.

In 2000 a new stratigraphic system was established (Gabunia et al. 2000) by Reid Ferring. This revised stratigraphy takes into account all of the stratigraphic horizons, sub-horizons and intrusive features. This stratigraphy is divided into two major Stratum, A and B, and multiple units within each (Ferring et al. 2011). The most complete stratigraphic record is found at Block M5 and comprises four A strata, with Unit A1 being the deepest, and at least five B strata with B5 as the youngest. All of the Strata A sediments are within the late Olduvai subchron whereas Strata B sediments are all within the early Matuyama Chron (Ferring et al. 2011).

Due to the change in the way the stratigraphy was defined at Dmanisi over its excavation history, attempts have been made to correlate archaeological material from the earlier system with the updated version, but those attempts have been fairly unsuccessful (Ferring et al. 2011, Mgeladze et al. 2011). All of the currently mapped materials are designated to the new stratigraphic sequence. This means that only archaeological materials recovered since 2000 can be analyzed meaningfully.

The stratigraphic sequence at Dmanisi is primarily composed of numerous volcanic ash-fall deposits (Ferring et al. 2011). Each of the Strata A sediments and several of the Strata B sediments can be attributed to ash-fall events. Secondary gravel colluvium and carbonate features are also major deposits within primarily the Stratum B sediments.

Artifacts

Artifacts have been recovered unequally in the different stratigraphic units across the site. The earliest of these artifacts were recovered from excavation Block M5 in Strata A2a (Ferring et al. 2011). Only the lowest Unit A1 stratigraphy is sterile of artifacts. These artifacts have all been classified to the Mode I industry found contemporaneously and earlier in Africa. Mode I artifacts are the earliest stone tool technology formally classified by paleoanthropologists and consist of simple and expediently manufactured flake and core pieces. Igneous rocks, most commonly varieties of tuff and basalt (Ferring et al. 2011, Mgeladze et al. 2011), appear to have been the primary raw materials selected for lithic manufacture by these hominins.

The Mode I artifact industry was first attributed in 1967 by Pierre Biberson as “pebble tools” (Schick and Toth 2006). Mary Leakey later formalized this typology by calling it the “Oldowan” type from her investigations at Olduvai Gorge in 1971 (Schick and Toth 2006). She grouped common morphotypes into discrete categories in order to more easily diagnose assemblage compositions. The term “Mode I” was later implemented to generalize these types of assemblages that are found in many parts of the old world. In general, the typology Leakey designed is the standard artifact designation system used by researchers.

The Mode I artifacts recovered from Dmanisi are broadly similar to the Oldowan artifact assemblages in East Africa. The Dmanisi assemblage is composed primarily of flakes and flake fragments, but also cores, choppers, scrapers, modified and unmodified cobbles and occasionally Karari-type implements; retouched artifacts are very scarce overall (Ferring et al., 2011). Artifacts have been recovered from every test pit on the site, but not in every stratigraphic unit. Artifacts from Stratum A sediments have only been recovered from Block M5 (Ferring et al. 2011). These artifacts have been recovered from as deep as Unit A2a through A4, but none have been recovered from the deepest Unit A1 sediments (Ferring et al. 2011). Artifacts from Stratum B sediments are much more frequently encountered across the site and have been recovered from Units B1 through B4.

Preliminary assessment of the Dmanisi artifact assemblage from M5 suggests a change in raw material preference, reduction techniques and intensity, and possibly artifact and raw material transport changes between Stratum A and B assemblages. Ferring et al. (2011) reported that artifacts in Stratum A (*n* = 73) exhibit a high proportion of red tuff (35.6%) and brown tuff (32.9%), and a low proportion of dorsal cortex (29%); the low proportion of dorsal cortex here may indicate these artifacts were reduced elsewhere and transported to this location. These observations are in sharp contrast to the raw material preferences in Stratum B (*n* = 49), where tan tuff (28.6%), basalt (24.5%), and andesite (18.4%) are most common. In addition, dorsal cortex was much more frequently encountered on artifacts from Stratum B (71%).

Dating

Multiple techniques have been used to precisely date the hominin occupations at Dmanisi. Potassium-argon (K/Ar) and argon-argon ($^{40}Ar/^{39}Ar$) were the first techniques used for dating the bedrock basalt. Initial dates indicated an age of just 0.530 +/- 0.02 Ma (Gabunia et al. 2000) but subsequent and more accurate dating techniques on the basalt produced an age of 1.85 Ma (Gabunia et al. 2000). Paleomagnetic analysis of the paleolithic sediments corroborate the absolute ages (Ferring et al. 2011).

The lower Stratum A sediments are dated to the end of the Olduvai subchron, between 1.85 and 1.78 Ma (Ferring et al. 2011). Sediments continued to accumulate during the beginning of the Upper Matuyama reverse polarity Chron and are collectively defined as Stratum B sediments. Typologically similar artifacts, hominin fossils and other faunal remains corroborate a continuous accumulation of Stratum B sediments shortly after the paleomagnetic reversal (Ferring et al. 2011, Messager et al. 2011, Agusti and Lordkipanidze 2011). The youngest age of Upper Matuyama Stratum B sediments at Dmanisi are capped at 1.76 Ma based upon stratigraphic and paleobotanical correlation to the nearby Zemo Orozmani basalt (Ferring et al. 2011, Messager et al. 2011). In all this constrains the hominin occupation period of Dmanisi within 100,000 years, and probably quite less.

Ecology

Paleoenvironmental reconstructions from Dmanisi have been undertaken by several of the Dmanisi team members including Erwan Messager, David Lordkipanidze and Abesalom Vekua. The site region is situated in the sub-Alpine zone 900m above sea level between the Loki and Sakire-Dmanisi basins (Mgeladze et al. 2011). Today the site is covered with patches of trees, shrubs, and grass, but the environment and flora on the promontory was probably quite different during Paleolithic occupations (Lordkipanidze et al. 2007, Messager et al. 2008, 2010a, 2010b).

Analysis of collected phytoliths, pollen, and carpophore (fossil fruit) implies a change in type and density of floral species throughout paleolithic hominin occupation (Messager et al. 2009, 2010a, 2010b). The overall paleo-occupation period is generalized as having xeric, Mediterranean-like ecological conditions of generally dry, grassland and shrub flora (Messager et al. 2010b). Lower Stratum A deposits (A1 to A3) appear to be dominated by grasses in a warm and relatively humid climate whereas Stratum B deposits have a stronger xeric moisture regime that is temperate and drier starting at the end of the Stratum A sequence (Messager et al. 2010b). Sediments in Stratum B also tend to be dominated by more herbaceous shrubs and grasses along with a greater presence of trees than those found in Stratum A (Messager et al. 2010b).

Biotic Resources

The relationship between local water sources, both fluvial and lacustrine, and associated plants likely resulted in a patchy mosaic of floral habitats. Rivers and streams often support riparian zones adjacent to the water course, while the presence of grasses and shrubs may indicate locations with a slightly lower water table possibly further from the headwater source. The result of local ecotonal diversity appears to have also attracted an equally diverse set of fauna to the area (Lordkipanidze et al. 2007).

There is an extensive diversity of paleo-fauna recovered from Dmanisi. At least 44 taxa are represented, including 1 amphibian, 3 reptiles, 3 birds, and 37 mammals; most of the mammals are macrofauna (Lordkipanidze et al. 2007). The presence of these animals coincides with the transition from Middle to Late Villafranchian of Western Europe and Asia (Lordkipanidze et al. 2007). The macrofauna include several herbivores and carnivores that occupied both arboreal and steppic environments. The seven species of micromammals, especially *Parameriones oberdiyensis*, additionally coincide with other former Late Pliocene, now middle Early Pleistocene, animals and help support the relative age of this site (Agusti and Lordkipanidze 2011).

Overall, the fossil assemblage is well preserved. More than 90% of the analyzed remains exhibit stages 0 or 1 weathering implying that many bones were quickly buried (Tappen et al. 2007). Most of these fossils appear to have been quickly buried in pipe and gully features of Strata B1. These pipe and gully features act as natural traps mitigating destruction of bone which would otherwise have occurred if left exposed on the surface. Many of the fossil remains recovered outside of these features exhibit a higher degree of weathering, and some stratigraphic units are essentially sterile of fossils altogether.

Summary

In summary, the sediments, artifacts, fossils and botanical remains play a critical role in understanding how the site developed at each location on the promontory. Each stratigraphic unit developed under slightly different conditions. As a result this affects interpretations about the archaeological materials both present and absent within these units. Therefore, on the onset it is critical to be able to interpret site formation processes within the context of this background information.

CHAPTER 3

SEDIMENTS AND STRATIGRAPHY FROM TEST PITS M11 AND M12 AT DMANISI

Introduction

Reconstructing the site formation processes of deposition, weathering, erosion and other disturbance factors at archaeological sites is an essential component for expanding the understanding of site development (Wood and Johnson 1978, Goldberg et al. 2001, Schiffer 2002). Sedimentology and pedology can provide important evidence for paleoenvironmental and paleoclimatic components of site formation history. With respect to Lower Pleistocene geologic and environmental history, the bedrock geology of the Dmanisi promontory and surrounding basins is important for assessing bedrock as: 1) a resistive component of landform evolution, 2) sources of eolian, colluvial, alluvial and lacustrine sediments, 3) parent material for sediment and soil formation, and 4) raw material for stone artifact manufacture. From an archaeological perspective, rates of sediment accumulation and surface stability act as controls on fossil and artifact preservation and accumulation.

Lab Methods

Five different types of sediment analysis were conducted in the lab, including 1) greater than 2mm fraction, 2) carbonate content, 3) pH, 4) texture, and 5) moisture. These analyses were conducted to address different components of the depositional of formation history of each stratigraphic unit.

>2mm Fraction

The greater than 2 mm sediment fraction was separated from the sand, silt and clay sediments using a 2.00 mm metal sieve in preparation for measuring their true particle fraction weight as well their post-depositional carbonate weight accumulation. This was conducted to understand the depositional forces accumulating sediment and different periods of time. All but one of the 25 samples measured contained clasts larger than 2 mm. These samples were placed in separate 600 ml glass beakers in preparation of removing carbonates adhering to the clasts. Carbonates were removed from the clasts by adding approximately 30 ml of water to the beakers followed by small additions of 20% HCl solution until all the carbonate had dissolved. The water and 20% HCl solution was then siphoned out of the beakers. The samples were placed in an oven to dry at approximately 110^{o}C for 18 hours. Once dry, the samples were re-screened through the 2.00 mm mesh sieve to separate any residual smaller sediment fraction from the greater than 2 mm fractions. The greater than 2 mm sediment fraction was then weighed to the nearest milligram and recorded on standard data recording sheets.

Carbonates

Carbonates were analyzed because they represent the result of secondary pedogenic formations corresponding with surface stability. Approximately 10 g of sediment from each of the 25 samples was separated from the original sample weight using a riffle splitter in order to begin the Chittick method (Dreimanis 1962). Each 10 g sample was split again until approximately 2.5 g of sediment remained. This new sample weight was then pulverized in a ceramic mortar and pestle and passed through a 200 mesh sieve until approximately 1.7 g of sediment could be analyzed.

pH

Sediment pH is especially important because it has a direct effect on how well bones may preserve underground. A more acidic sediment or soil will break down bone more quickly than if the sediment was more alkaline (Ryder and Graham 1996). Between 5 g and 10 g of sediment from each sample was gently ground with a rubber pestle in a ceramic mortar after having been divided using a riffle splitter. The samples were then added to individual 50 mg glass beakers. An equal amount of de-ionized (DI) water was added to each sample. Each sample was thoroughly mixed with a glass stir rod. The well mixed sample was left to settle for approximately one hour. A digital pH meter was then used to probe into the sample.

Texture

Sediment texture represents both the parent material as well as particle size sorting due to pedogenesis. Approximately 30 g of sediment was analyzed from each sample. Samples were first treated with 20% HCl solution in appropriately labeled centrifuge tubes to remove as much carbonates as possible adhering to the clasts and disaggregate those particles. The HCl solution was then siphoned out of the centrifuge tube. Approximately 200 mg of DI water was added to the centrifuge tube. Samples were then placed in a centrifuge for five minutes at 1,500 rpm to separate the water from the sediment particles. Most of the water was then siphoned out of the centrifuge tube and the sediment drained into a 500 mg beaker. All sediment was carefully removed from the centrifuge tube using a spray bottle. 100 mg of 0.5% Calgon solution ($Na(PO_4)_6$) was added to each sample and thoroughly stirred with a glass stir rod to disaggregate the clay and silt bonding to the larger particle clasts. Samples were left to settle overnight.

The pipet method, as described by Gee and Bauder (1986:383) was used to assess the different particle sizes. Clay and sand weights were directly measured. Silt weight was ascertained by finding the difference of the original sample weight from the clay and sand weights.

In order to measure the sand content from each sample the dry sand was carefully brushed out of each beaker and weighed to the nearest milligram. This provided an initial value for the percent sand in each sample. The sand fraction from each sample was further separated through five different sized sieves. Those sieve sizes were 1.00 mm, 0.5 mm, 0.25 mm, 0.125 mm, and 0.063 mm. Each sample was added to the sieves and then attached to a Ro-Tap machine and let to separate into the five screens for ten minutes. After the ten minutes the sand fraction from each sieve was removed and weighed; the remaining silt and clay content in the bottom pan was also weighed. The final sand weight was the combined weight of all the five sand sieves.

Moisture

Sediment moisture was assessed to understand how much this could affect texture sample weight. Approximately 5 g of sediment was weighed and placed into pre-weighed beakers. Samples were placed in an oven set at 110°F overnight. The weight of the dry samples was taken, and percent moisture was calculated from the weight difference.

Geology of Test Units M11 and M12

In this chapter sediment data from M11 and M12 are new contributions that expand our understanding of how portions of the north-south axis of this site developed overall. This analysis has implications for reconstructing not only the depositional and formation environments but also placing the chronostratigraphic record of hominin occupations and other archaeological materials into greater context. These data are reviewed with respect to source, sediment morphology, and sediments as stratigraphic and paleoenvironmental markers. Jenny's (1941) factors of soil formation and the interplay between deposition and erosional events are stressed.

First, a brief discussion of the location and context of the two selected test pits is laid out. Second, a detailed description of each stratigraphic unit is presented. Here, stratigraphic units are defined by sedimentological comparisons with the M5 type section. Third, discussions are presented from each test pit signifying the site formation importance of specific stratigraphic units and their corresponding sedimentological data. Finally, conclusions are presented to summarize broader site formation processes.

Test Pit M11

Excavations at M11 revealed two occupation surfaces, medieval and paleolithic. The most recent occupations were medieval and included three separate occupation surfaces extending up to two meters deep and penetrating more than a meter through the paleolithic sediments. Recovered medieval artifacts included three earthen bread ovens and a 1.5 m tall wine vessel all surrounded by a mix of midden debris of bones and broken pottery.

A profile of paleolithic sediments more than two meters wide and two meters thick was exposed here. An initial profile survey revealed lighter than usual colored sediments along with several large fossils emanating from throughout this exposure. This initial exposure obviated the importance for further testing to document the site development and potential significance of this location. Later profile analysis revealed several complex sediment facies (Figure 3.1). Overall, the efforts put forth here yielded a remarkable record of paleolithic site development that included artifacts and subsequently hominin and other fossil remains.

Stratigraphy

Stratum A consists of dark volcanic ash-fall sediments and represents the oldest exposed sediments at this test pit. More than one meter of volcanic ash was preserved in this test pit but the entire thickness of these deposits was not fully exposed during this field season and may be deeper still. These sediments are massive pale-brown (10YR 5/2.5) fine-sand grading up to brown (10YR 5.5/3) sandy-loam ash-fall primarily of mafic igneous grains surrounding a single exposed pillar of basalt (Table 2.1). This unit has fairly uniform texture of ~65 to 67% sand, 30 to 35% silt and 0 to 3% clay. Very few granules or cobbles were recovered and few coarse sand-sized clear obsidian grains were observed during lab analysis. Pedogenic carbonate is common overall, from 6 to 8%, with thick carbonate veins and nodules suggestive of surface stability and soil development. Few small krotovina were noticed with grey calcareous fill.

Several *in situ* well-preserved macrofaunal bones were also noticed in the upper half-meter of this unit. This unit was only analyzed on the southern extent of this test pit; two Strata B1 pipe/gully features were exposed within these sediments.

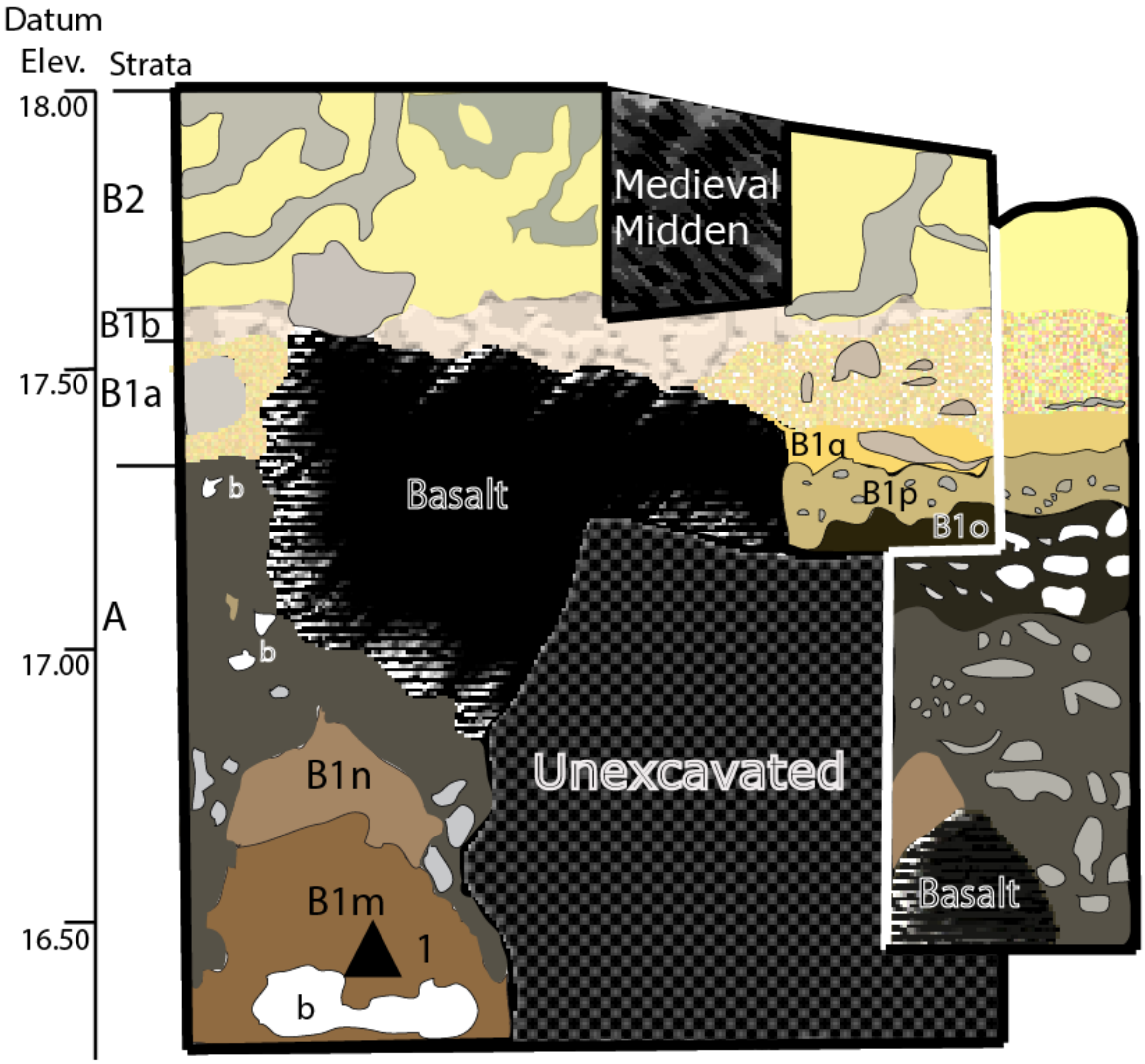


Figure 3.1. M11 stratigraphic profile. The right side of this profile is outlined in white signifying that this profile has been superimposed from 50 cm in front of the main western profile. There are two pipe/gully features represented by Units 1) B1m, B1n, and 2) B1o, B1p, B1q; many of these pipe/gully units were filled with fossils, here designated with the letter ‘b’.

Several depositional episodes occurred here after Stratum A and are discussed in chronostratigraphic order. The first deposits are Strata B1a and B1b, which were deposited directly over Stratum A sediments. This was followed by a period of erosional events forming pipe/gully features that were filled with B1m and B1n, and B1o, B1p and B1q sediments. The last sediments to be deposited here are tentatively designated as Strata B2 due to their truncation with medieval deposits as well as sediment characteristics.

Stratum A is conformably overlain by Unit B1a, a pale brown (10YR 6/3) indurated calcareous sandy loam with primarily silt to fine grained sand and various common igneous angular and rounded granules to small cobbles. Texture is distributed between 60 to 65% sand, 30 to 35% silt and 3 to 4% clay. Secondary carbonates are moderately abundant with concentrations up to 15%. Several krotovina, some with large chambers, were filled with grey sediment. Occasional well-preserved bones were recovered from the lower portion of this unit. This level terminates with an abrupt wavy boundary.

Overlying Unit B1a is Unit B1b. This bed is up to 15 cm thick but is unevenly developed and disappears laterally in places. The sediment is a pale brown (10YR 6/3.5) sandy loam with primarily silt to medium-sand sediments with very few rounded to subrounded igneous granules and pebbles; no obsidian was observed. The texture is approximately 65% sand, 30% silt and 5 to 6% clay. This is in conjunction with a weakly laminated secondary subhorizontal to anastomosing indurated calcareous laminae with 10% carbonate content.

Stratigraphic Units B1m and B1n are two separate pipe/gully deposits. Unit B1m is at least 40 cm thick and 60 cm wide filled with dark grey (10YR 4/1) loamy sand fining upwards to a grayish brown (10YR 5/2.5) sandy loam filled with very few large angular to subrounded pebbles, several of which are igneous. The texture is fairly uniform throughout with 68 to 72% sand, 28 to 31% silt and 0 to 1% clay.

Table 3.1

M11 Sediment Data

			Texture (%)			Gravel (%)						
Strata	Depth (cm)	Munsell Color	Clay	Silt	Sand	<1cm	1-2cm	2-5cm	>5cm	Gravel Density (g/m^3)	CaCO3	pH
B2	0-40	10YR 6/4	4.31%	33.44%	62.25%	3.2	24.2	12.6	60	3335	5.36%	8.88
B2		10YR 7/4	6.07%	52.57%	41.36%						15.66%	8.86
B1b	40-46	10YR 6/3.5	5.17%	30.14%	64.69%	3.1	11.6	12.9	72.4	6531	10.01%	8.90
B1a	46-72	10YR 6/3	3.53%	34.23%	62.24%						14.08%	8.74
B1q	62-72	10YR 5/3	1.78%	29.67%	68.55%						5.63%	8.96
B1p	72-82	10YR 6/3	1.77%	52.73%	45.50%	3.1	61.5	35.4		N/A	9.14%	8.99
B1o	82-104	10YR 4.5/2	2.39%	38.94%	58.67%	7.5	92.5				7.19%	8.97
B1n	114-134	10YR 5/2.5	0.22%	37.59%	62.19%	0.6	10.7	88.7		N/A	9.40%	8.55
B1m	134-176	10YR 5/2.5	1.01%	30.55%	68.44%						7.62%	8.79
B1m		10YR 4/1	0.07%	28.54%	71.39%						4.89%	8.72
A	70-164+	10YR 5.5/3	2.27%	30.81%	66.92%	0.4	13.1		86.4	N/A	6.09%	8.54
A		10YR 5/2.5	0.00%	34.80%	65.20%						7.26%	8.76

Carbonates are moderately common increasing in abundance from 4 to 8% and formed or were introduced during the sediment fill episode. Articulated long bones from at least two species of macrofauna were uncovered concentrating at the bottom of this pipe/gully feature.

Unit B1m is conformably overlain by Unit B1n. This unit is 20 cm thick with grayish brown (10YR 5/2.5) sandy loam sediments which are slightly finer in texture than the upper Unit B1m sample. There was only a trace of clay and no gravels. A large concentration of hard brown rip-ups was encountered on the northern part of this unit. This unit also shows anincreased concentration of secondary carbonate to approximately 10%. So far this unit is sterile of any artifacts, bones or other secondary features.

The overlying pipe/gully feature contains three episodes of sediment deposition. The earliest and deepest Unit is B1o. This Unit is 20 to 30 cm thick and is a dark grayish brown (10YR 4.5/2) sandy loam with few angular igneous granules and small pebbles including red porphry and very rare clear obsidian. The texture is approximately 58% sand, 39% silt and 3% clay. Secondary carbonates account for 7 to 8% of the overall composition. This unit contained a dense accumulation of assorted macrofaunal remains including several hominin elements.

Unit B1o is disconformably overlain by Unit B1p. This unit is approximately 10 cm thick with pale brown (10YR 6/3) fine sandy loam. Very few rounded to subrounded basalt and other igneous granules and pebbles were recovered; few clear and grey obsidian grains were also observed. The approximate texture is 45% sand, 58% silt and 2% clay. Secondary carbonates account for 9 to 10% of the overall composition. There were far fewer macrofaunal remains recovered from this unit, including several intruding from Unit B1o. In addition, abundant small krotovina with gray calcareous fill were observed in the profile.

The final pipe/gully episode is Unit B1q which is a 10 cm thick brown (10YR 5/3) sandy loam much coarser in texture than the underlying Unit B1p. The texture is approximately 68% sand, 30% silt and 2% clay with extremely rare additions of angular to subangular basalt, obsidian and other igneous granules. There is also a sudden reduction of secondary carbonates to between 5 and 6%. Very rare, but large krotovina 4-5 cm wide are present and traverse the lower part of this unit contacting the top of Unit B1p.

The last unit exposed in this test pit broadly resembles Unit B2 from M5. Here this unit is at least 40 cm thick with a very pale brown (10YR 7/4) to light yellowish brown (10YR 6/4) upwards coarsening silt loam to sandy loam with moderate quantities of various sized round to subrounded igneous gravels (i.e. andesite, basalt and few small clear obsidian) up to the size of small cobbles. The lower portion of this unit is approximately 41% sand, 53% silt, and 6% clay with 15 to 16% secondary carbonates. Near the top of this unit the texture is much coarser with approximately 62% sand, 34% silt, and 4% clay with a decrease to just 5 to 6% secondary carbonates. Faunalturbation is quite common, with burrows and chambers up to 6 to 8 cm wide.

Test Pit M12

Excavations at M12 revealed two occupation surfaces, late Bronze-Age and paleolithic. A short surface disturbance of late Bronze-Age trash was uncovered right above and surrounded by the paleolithic sedimentary Units B-L2 and B-L1; Unit B-L1 and B-L2 are temporary designations and subject to change given that they are at least local features which have not been identified elsewhere on the promontory and no precise chronostratigraphic correlation has yet been determined. Excavations revealed well stratified sediments and several paleolithic occupation surfaces corresponding to different deposition events. Testing revealed a record of sediment deposition and soil development more than three meters thick (Figure 3.2; Table 3.2). Several artifacts were recovered but only from the upper B units; very few fossils were uncovered as well.

The facies and formation of M12 is complex having formed on unstable surfaces near the edge of the promontory with multiple episodes of erosion. At least five strata along with their corresponding subunits were defined at this locality. These units are discussed in detailed chronostratigraphic order below.

Stratigraphy

The deepest Stratum A sediments exposed and analyzed at M12 is Unit A1. This unit is approximately 35 cm thick with very dark brown (10YR 2.5/2) very fine sand and silt loamy-sand mafic ash (Table 3.2). Very few particles larger than sand grains were recovered and those appear to be fragments of the underlying basalt. The texture is approximately 73% sand and 27% silt with no clay detected. Relict burrows with gallery chambers filled with grey-brown sediments were observed near the base of this unit. A well-worn bovid molar was recovered from one of these burrows but originated further up in the stratigraphy. Overall, this unit had a very weak secondary carbonate presence of 0 to 1%; a long carbonate concretion from the overlying unit penetrated the upper portion of this unit. This unit terminates at the top with an abrupt wavy boundary sloping 8^{o} to the southeast.

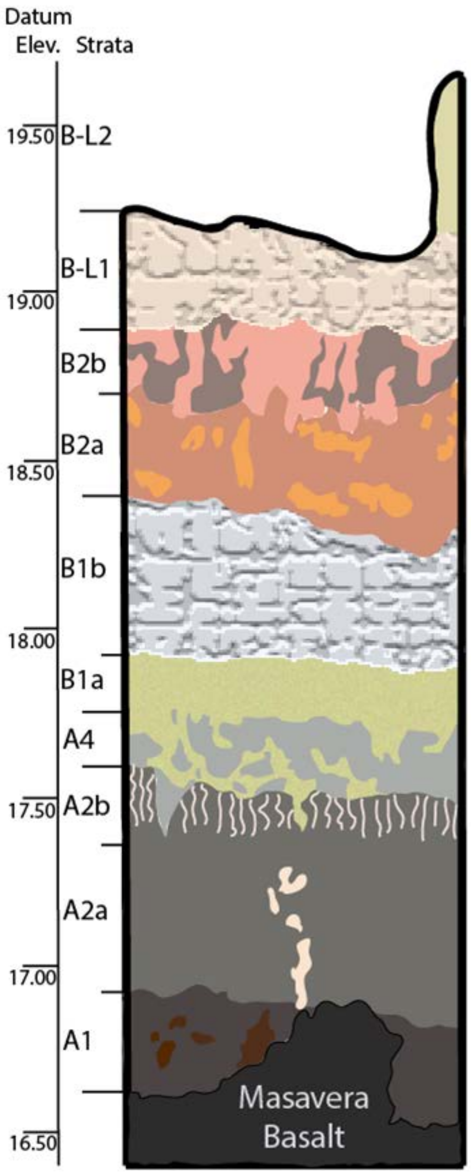


Figure 3.2. Illustrated M12 stratigraphic profile

Immediately above Unit A1 is Unit A2a. This unit is a 40 to 45 cm thick dark brown (10YR 3.5/3) sandy loam subtly coarsening upwards to dark yellowish-brown (10YR 4/4) loamy sand ash-fall deposit. The texture ranges from 67 to 73% sand and 27 to 33% silt with no presence of clay detected. There was a small quantity of angular to subrounded granules, small pebbles and a small cobble. The lithology is unevenly distributed between obsidian, basalt, microcline, quartz, granite and other unidentified igneous stone. Secondary carbonate content is very low, between 0 and 2%, and uniformly distributed throughout. Several vertical carbonate concretions were observed within this unit. Krotovina are very rare. Those burrows are small, mainly 1 to 2 cm wide, and were only noticeable at the top of this unit. In addition, many thin brown and dark grey laminations were interfingered throughout this unit.

Unit A2b is a slightly lighter dark yellowish brown (10YR 4.5/4) sandy loam of approximately 68% sand and 32% silt with rounded and subrounded basalt, obsidian as well as other unidentified igneous granules and pebbles. Extending down from the surface of this unit are several thin carbonate-lined pores which all abruptly terminate at the same elevation; these features are similar to those found at M5.

Table 3.2

M12 Sediment Data

			Texture			Gravel						
Strata	Depth (cm)	Munsell Color	Clay	Silt	Sand	<1cm	1-2cm	2-5cm	>5cm	Gravel Density (g/m^3)	CaCO3	pH
B-L2		10YR 8/2	0.74%	39.90%	59.36%	9.4%	15.5%	8.8%	66.3%	14,626	27.06%	8.71
B-L2	0-45	10YR 8/2	1.43%	77.41%	21.16%						25.14%	9.13
B-L1	45-79	10YR 6.5/3	0.00%	33.37%	66.63%	3.7%	24.3%	5.7%	66.3%	24,200	7.16%	9.25
B2b	79-93	10YR 5.5/4	0.00%	26.32%	73.68%	1.1%	14.6%	6.7%	77.6%	73,274	0.36%	8.91
B2a	93-135	10YR 6/4	0.00%	38.60%	61.40%						3.29%	8.99
B1b	135-177	10YR 7/3	1.21%	51.96%	46.82%	1.3%	28.3%	30.5%	39.9%	14,535	30.79%	9.37
B1a	177-193	10YR 6/4	0.00%	51.94%	48.06%						15.95%	9.29
A4	193-217	10YR 5.5/4	0.00%	32.32%	67.68%	4.4%	31.0%	46.9%	17.6%	2129	7.76%	9.23
A2b	217-232	10YR 4.5/4	0.00%	32.80%	67.20%	7.7%	86.6%	5.8%	0.0%	2700	2.17%	9.06
A2a	232-275	10YR 4/4	0.00%	27.79%	72.20%	3.5%	47.3%	0.0%	49.2%	454	1.24%	8.87
A2a		10YR 3.5/3	0.00%	27.42%	72.58%						0.75%	9.19
A2a		10YR 3.5/3	0.00%	32.16%	67.84%						1.34%	8.74
A1	275-305	10YR 2.5/2	0.00%	27.20%	72.80%	0.0%	0.0%	0.0%	0.0%	0	0.46%	9.15

This suggests some period of surface stability prior to the erosional disconformity developing. This unit exhibits very little secondary carbonate overall, between 2 and 3%. Krotovina are still uncommon, with small 1-4 cm wide burrows filled with grey sediments. This unit terminates at the top with an abrupt wavy boundary sloping approximately 7^{o} to the southeast.

The last of the dark volcanic Stratum A ash-fall sediments is Unit A4. Unit A4 is approximately 24 cm thick with yellowish-brown (10YR 5.5/4) sandy loam sediment of 68% sand and 32% silt. Some large black and small clear obsidian grains are among larger rounded and subrounded igneous granules, pebbles and a basalt cobble. This unit exhibits an intensive network of large burrows and gallery chambers up to 6 cm wide some of which penetrate into Unit A2b. These burrows are filled with light yellowish brown sediment, the same color as overlying Unit B1a. There is a marked increase in secondary carbonate content to between 7 and 8%. This unit terminates at the top with an abrupt, wavy and faunalturbated boundary.

Stratum B begins with Unit B1a. This Unit is a 20 cm thick light yellowish brown (10YR 6/4) sandy loam ash-fall deposit with an abundance of mostly round to subangular granules, pebbles and rare cobbles of hornblende diorite, basalt, rhyolite, rhyodacite, rare obsidian and other igneous rocks. The texture is approximately 48% sand and 52% silt without any detection of clays. This unit later formed a very fine secondary massive carbonate feature of between 15 and 16%. Krotovina are rare and are only evidenced near the top of this unit. This unit terminates at the top with an abrupt, lightly wavy boundary.

Immediately overlying Unit B1a is Unit B1b, a 40 to 45 cm thick very pale brown (10YR 7/3) fine sandy loam with trace amounts of clay and obsidian. The texture is approximately 47% sand, 52% silt and 1 to 2% clay. Gravels were very abundant including many rounded and angular granules, pebbles and cobbles of tuff, andesite, basalt, diorite as well as other igneous and metamorphic types. This unit developed secondary, subhorizontal indurated calcareous laminae with concentrations between 30 to 32%. No intrusive features were observed. This unit terminates with an abrupt wavy boundary dipping 5 to 6^{o} to the southeast.

Unit B2 consists of two subunits. The deepest is Unit B2a, a 30 cm thick light yellowish brown (10YR 6/4) fine to medium coarse sandy loam colluvium with rare very-fine clear obsidian grains. This unit contains a very high density of round and angular igneous and metamorphic granules, pebbles and cobbles, as well as small-sized boulders. These sediments exhibit a very light trace of secondary carbonates between 0 and 4%. Large vertical and horizontal burrows 4 to 6 cm wide are filled with grey sediment and are scattered throughout this unit. This unit terminates with an abrupt, wavy and faunalturbated boundary.

The upper portion of Stratum B2 is Unit B2b which is between 20 and 40 cm thick depending upon associated faunalturbation activity. This unit is a yellowish-brown (10YR 5.5/4) medium to coarse loamy sand colluvium which contains a small quantity of medium-sand sized clear and black obsidian grains. The texture of this unit is coarser than the underlying unit with approximately 74% sand and 26% silt and no trace of clay. Overall, there are fewer cobbles but an increased presence of smaller pebbles when compared to underlying Unit B2a. These larger gravels are mostly tuff and basalt but rhyolite and other plutonic, igneous and metamorphic gravels are present in lesser quantities. There is hardly a trace of secondary carbonates, between 0 and 1%. 4 to 6 cm wide relict rodent burrows are very common; the vertical and less numerous horizontal passages are filled with darker grey sediment.

Strata B-L1 is a 30 cm thick pale brown (10YR 6.5/3) coarse to medium-fine sandy loam. The texture is approximately 67% sand and 37% silt with no clay or obsidian observed. This unit has many rounded, subrounded and angular pebbles with lesser quantities of granules and cobbles. These larger clasts are primarily tuff and basalt with lesser quantities of other igneous and metamorphic rocks. Secondary carbonates of 7 to 8% formed a nodular and laminated structure. No intrusive features were observed within this unit. It is unclear how this unit terminates because the upper part of this unit was disturbed by Bronze-Age occupations.

The last stratigraphic unit at M12 is Unit B-L2. Only a small portion of this unit remained preserved, while the rest was disturbed by a Bronze-Age occupation. This unit is at least 40 cm thick consisting of very pale brown (10YR 8/2) fine to coarsening upwards textured silt loam to sandy loam sediment with secondary fine massive indurated carbonates and moderate quantities of very-fine clear obsidian grains present at the base of this unit. The base of this unit consists of 20 to 22% sand, 76 to 78% silt and 1 to 2% clay. The upper part of this unit is much coarser with approximately 58 to 60% sand, 39 to 40% silt and 0 to 1% clay. A fair amount of primarily igneous, angular and rounded granules, pebbles and cobbles were recovered from the small volume of excavated sediment. In addition this unit contained strong carbonate content between 25 and 28%.

Discussion

M11 Formation Analysis

This section focuses on different components of site formation at test pit M11. This discussion has implications for local and possibly site-wide deposition and soil development through the comparison with other test pit data. Here the discussion is focused on sediment texture, pedogenesis through secondary carbonate development, as well as the erosional pipe/gully features.

Stratum A

The Stratum A sediments appear to be a relatively well preserved mafic ash although the precise stratigraphic association is still undetermined. This stratum shows signs of pedogenesis with small traces of clay and secondary carbonate development in the form of nodules, concretions and large veins. The presence of secondary carbonate features suggests a relatively dry environment for formation, possibly indicative of grasslands. Unusual for these sediments are the well preserved macrofauna bones uncovered in the upper part of this unit because bones are not generally found within these sediments. Further the sediments here are much lighter in color (10YR 5.5/3) than most other Stratum A sediments described on the promontory. In contrast, the texture of these sediments and carbonate content are similar to some Stratum A sediments on the promontory. Here, the sandy loam texture, with up to 3% clay, and common 6 to 8% carbonates are similar to some Stratum A sediments at M5 and the main blocks (Ferring et al. 2011, Gabunia et al. 2000). These sediments are further defined as Stratum A because of their association with intrusive, erosional Strata B1 pipe and gully features which cross-cut through this unit (Lordkipanidze et al. 2007).

Stratum B

These Stratum B sediments show much more evidence of pedogenesis and secondary carbonate formations than underlying Stratum A. Overall, Strata B1a, B1b and B2 show some of the highest concentrations of clay, between 3 and 7%, anywhere on the promontory. Further, secondary carbonates accumulated and developed features within these sediments. Again, the presence of secondary pedogenic carbonates suggests a dry climate for these features to form. This indicates that this location may have been stable for longer periods of time relative to other locations so far analyzed on the promontory.

Unit B1a is a massively indurated calcareous sandy loam. The calcrete which formed this unit likely developed before and during deposition and soil development of overlying Unit B2 (Gabunia et al. 2000). This massive and indurated carbonate horizon likely greatly restricted deeper water percolation. As a result this may have contributed to the preservation of bones in the B1 pipe and gully features (Gabunia et al., 2000).

Unit B1b formed a weakly laminated secondary subhorizontal to anastomosing indurated calcareous laminae. The resulting solution and reprecipitation of carbonates could have developed this horizontally uneven laminar horizon (Laity 2008). The gravel density within these sediments is also moderately typical of B1 units observed elsewhere on the site.

The highest stratum to be preserved is tentatively designated as Strata B2. This stratum exhibits a suite of characteristics which compare and contrast with the Strata B2 sediments described elsewhere on the promontory. Here the sediments are much lighter in color (10YR 6/4 and 10YR 7/4) and not as red as at M5 (7.5YR 4/4 and 7.5YR 4/6) or the main blocks (10YR 4/4 and 10YR 5/6) (Gabunia et al. 2000, Ferring et al. 2011). Yet, in contrast the color of these sediments is very similar to Strata B2 sediments from M12 (10YR 6/4 and 10YR 5.5/4). This unit also shows signs of intense faunalturbation with large burrows 4 to 6 cm wide, similar to those found nearby at the main block excavations as well as at M12 (Gabunia et al. 2000). This stratum is also similar to the sediments at the main block excavations with regard to the higher secondary carbonate content (Gabunia et al. 2000). In contrast the more westerly excavations of M5 and M12 show little evidence of carbonates (Ferring et al. 2011).

The low density of gravel in these sediments is unusual when compared against other Strata B2 sediments on the promontory. Pebbles and cobbles make up the majority of the gravel mass here, but the overall density of gravels in this stratum is low. Here gravel density is approximately 3,335g/m^3, merely 5% of the M12 Strata B2 gravel density represented at more than 73,000g/m^3. Several reasons could explain the general absence of gravels here including the location of M11 being outside of the greater depositional vector of these gravels.

This location also shows evidence of instability with marked erosional features forming at the end of the Strata B1 phase. Two pipe/gully features formed, possibly contemporaneous with each other, within these Stratum A sediments. Their orientations initially appear to be perpendicular to each other (Figure 3.3). Understanding their orientation is important for both their direction of flow and identifying possible larger drainage outlets but also for future excavation planning here and expectations for where fossils are more likely to be found. These features may only have existed for a short period of time. Evidence for this comes from the generally short life-span of pipes in general (Verachtert et al. 2010), as well as the well-preserved macrofaunal fossils, some still in articulation. This general lack of bone weathering suggests this feature quickly filled with Unit B1o sediments thereby burying and preserving the bones. Two subsequent sediment depositional episodes, Units B1p and B1q, finally filled this feature. Overall, the presence here of pipe/gully features indicated that these erosional features were forming over a much larger area of the promontory than previously observed.

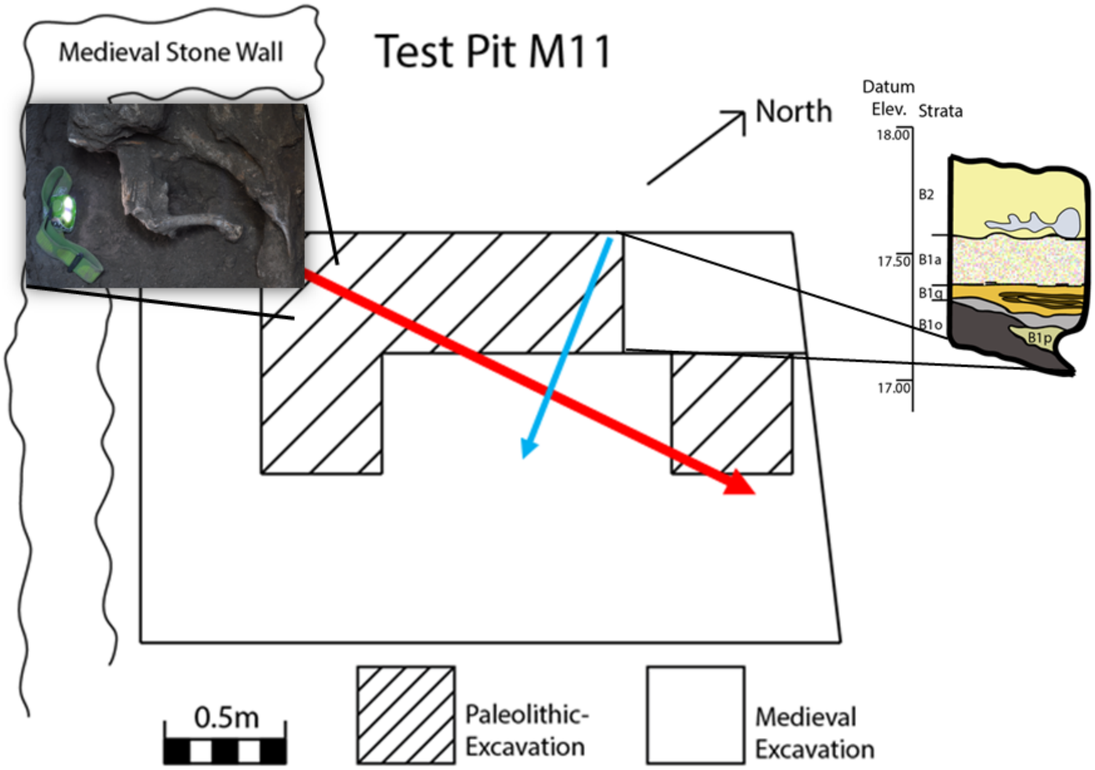


Figure 3.3. Test Pit M11 with the estimated direction of the pipe and gully features. The arrow in red is the direction of the pipe and the arrow in blue is the direction of the gully. The image on the left shows articulated long bones in the lower pipe/gully features. The profile on the right shows the direction of the upper pipe/gully feature.

M12 Formation Analysis

This section focuses on multiple components of site formation at test pit M12 and their implications for possible site-wide deposition and soil development through the comparison with other test pit data. Here the discussion is focused on both the textural and gravel particle size data with comparisons within and between carbonates and pH to show that site development can be both highly variable and can distort archaeological interpretations. Similar in-depth analyses could not be conducted as effectively from M11 due to the complicated formation of those sediments. In addition, the smaller sample size of recovered materials at M11, especially gravels, reduces the effectiveness of such analyses.

Stratum A

The Stratum A sediments are represented by three major Units: A1, A2 and A4. Strata A1 is represented by a fairly sterile loamy-sand ash-fall deposit with little evidence for pedogenesis or gravels. Moderate faunalturbation forming gallery chambers was noticed. Directly overlying Strata A1 is A2 which formed two substrata. These two substrata with their clear contacts likely represent the same type of serial ash-falls observed at M5 (Ferring et al. 2011). Each unit shows evidence for surface stability and pedogenesis in the form secondary carbonate nodules, concretions and carbonate-lined pores. There is a small accumulation of granules and pebbles and a single cobble. The final Stratum A bed is the Strata A4 ash-fall. This unit also shows evidence of pedogenesis in the form of an increase in secondary carbonate concentration and a slight decrease in gravel content. Further, this unit exhibits intense faunalturbation with large burrows throughout. Overall, while some strata and substrata are missing, these sediments are very similar to those observed at M5.

Stratum B

These Strata B sediments represent at least three separate depositional and formation events on the promontory. The principal depositional context in these strata is primary ash-fall deposits along with secondary gravels and pedogenic carbonate features.

The ash-fall sediments of Strata B1 developed into two secondary calcareous features, Unit B1a as a massively indurated calcareous sandy loam followed by Unit B1b which exhibits a weakly laminated secondary subhorizontal to anastomosing indurated calcareous laminae. These two secondary carbonate formations appear at M5, M11 as well as at the main block excavations (Gabunia et al. 2000, Ferring et al. 2011), and may have developed homogenously across the site. The origin of these carbonates has still not been resolved but they may broadly correspond to the sudden shift from a more humid climate during Stratum A to a drier climate during Stratum B (Messager et al. 2011). In addition, their thick accumulation and rapid development may suggest a more stable surface and some soil formation; the small amount of clay recorded from Unit B1b may corroborate such a hypothesis.

Strata B1 also contains a fair density of gravels. Approximately 14,500 g/m^3 of gravel was collected from this stratum which included primarily rounded cobbles of mixed lithology. Gravels and especially cobbles are not uncommon in Strata B1. In the main block excavations at the center of the promontory gravels and small cobbles are noted as being locally concentrated in colluvium (Gabunia et al. 2000) while not far away at M11 the density of gravels is approximately $6{,}500 g/m^3$ and the lithology mimics that from M12.

Strata B2 is broadly a faunalturbated dense gravel colluvium with trace deposits of obsidian possibly indicative of an ash-fall sediment origin. These sediments exhibit evidence for pedogenesis through rubification, although clay presence and secondary carbonate content is weak. This could indicate a sudden shift to a slightly moister climate and/or arboreal setting on the promontory especially given the similarities to arboreal B horizons. In addition, there is a sudden and abrupt increase in the quantity and density of gravels in this stratum from those exhibited in B1, both here and at M5 (Ferring et al. 2011).

The presence of intense rodent burrowing with vertical passages up to 6 cm wide and even larger horizontal chambers at M12 may suggest that some of these gravels, and possibly artifacts, were artificially sorted creating a biomantle (Johnson 1989). Translocation of gravels is immediately limited to the size of the burrow. The larger gravels which cannot fit through the burrow passages will gradually sink to the depths of the burrows while smaller gravels will become mixed throughout the evolving biomantle (Johnson 1989).

As mentioned above, during excavation gravels were collected at discrete intervals and were subsequently divided into four size classes. For the purposes of this analysis the largest size class, cobbles, were measured at >6 cm, instead of >5 cm, to reflect the maximum width of these rodent burrows. The granule and pebble data were measured at 10 or 20 cm intervals whereas cobble data were more finely analyzed and are measured here at 5 cm intervals. Figure 3.4 shows the distribution of gravel sizes at each level.

Despite somewhat coarsely measured collections data, the accumulation of cobbles deep in the B2 strata with a progressive fining upwards of smaller pebbles and granules may indicate that the gravels were either 1) naturally deposited in a fining upwards distribution or 2) an artificial stone zone (or biomantle) formed in Unit B2 stratigraphy. If a biomantle did not form then we would expect to see a more random distribution of all gravel sizes throughout this unit. Interestingly, the base of the densest cobble stone zone is near the boundary between Unit B1b and Unit B2a. It can be speculated that the secondary pedogenic carbonate formation of Unit B1b acted as a barrier for the burrowing fauna subsequently preventing cobbles from being translocated deeper in the profile.

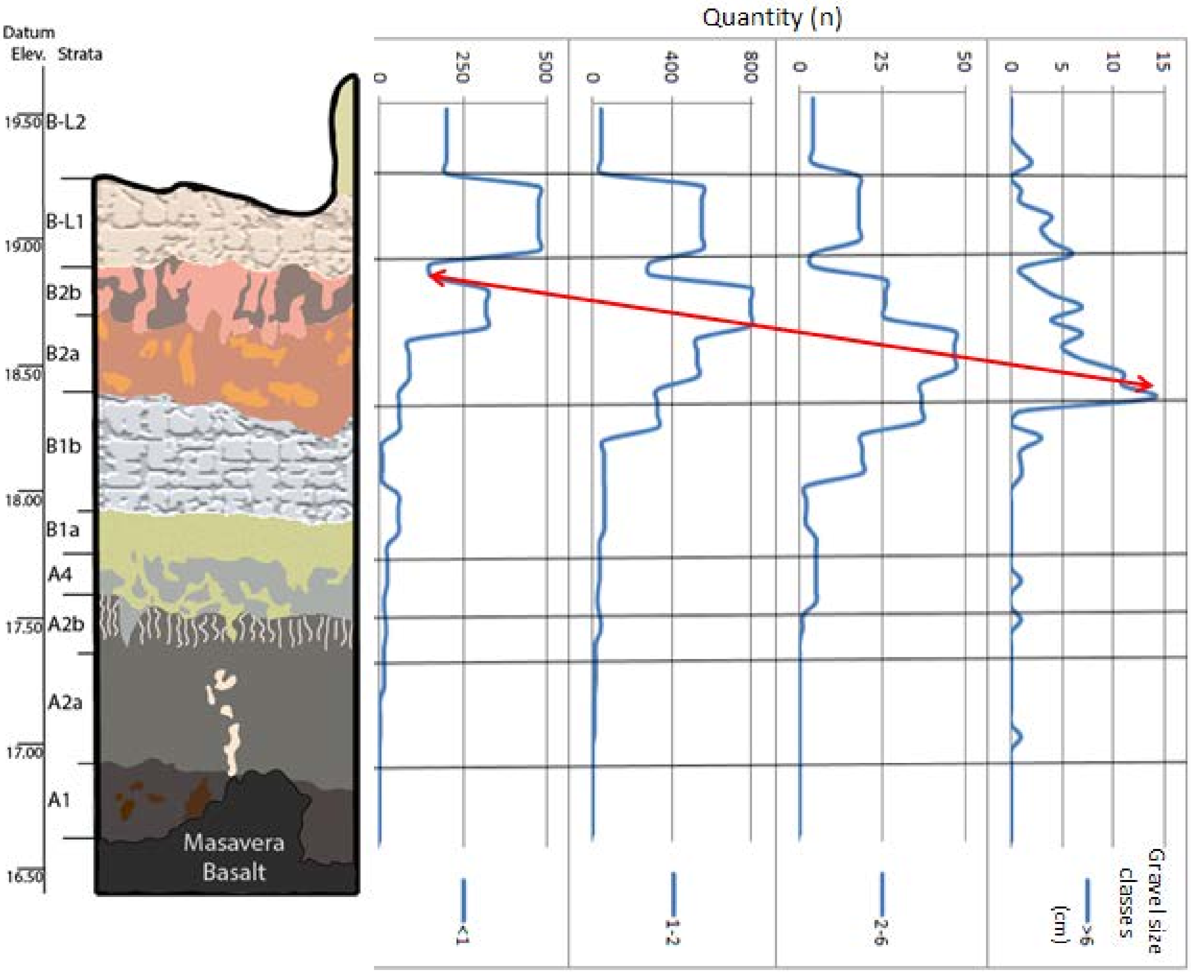


Figure 3.4. M12 gravel distribution divided by quantity and stratum. This figure provides evidence for a biomantle in Strata B2 sediments due to the fining upwards distribution of gravels as indicated by the arrow.

A stone zone and biomantle formation may also have affected the distribution of artifacts in Unit B2 stratigraphy as well. Thirteen artifacts were recovered from Unit B2, although only six of those were recovered and measured in situ; the remainder were recovered from collections. All of the artifacts were fairly small and only two were larger than 6 cm. The two largest artifacts, ranging in size from approximately 6.1 and 7.9 cm, were recovered deep in

Unit B2 at 18.35 m and 18.46 m above datum, respectively. The remaining eleven artifacts were all small, ranging from 1.9 to 5.6 cm long, with an average length of 3.2 cm. This distribution of artifacts mimics the distribution of gravels, and further suggests that burrowing fauna may have affected the distribution of these artifacts.

The sediments above Strata B2, Unit B-L1, are possibly a locally developed feature and so far do not correspond to any other stratigraphic unit observed or described elsewhere on the site. The precise chronological development of this unit is so far undetermined and two initial hypotheses are presented to place this unit within some chronological order.

This stratum has nodular and laminated pedogenic carbonates and may be a petrocalcic horizon associated with development during Strata B2; at M5 Strata B4 developed a similar petrocalcic feature, B4c, above a moderately developed soil (Ferring et al. 2011). In addition, this carbonate rich unit suggests a return to dry climates on the promontory. Further, this unit contained a high density of gravels, approximately 24,200g/m^3, with diverse lithology akin to underlying Units B2a and B2b suggesting possible contemporaneous deposition.

An alternative hypothesis is that this unit developed some time after the Strata B3 ash-fall. The sediments that filled the Unit B2b burrows were particularly dark and could have originated from the Strata B3 ash-fall. At M5 the burrows in Unit B2b are filled with grayish brown (10YR 5/2) B3 ash making it possible that the B2b burrows from M12 were also filled with the same B3 ash.

The sediments above B-L1, here designated as B-L2 are also possibly a locally developed feature and so far do not correspond to any stratigraphic unit observed or described elsewhere on the site. The coarsening upwards sediment texture, with a particularly high concentration of silt at the base, suggests some soil development and sediment sorting was at work. The density of gravels here is approximately 14,600g/m^3, which is slightly less dense than underlying Strata B-L1, but still suggests that this location was accumulating a fair bit of erosional debris. This strata further developed a secondary fine massive indurated carbonate horizon adding to evidence of a relatively dry climate on the promontory.

Sediment Texture Analysis

The textural composition of each sampled stratigraphic unit at M12 is different and corresponds principally with changes in sediment origin and soil development. In general, there is little soil development within the Stratum A sediments at Dmanisi, as indicated by the extremely low or non-existant clay fraction and carbonate content within these samples. In contrast, the Stratum B sediments show more evidence of soil development features and a slight increase in clay content from Stratum A. As a result, the primary texture comparison is between the sand and silt particle fraction.

Volcanic ash-fall sediments occur throughout the entire Dmanisi stratigraphic sequence and are texturally defined by primarily silt and very fine sand. The Stratum A sediments preserve these ash-fall sediments the best (Figure A3). In general, the lithologic properties of the mafic Stratum A ash-fall sediments is remarkably uniform (Table 3.2) suggesting quick, successive deposition and little soil development.

The lithologic composition of the Stratum B textural sediments is much more variable than Stratum A due to different types and rates of primary and secondary sediment deposition and soil development here. These sediments contain a much higher concentration of secondary carbonates as well as gravel colluvium than Stratum A. The origin of many of these carbonates is pedogenic while the origin of the laminated carbonates is still unknown. The carbonate did accumulate and form quite rapidly, especially at M12. In contrast the evidence provided here for the origin of the Stratum B gravels tentatively supports erosion from the slopes west of the basalt promontory.

M12 Gravels

The gravel characteristics for Stratum A and B at M12 are different and may correspond to temporal changes in depositional and erosional episodes on the promontory. The majority of the gravels in the paleolithic sediments occur within the Stratum B sediments; of the almost 60kg of gravels recovered from M12, less than 1% were recovered from the Stratum A sediments (Figure 3.5). In addition, many of the gravels are well rounded with a diverse lithology (Table 3.3) suggestive of a common, possibly relict fluvial origin; no fluvial sediments have been identified in these paleolithic sediments although relict terraces are present west of M5 and M12.

The general lack of gravels within Stratum A sediments may be due to both a general lack of erosion and/or shorter temporal period for gravels to accumulate between stratigraphic units. These gravels begin to densely accumulate during Strata B1. This initial accumulation of gravels may be related to the erosional episode forming pipes and gullies at the center of the promontory. The erosional disconformity between Strata A4 and B1 also indicates a period of surface instability. The origin of the Stratum B gravels could possibly be due to a failing terrace on the western part of the promontory (Ferring, personal communication).

Table 3.3

Lithologic Diversity of M12 Cobbles

M12 Cobble Data				Strata						
Raw Material	B-L2	B-L1	B2	B1	A4	A2b	A2a	TOTAL	% Rounded	% Angular
Tuff		1/3	4/29	-/4		1/-		6/36	14.3%	85.7%
Vit. Tuff			1/2					1/2	33.3%	66.7%
Rhyolite		1/-	3/2					4/2	66.7%	33.3%
Rhyolite Porphry		-/1	6/-					6/1	85.7%	14.3%
Andesite			3/-	2/-				5/-	100.0%	0.0%
Basalt	2/-	4/1	16/7	1/2				23/10	69.7%	30.3%
Plutonic		1/1	8/-	4/-				13/1	92.9%	7.1%
Quartz	-/1		1/2				1/-	2/3	40.0%	60.0%
Metamorphic			1/-	1/-				2/-	100.0%	0.0%
TOTAL	2/1	7/6	43/42	8/6		1/-	1/-	62/55	53.0%	47.0%
Percent Rounded	66.7%	53.8%	50.6%	57.1%		100.0%	100.0%			
Percent Angular	33.3%	46.2%	49.4%	42.9%		0.0%	0.0%			

(n/n shows rounded and angular cobbles)

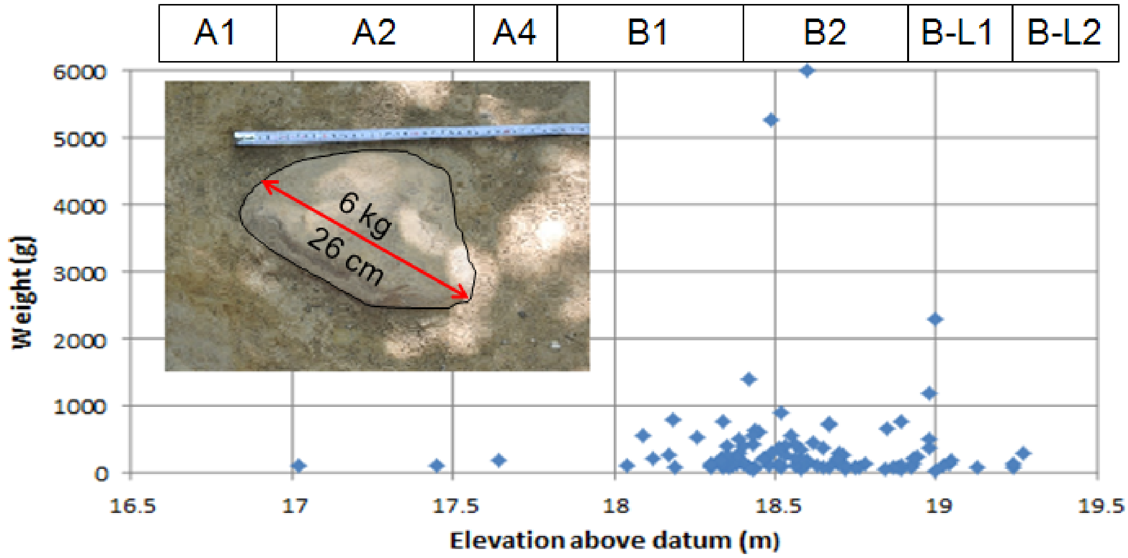


Figure 3.5. M12 cobble weights with associated elevation above the established datum; photo on the left side of the figure shows the 26 cm wide 6kg boulder collected from Strata B2.

It should not be discounted that some of these recovered cobbles may have been transported to the site by hominins and may have been used as manuports. Noting the general distribution of cobbles from throughout the entire M12 section, Figure 3.5, most weigh less than 1,000g and cobbles heavier than 1,000 g are rare. Especially unusual are the two cobbles in Strata B2 weighing between 5 and 6 kg at 18.5 m above the datum. It would be expected that several additional cobbles should have been recovered between 1 and 5 kg before cobbles much heavier were deposited. This distribution corresponds with transport load and the amount of energy it would have taken to naturally mobilize these cobbles downhill and at a very similar time. Without a doubt the sizable gap in cobble mass at that period of time is peculiar, but may also not be representative of the true gravel distribution given the small sample area excavated. Tentatively, this anomaly stands to suggest that the two heaviest cobbles may have been transported to the site by hominins, although no physical traces on these two cobbles indicate that they were altered.

M12 pH

At test pits M11 and M12 the pH throughout each facies is consistently between 8.5 and 9.5. This high pH is particularly useful for the long-term preservation of bones and fossils within these sediments; that may partially explain why the fossils in the pipe and gully features at the center of the promontory preserved so well, but it does not necessarily explain the general absence of fossils outside of these strata. The pipe and gully features along with rapid burial likely contributed more to the initial preservation of bone. The goal of this section is to suggest possible explanations for why the pH of these sediments is higher than expected given the associated parent material.

The primary parent materials within the Dmanisi sediments are volcanic ash. Volcanic ash generally ranges in pH from slightly alkaline to moderately acidic given changes in composition (Dawson 2010). Secondary carbonates are alkaline minerals which generally range in pH from 7.0 and 8.0 in sediments, but can get as high as 8.4 depending on how much of the CO_2 concentration is enhanced by biological activity (Brady and Weil 2002: 414). Therefore typical alkaline ash and carbonates with strong biological activity cannot fully explain the high pH observed within these Dmanisi sediments. Other soluble minerals, which have yet to be detected, may be responsible for the higher pH values observed here.

The volcanic ashes of Strata A, most of which are particularly unaltered, have an initial pH ranging between approximately 8.5 and 9.25 (Table 3.1 and 3.2, Figure 3.6). This may suggest that the original chemical composition of the Dmanisi ashes was particularly alkaline. Further, in general it was observed that as carbonates are added to the sediments and concentrations increase the pH level slowly increases (Figure 3.7), although no significant trend was noticed and outliers were common. This last point runs counter to how carbonates should affect the pH of sediments, especially if the pH of the parent material from most sedimentary units was at or above a pH of 8.5. This may imply that coinciding with carbonate additions are other more alkaline minerals which enhance the pH of the sediment. Additional chemical analyses of the Dmanisi sediments may identify an abundance of highly alkaline minerals which are raising the pH of these sediments.

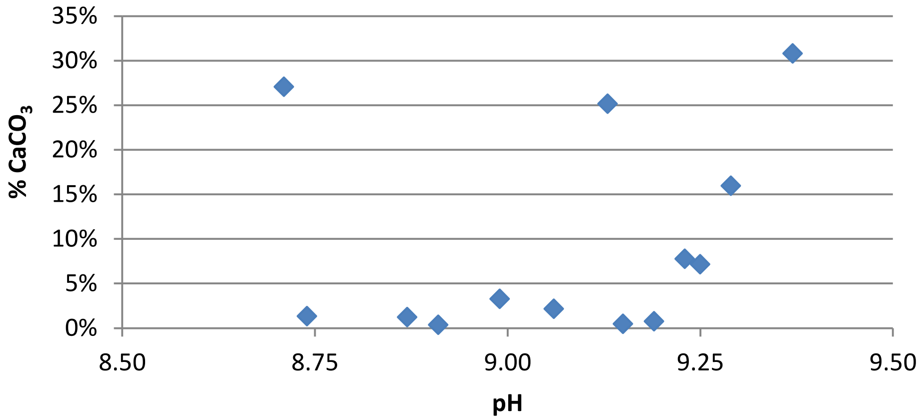


Figure 3.6. M12 carbonate and pH values.

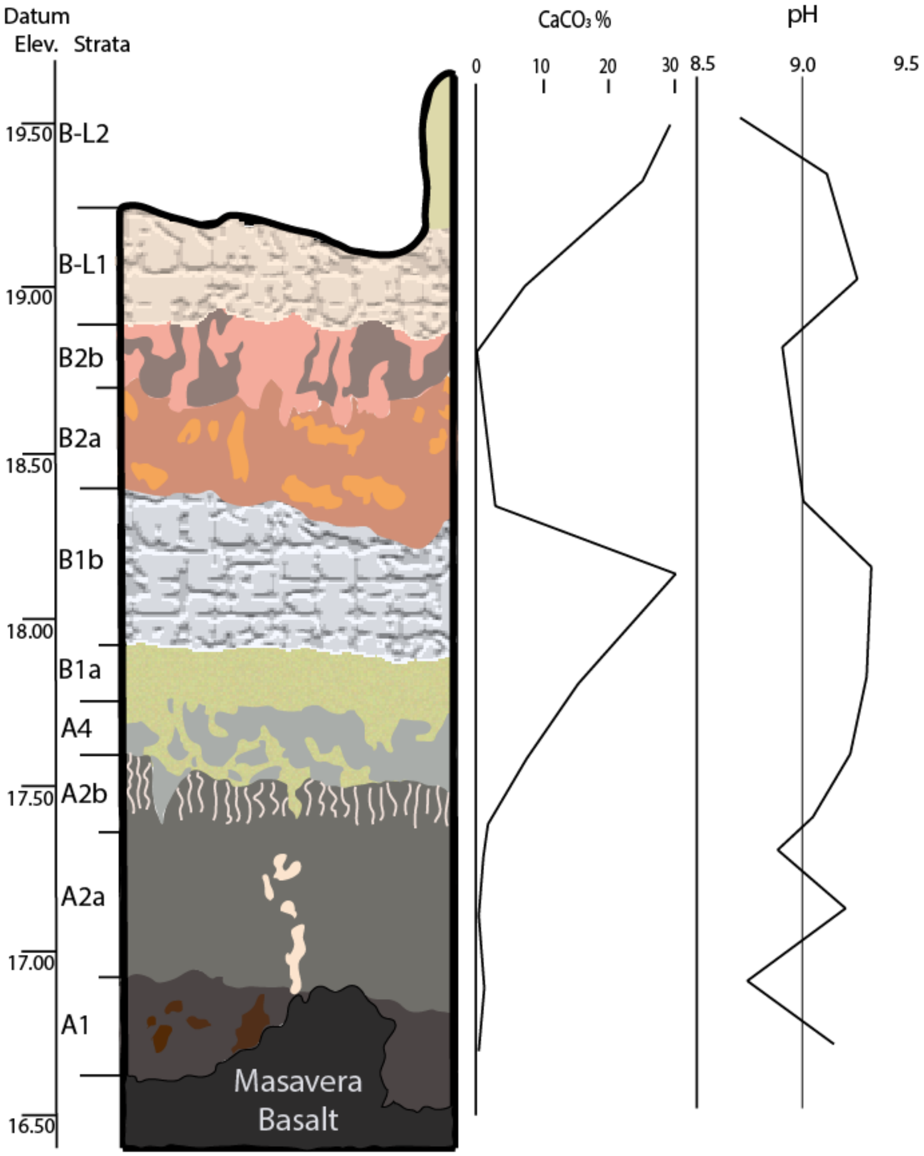


Figure 3.7. M12 carbonate and pH stratigraphic comparison

Conclusion

The accumulation and development of sediments at Dmanisi was active for a relatively brief period of time. The origin of the sediments (i.e. volcanic ash-fall, carbonates, gravels, etc.) in each stratigraphic unit is a key component to understanding the environmental origin (i.e.

eolian, fluvial, colluvial) of the deposited sediments in this setting. Primary sediments, those with little or no soil development and lacking evidence for major pedoturbation, provide the best information of origin. Complications arise when sedimentary units begin to develop soils, when secondary deposits and features are added or form within that unit, and when sediments are disturbed from pedoturbation or erosion events. Alternatively, pedogenic features can be important climatic and environmental markers.

Sedimentary Environments

The origin of many of the particles in many of the stratigraphic units at Dmanisi is volcanic ash-fall sediments. Intensive volcanism occurred around Dmanisi during paleolithic occupation of the promontory. Tephra can accumulate rapidly, burying previously exposed surfaces and retarding further soil development. Upon initial deposition, the particle size of this volcanic glass is generally in the silt to fine sand range. The structure is amorphous and porous, allowing for both rapid weathering to quickly form clays as well as allowing for the infiltration and translocation of other minerals, such as carbonates to accumulate between pore spaces (Birkeland 1999, Buol et al. 2003).

The Stratum A sediments contain well-preserved mafic ash-fall. These sediments are relatively undisturbed with little evidence of pedogenesis suggestive of rapid successive deposition (Figure A3). This probably meant that the promontory was only marginally vegetated during this time and would not have attracted many fauna, including hominins to this location. This idea may be further corroborated by the general lack of fossil evidence as well as few artifacts recovered from within these sediments.

The general lack of fossil evidence throughout Stratum A also may have to do with preservation bias than a total lack of bone presence on the promontory throughout this time. As was discussed many of these sediments are highly alkaline which favor bone preservation, but it also seems that subterranean burial in pipe/gully features was a more favorable environment for bone accumulation, preservation and fossilization overall. Therefore, given the lack of pipe/gully features during Stratum A, it can be assumed that the skeletal remains of an animal which died on the promontory over this time would most likely preserve during a renewed ash-fall event.

The hominins occupying the promontory during Stratum B were experiencing similar depositional environments but with much more stable surfaces and soil formation than Stratum A. Excavations at test pits M11 and M12 primarily revealed just two Stratum B Units, B1 and B2. Each of these units shows strong evidence for pedogenesis including the presence of clay. Strata B1 generally developed secondary pedogenic carbonate features, some more than half a meter thick. Strata B2 is generally well rubified and dense in cobble colluvium.

Secondary carbonates are found within the Dmanisi sediments towards the end of Stratum A and developed into indurated features during Stratum B. The origin of these carbonates is still under investigation but most appear to be pedogenic, but the climate may have been a factor. In contrast, units with weak carbonate content, such as B2, may have been experiencing a moister climate whereby carbonates could not accumulate in the sediment and were thus flushed out.

The Stratum B units contain secondary deposits of gravel colluvium, such as in B2, and carbonate formations, such as in B1. Colluvium consists of debris carried by slope wash into the valley and mixed with varying amounts of talus (Thornbury 1969: 164). The processes that affect the rate of colluvial accumulation are climate, rock type, thickness and type of soil (or sediment) cover, slope angle, and vegetation (Courty, Goldberg and MacPhail 1989). There were at least favorable conditions for gravel to accumulate during at least Strata B1 and B2; such conditions may not have been as apparent during other periods on the promontory.

At the center of the promontory relict natural pipe and gully features formed towards the end of the Strata B1 phase (Lordkipanidze et al. 2007). In general, piping can be defined as the corrosion of subsurface sediments, often of a clastic matrix, with a temporarily supportive roof structure caused by the infiltration of water moving laterally across a subsurface layer and discharging those sediments onto the surface through an outlet such as a gully (Barendregt and Ongley 1977, Verachtert et al. 2010). Pipes most easily form in dry climates with sparse, often shrubby vegetation (Verachtert et al. 2010). Evidence of this can be seen from the pedogenic carbonate features which formed during Strata B1. Alternatively, pipes often fail within a few years (rarely lasting more than 10 years) due to gravity (Faulkner et al. 2008, Verachtert et al. 2010, 2011). The re-filling of these pipes with younger sediment may be a response to a moister climate which is evident within Strata B2. Overall, these features are responsible for the preservation of the majority of the fossils recovered from Dmanisi (Lordkipanidze et al. 2007).

Across the north-south axis of the site contemporaneous stratigraphic units were forming at different elevations and affecting relative topography (Figure 3.8). This was partially the result of the underlying bedrock but also probably due to differential effects of accumulation and erosion of sediments. For instance, the deeper basalt at M5 may have been responsible for the preservation of a thick and very complete Stratum A profile. In contrast, at

M11 and M12, where the bedrock was about 2m higher these units are relatively thinner and may have been more prone to erosion.

Interpretations for the formation of Stratum B sediments are more difficult given the variability in unit preservation and pedogenesis among contemporary units across the site. During Unit B1, relatively thick pedogenic carbonate features appear to develop further away from the pipe/gully episode occurring at the center of the promontory. This would have been a relatively dry period on the promontory and probably promoted the grasses and shrubs Messager et al. (2010a) suggest. Alternatively, Strata B2 is similarly thick, rubified, devoid of carbonates and dense in gravels on the western axis of the site. This suggests that at least the western portion of the promontory was developing fairly homogenously. In contrast it is currently difficult to interpret the presence of B2 sediments at M11 and if these are B2 sediments they are very different from those on the west side of the promontory. Finally, units above B2 appear to have preserved and developed more erratically along this north-south axis. Previously undiscovered and carbonate rich units were at least locally present at M12, whereas at M5 most of these sediments are rubified and no younger units preserved at M11.

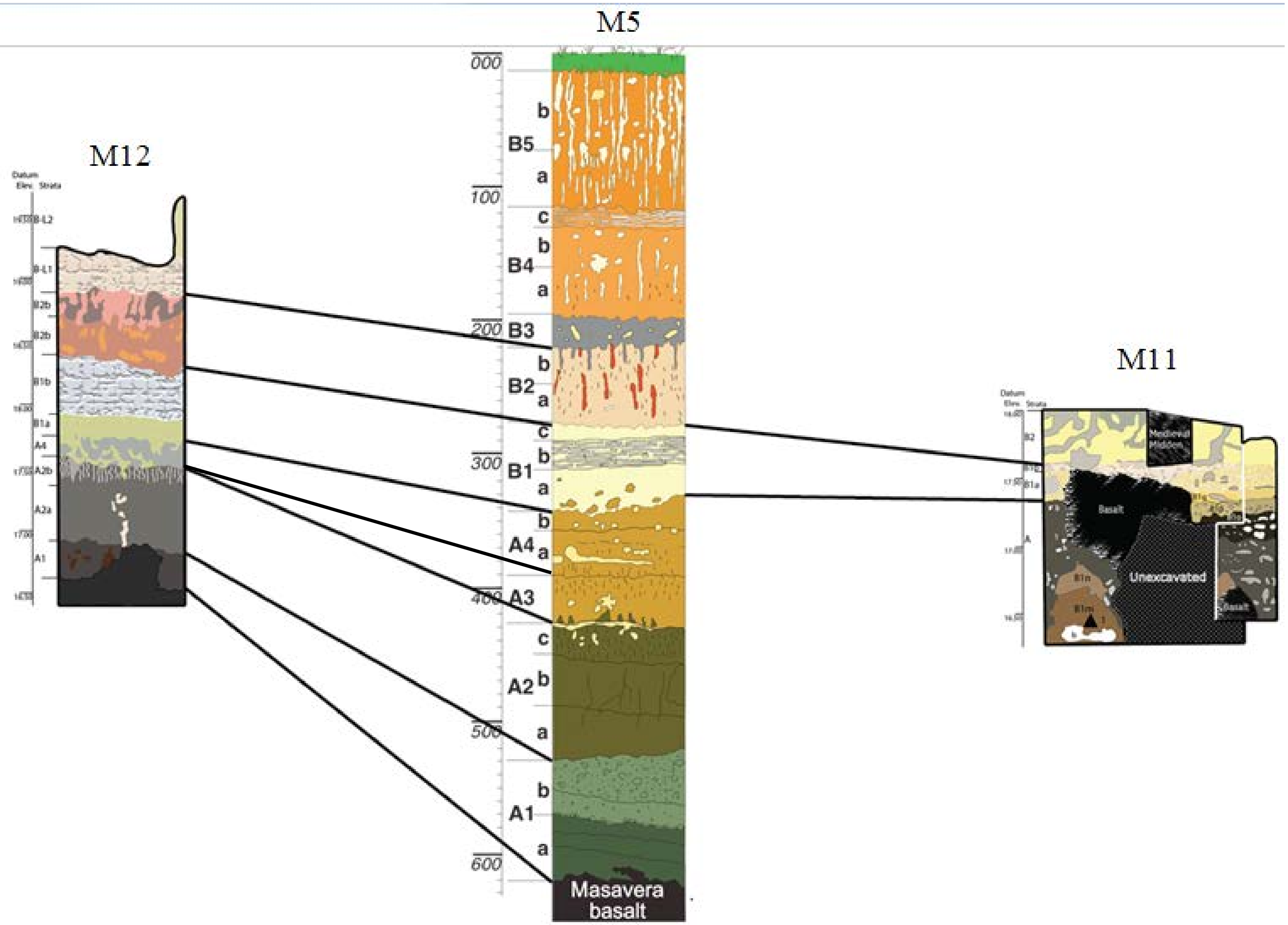


Figure 3.8. Stratigraphic comparison between M12, M5 (Ferring et al., 2011) and M11.

CHAPTER 4

ARCHAEOLOGY OF M11 AND M12 UNITS AT DMANISI

Introduction

Paleolithic flaked stone artifacts were first recognized by archaeologists at Dmanisi in 1983 (Gabunia et al. 2000). Over the course of almost three decades of excavations several thousand simple flaked stone artifacts have been recovered (de Lumley et al. 2005, Mgeladze et al. 2011). These artifacts have been recovered from more than a dozen excavation pits and, although unequally, from almost every stratigraphic unit on the site. All of these artifacts fit into the Mode I industry, characterized by a simple flake-core technology.

Initial paleolithic excavations, including both large blocks and small test pits, were concentrated near the center of the promontory. Many of these early excavations stopped at the cement-like pedogenic carbonate layer of Unit B1, exposing and recovering just the Stratum B materials which were primarily stone artifacts. Later excavations penetrated through the B1 calcrete and into the deeper Stratum A sediments. Within the Stratum A sediments are erosional pipe and gully features that formed at the start of Stratum B. Both features are especially abundant here, with concentrations of numerous fossils including hominin skeletal remains and some artifacts. All of the artifacts recovered here come from Stratum B.

The initial tendency to excavate at the center of the promontory shifted in 2005 when Reid Ferring excavated test pit M5 approximately 100m up-slope and to the west of the main block area. Excavations here revealed the thickest and most complete stratigraphic sequence on the promontory as well as the only artifacts so far recovered from Stratum A.

At Dmanisi, artifacts have been recovered from at least thirteen stratigraphic units between A2a and B4 (Ferring et al. 2011). Despite this long period of hominin occupations, only recently have these artifacts been analyzed between successive stratigraphic units. Changes in occupation intensity and periodicity, as well as procurement and provisioning practices, especially for artifacts between Stratum A and B, were first identified by Ferring et al. (2011). Recently, Ferring et al. (2011) identified changes in raw material selection preferences as well as reduction intensity between these two time periods. The initial and subsequent results of M5 excavations indicated that more test pits should be dug around the promontory in order to get a better and more accurate understanding of how the site was formed and utilized by these early hominins.

Methods

All of the M11 and M12 artifact data was recorded at the field lab at Dmanisi. Individual artifact characteristics were measured based upon a system devised by Reid Ferring. These included recording each artifacts stratigraphic association and plotted field recovery location, recording the artifact class, platform type, dorsal scar pattern, cortex type, percent cortex, presence of a dorsal hinge, and termination, as well as measuring the length, width, thickness and weight. Complete descriptions of each artifact can be found in Appendix B.

Artifact Analysis

Artifact analysis is an important component within geoarchaeology because it addresses questions about general hominin behaviors. It can show us how hominin occupation intensity and periodicity may have fluctuated with time, but also how procurement and manufacturing processes may have changed as well. Identifying such changes is made possible through the stratigraphic record which breaks up the hominin occupational chronology at a location. The change to a new and more accurate stratigraphic system at Dmanisi in 2000 meant that only the artifacts excavated since that time can be analyzed meaningfully. As a result only artifact data from M11, M12, and sometimes M5 (Ferring et al. 2011) are used here.

Occupation intensity and periodicity, and therefore changes in procurement and provisioning, can be identified and compared from sites with multiple successive occupations. This is performed here by comparing artifact densities both between multiple stratigraphic units and within contemporaneous stratigraphic units spread out over a wide area. Artifact density analysis measures the quantity of artifacts against a given unit of space. In this case artifact density analysis is measured against surface area of a unit and is being compared between M11 and M12 to assess potential changes in occupation intensity and periodicity at these parts of the site. This type of analysis is only a relative assessment of occupation intensity as other factors, such as sedimentation rates and soil development can temporally skew this perception between units. Caution is taken and other factors are assessed prior to making claims about differences in occupation intensity between stratigraphic units.

Raw material procurement, reduction and transport are important facets of Mode 1 lithic manufacturing behaviors which can be directly studied from the archaeological record. Raw material analysis measures patterns of raw material selectivity, procurement strategies, and whether those strategies change over time. This can potentially inform archaeologists about hominin raw material preferences relative to the distribution of raw materials in the study area. It can also be used to understand where these raw materials originated on the landscape and which environments, fluvial-aquatic or terrestrial, they were deposited. The origin of the raw material is measured here by identifying the type of cortex, cobble or bedrock, on flakes and cores.

Flake-to-core ratios have been proposed as one method of potentially understanding raw material reduction and transport strategies of stone from source to site. It is tentatively assumed that higher, albeit arbitrary, ratios, in concert with low quantities of artifact re-fits, could suggest reduction off-site and subsequent transport of those flakes across the landscape. Alternatively, lower ratios, those where many more cores are recovered (although not necessarily in greater quantity than flakes) may suggest that primarily unmodified raw materials are being transported to sites and subsequently reduced locally.

In conjunction with flake and core ratios, artifact procurement and reduction strategies can further be diagnosed by the type and amount of cortex with respect to dorsal scar patterns. The type of cortex, cobble or bedrock, can potentially indicate the source of the raw material and therefore the relative distance that raw material may have been transported from source to site. In addition this type of analysis can provide clues to reduction patterns of how the artifact was flaked as well as how intensively the artifact was reduced upon deposition.

M11 Artifact Descriptions

In all, six artifacts were recovered from three stratigraphic Units in B1 and B2 sediments along the western profile (Figure 4.1), while a seventh artifact, described in greater detail at the end of this section, was recovered from a pipe feature probably belonging to the B1 piping phase. Five of those six artifacts were flakes, while the sixth artifact, a core, was recovered from Unit B1b (Table 4.1). Descriptions of the M11 artifacts can be found here and in the appendix under Table B2.

Table 4.1

Summary of M11 Artifacts

Raw Material	B1a	B1b	B2	Pipe	Total
Tan Tuff		1/-			1/-
Vit. Tan Tuff	1/-				1/-
Green Tuff			1/-		1/-
Vit. Green Tuff				1/-	1/-
Fine Black Basalt		-/1			-/1
Diorite			1/-		1/-
Andesite Porphry		1/-			1/-
Total	1/-	2/1	2/-	1/-	6/1
Artifact Density (n/m2)	2.86	4.00	3.45	N/A	

n/n = flakes/cores

Unit B1a Artifacts

Only one artifact, a small flake of vitreous tan tuff, was recovered from this unit. This artifact was recovered *in situ* within this unit. This flake has an unfacetted platform with one unidirectional dorsal scar on bedrock cortex.

Unit B1b Artifacts

Three artifacts were recovered *in situ* from Unit B1b including two small flakes and a large core. The larger flake was manufactured from tan tuff whereas the slightly smaller flake was of andesite porphyry. The tan tuff flake platform is unfacetted, with a single opposing scar and more than half of the dorsal surface has cobble cortex. The andesite porphyry flake has a cortical platform, with no dorsal scars and with its entire cobble cortex intact. The cobble basalt core is large, weighing approximately 870g. It has been radially flaked with nine large scars on a mixed platform with less than half of its cortex remaining.

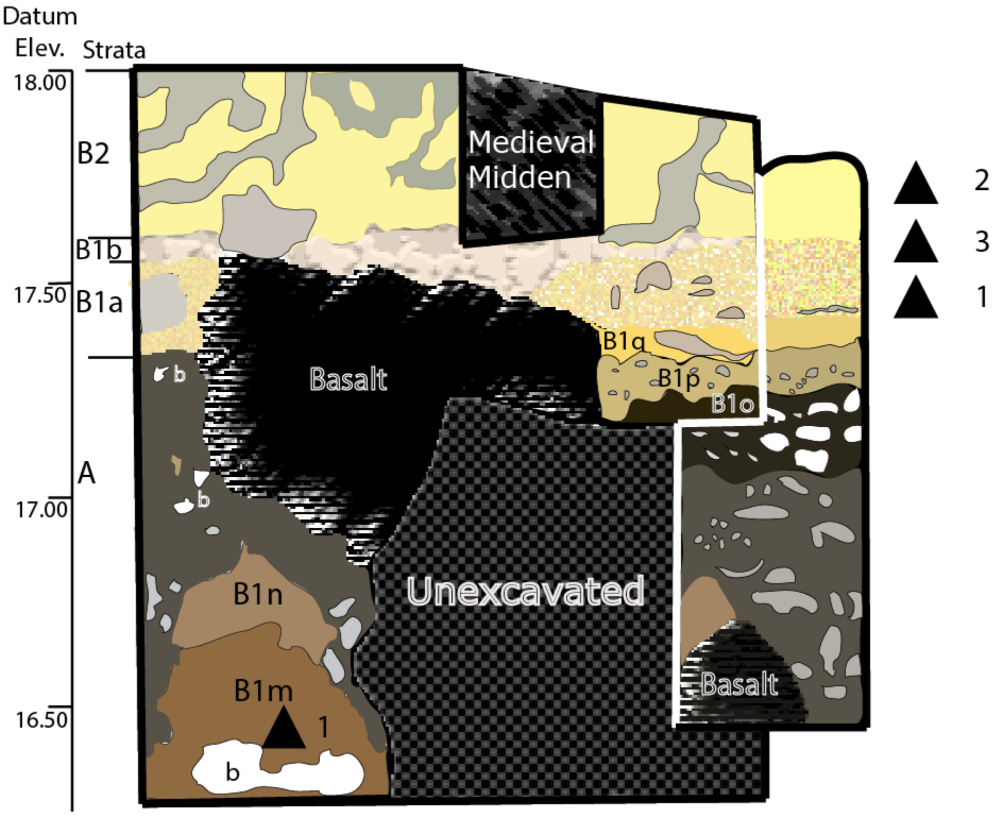


Figure 4.1. M11 profile with corresponding artifact quantities recovered from each stratum.

Unit B2 Artifacts

Two artifacts, each very small flake's weighing less than 5g were recovered from Unit B2. The first flake was recovered *in situ* and is composed of diorite. This flake has an unfaceted platform with a single unidirectional scar with very little cobble cortex remaining. The second flake is composed of green tuff and was recovered while screening sediment. This flake has a cortical platform with two unidirectional scars on bedrock cortex.

Figure 4.2. Sample of M11 artifacts. Artifact 1 is a basalt core recovered from Unit B1b showing two sides. Artifact 2 is a green tuff flake recovered from the Strata B1 pipe feature and is shown with both its ventral and dorsal sides.

Pipe Feature Artifact

One small flake of vitreous green tuff was recovered from a pipe feature, probably during the B1 pipe and gully phase, just above the bedrock basalt. It has an unfacetted platform with two unidirectional dorsal scars. No cortex was left on this flake. Overall this flake is very small, weighing less than 4g with its greatest dimension just 22mm long. This flake's small size likely made it more susceptible to the processes of erosion and re-deposition in this pipe feature.

M12 Artifact Descriptions

A total of 27 artifacts were recovered from five stratigraphic units between Strata B1 and B-L1 (Figure 4.3). There were 24 flakes and 3 cores recovered; a single core was recovered from each major strata (Table 4.2). A sample of artifacts is shown in Figure 4.4. Complete descriptions of the M12 artifacts can be found in Appendix Table B3.

Table 4.2

Summary of M12 Artifacts

	B1		B2a		B-L1		Total, %		
Raw Material	B1a	B1b	B2a	B2b	B-L1	Total	B1	B2	B-L1
Tan Tuff			2/-	2/1	1/-	5/1		83.3	16.7
Vit. Tan Tuff			1/-	2/-		3/-		100.0	
Green Tuff		1/-		1/-	2/1	4/1	20.0	20.0	60.0
Vit. Green Tuff	1/-	1/-	1/-	2/-	1/-	6/-	33.3	50.0	16.7
Vit. Brown Tuff					1/-	1/-			100.0
Basalt	-/1	1/-				1/1	100.0		
Fine Black Basalt			1/-		1/-	2/-		50.0	50.0
Diorite		1/-				1/-	100.0		
Rhyodacite					1/-	1/-			100.0
Total	1/1	4/-	5/-	7/1	7/1	24/3	5/1	12/1	7/1
Artifact Density (n/m2)	2.0	4.0	5.0	8.0	8.0		6.0	13.0	8.0

n/n = flakes/cores

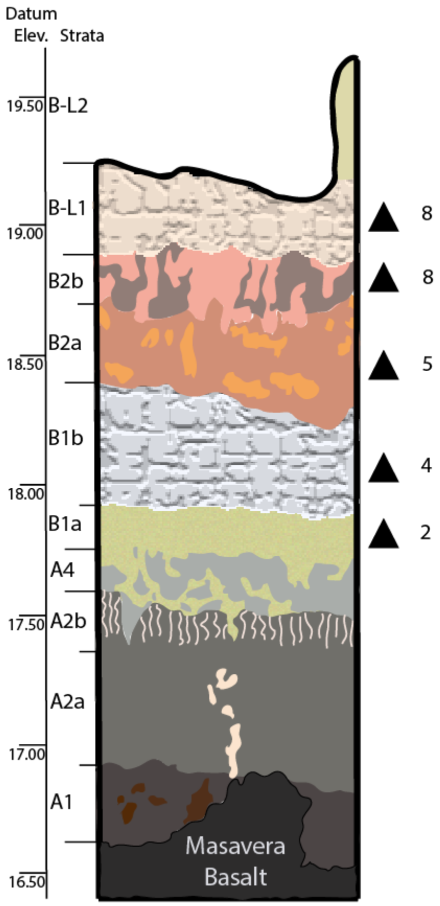


Figure 4.3. M12 profile with corresponding artifact quantities per stratum.

Unit B1a Artifacts

Two artifacts, a tiny vitreous green tuff flake and a large basalt core were recovered from Unit B1a. The small flake was recovered while screening sediment and weighs just 3.6g. It has a cortical platform with two core trimming element scars with moderate quantities of cobble cortex remaining. The basalt core was recovered *in situ* and is fairly large, weighing more than 650g. It has a mixed platform with a moderate quantity of cobble cortex; at present the scar pattern and number of scars was not recorded for this artifact.

Unit B1b Artifacts

There were four artifacts recovered from Unit B1b and all are flakes composed of different raw materials. Two flakes were recovered *in situ*. The largest is composed of diorite and has an unfacetted platform with two unidirectional scars and was struck on cobble cortex. The smaller flake is made of vitreous green tuff with an unfacetted platform and four radial scars. The two other flakes were recovered while screening sediment. Both are fairly small, weighing between 10 and 15g, respectively. One of these flakes was struck on basalt with a cortical platform, a unidirectional dorsal scar, and is retouched on one side. The last flake is composed of green tuff struck from bedrock cortex and has more than 50% dorsal cortex.

Unit B2a Artifacts

Five artifacts were recovered from Unit B2a. Four of these flakes were tuff while the fifth flake was basalt. Two flakes are tan tuff. The smallest weighs just 2.7g. It has a missing platform, three unidirectional scars and is missing all cortex. The second tan tuff flake is larger and weighs 30g. It also is missing its platform and has three unidirectional scars, and has more than 50% dorsal cortex. The third flake, an inverse denticulate, is vitreous tan tuff and weighs nearly 50g. This flake has an unfaceted platform with two crossed scars and has more than 50% dorsal cortex. The last tuff flake is green tuff. This flake is also very small, weighing just 2.9g. It is missing its platform but has two unidirectional scars with only a very small quantity of cortex remaining. The fifth flake, struck from a basalt cobble, was the largest flake recovered from this unit and weighs 66.5g. It has an unfacetted platform with four unidirectional scars and less than 50% dorsal cortex.

Unit B2b Artifacts

Eight artifacts recovered from Unit B2b. Seven of these are flakes while an eighth is a tan tuff core. Interestingly, each of these artifacts was composed of either green or tan tuff, some being vitreous. In addition, all but one of the seven flakes weighed less than 5g, while the seventh flake weighed 16g.

The flake struck on green tuff has a missing platform with three core trimming element scars and has less than 50% dorsal cortex. There were also two vitreous green tuff flakes. One of these has an unfacetted platform with four core trimming element scars and no cortex remaining. The second vitreous green tuff flake has a dihedral platform with three unidirectional dorsal scars and all the cortex is missing.

The tan tuff artifacts include two flakes and a core along with two vitreous tan tuff flakes. One of the tan tuff flakes has a cortical platform with one unidirectional scar and has less than 50% dorsal cortex. The second tan tuff flake is similar to the last. It has two unidirectional flake scars and less than 50% dorsal cortex. The tan tuff core weighs approximately 200g. This core has an unfacetted platform with one unidirectional scar and more than 50% cobble cortex. The last two flakes are each struck on vitreous tan tuff and each exhibits unilateral edge retouch. One of these flakes is a core trimming element with a crushed platform without any cortex. The second vitreous tan tuff flake is also a core trimming element with two dorsal scars and an unfacetted platform with less than 50% dorsal cortex.

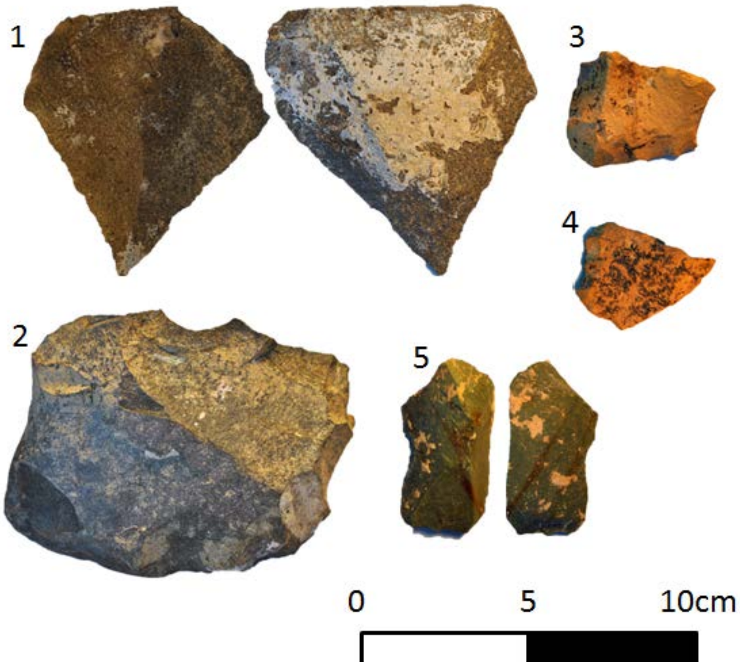


Figure 4.4. Sample of M12 artifacts. Artifact 1 is a large diorite flake from Unit B1b showing both its dorsal and ventral sides (note the secondary carbonates affixed to the ventral side). Artifact 2 is a large basalt core from Unit B1a. Artifact 3 is a retouched flake of tan tuff from Unit B2b. Artifact 4 is another retouched flake of tan tuff from Unit B2b. Artifact 5 is a vitreous green tuff flake showing both the dorsal and ventral sides

Unit B-L1 Artifacts

Eight artifacts were recovered from Unit B-L1. Seven of these artifacts are flakes and the eighth is a core. Three different types of raw materials are represented by these eight artifacts. One of these artifacts resembles a large Karari scraper.

One small flake was struck on tan tuff. Its platform is missing and has one unidirectional dorsal scar and is missing all cortex. Two flakes and a core were struck from green tuff. One of these flakes exhibits excavation damage. This flake is a core trimming element with a cortical platform, four dorsal scars, and has less than 50% cortex. The second green tuff flake has two unidirectional scars and is missing a platform and cortex. Another flake was struck on vitreous green tuff and has a bifacial platform with one unidirectional scar. The green tuff core has a simple single platform with one unidirectional scar and has more than 50% bedrock cortex. The last flake was quite large, weighing just over 600g. It was struck on vitreous brown bedrock tuff and resembles a Karari scraper. This piece has a cortical platform with unidirectional dorsal scarring.

The last two flakes are small and were struck on different raw materials. One flake was struck on fine black basalt. Its platform is missing and has no dorsal scars with more than 50% dorsal cortex. The final flake was struck on rhyodacite. Its platform is missing but has two unidirectional dorsal scars and no cortex remains.

Discussion

The artifacts recovered from test pits M11, M12 and M5 can provide additional information about how the northern and southern portions of the promontory were utilized at different periods in time. Several analytical methods are presented here to assess possible differences between occupation intensity and periodicity as well as procurement and provisioning decisions within and between stratigraphic units from the M11, M12 and M5.

Artifact data from test pits M11, M12 and M5 (Ferring et al. 2011) are in Tables 4.1, 4.2 and 4.3, respectively.

Specifically, three types of analyses are performed here. The first is comparing the artifact density at each test pit within each stratigraphic unit. This type of analysis can indicate how intensively different locations on the promontory were being occupied by hominins. The second type of analysis is assessing raw material procurement strategies. This type of analysis can indicate preferential selections for different types of raw materials over time. Finally, artifacts will be assessed in terms of reduction intensity by measuring flake-to-core ratios, the type and amount of cortex, as well as dorsal scar patterns. This type of analysis has the ability to highlight patterns of raw material transport and reduction strategies as well as any changes which may have occurred over time. Overall, the artifact sample size from M11, M12 and M5 is particularly small and will only provide a relative assessment for these three types of analysis.

Table 4.3

Summary of M5 Artifacts

Raw Material	B1a	B1c	B2	TOTAL
Tan Tuff	1/1	1/-	8/3	10/4
Green Tuff			3/-	3/-
Vit. Green Tuff		1/-	4/-	5/-
Red Tuff		1/-		1/-
Brown Tuff	1/-			1/-
Basalt		-/1	9/2	9/3
Rhyolite		1/-		1/-
Andesite	-/1	2/1	1/4	3/6
Aplite			1/-	1/-
Diorite			1/-	1/-
Chert			1/-	1/-
TOTAL	2/2	6/2	28/9	36/13

n/n shows counts of flakes/cores

Artifact Density

Artifact density was assessed from up to five stratigraphic units in Stratum B from M11 and M12 (Table 4.4, Figure 4.5). When comparable, the general artifact density is similar between corresponding stratigraphic units from each test pit. The largest difference in artifact density between M11 and M12 occurs in Unit B2. At M11 the artifact density is slightly lower if these artifacts correspond with Unit B2a or quite a lot lower if these artifacts correspond with Unit B2b. In general there is a trend for artifact density to increase over time.

Table 4.4

Artifact Density from M11 and M12

Artifact Density (*n*/m2)	B1a	B1b	B2a	B2b	B-L1
M11	2.86	4.00	3.45[1]	3.45[1]	N/A
M12	2.00	3.00	5.00	8.00	8.00

[1] May belong to either B2a or B2b

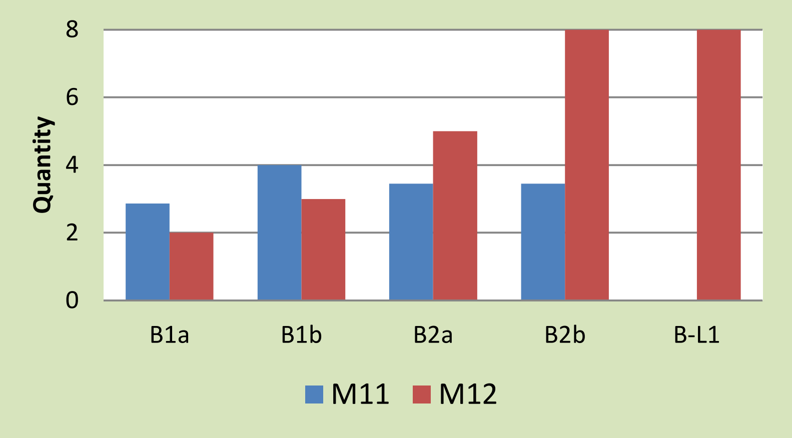


Figure 4.5. Artifact density from M11 and M12

Raw Material Procurement Strategies

Raw material data from M11, M12 and M5 were analyzed for possible changes in raw material procurement strategies between Units B1, B2 and B-L1. The data from each test pit was examined separately (Figure 4.6) to look for possible changes at different locations on the promontory, as well as pooled together (Figure 4.7) to look at broader changes over time.

Presently the artifact raw material sample sizes from each stratigraphic unit at M11 and M12 are very small (Figure 4.6). In slight contrast, the sample size from M5 is larger and provide more meaningful results. Tuff is generally the preferred raw material from each stratigraphic unit at each excavation location. The presence of basalt is generally comparably weaker, and in several instances comparable in quantity to *other* raw materials used.

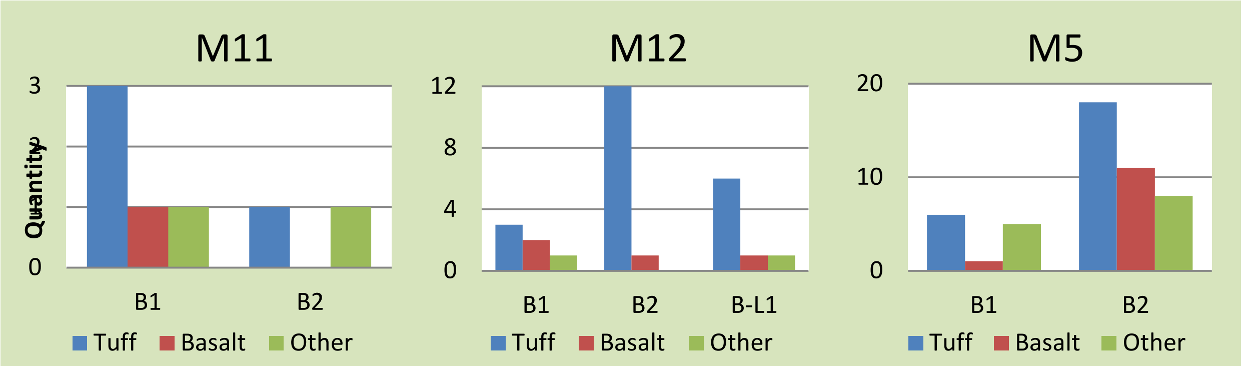


Figure 4.6. Raw material distribution

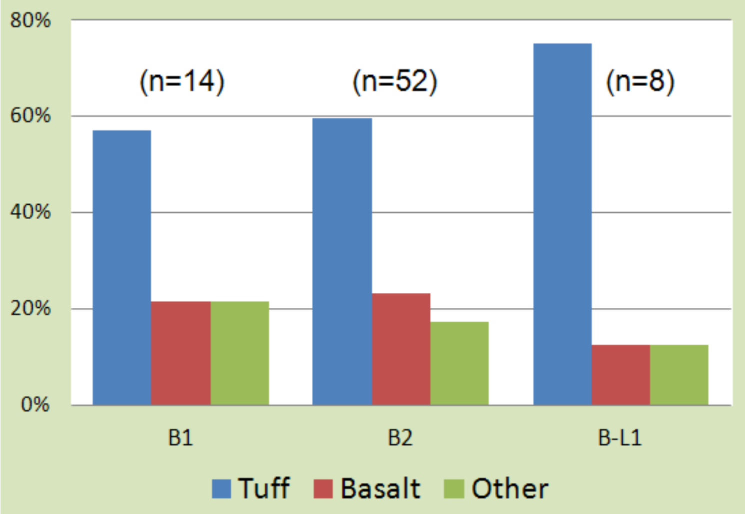


Figure 4.7. Pooled raw material distribution

When the data from these three excavation locations and three stratigraphic units are combined (Figure 4.7) the results become more meaningful for examining broader changes in raw material selection over time. So far the sample size for artifacts from Strata B1, *n* = 14, is small. There are initial indications that these hominins preferred the raw material tuff (57%) than basalt (21%) and *other* types of raw materials (21%). The artifact sample size from Strata B2 is much larger, *n* = 52, than Strata B1 and provides stronger data for raw material preferences. During the Strata B2 occupations tuff also seems to be the preferred raw material (59.6%) at a similar frequency of appearance to B1. Basalt too shows a similarly small proportion (23%), and even fewer artifacts were manufactured on *other* types of raw material (17%) although andesite was the favorite from this group. Finally, the artifact sample size from Unit B-L1, *n* = 8, is very small but tentatively shows a similar distribution of raw material preference like those in Strata B1 and B2. During this latest occupation tuff appears to be the preferred raw material (75%) with a low frequency of basalt (12.5%) and *other* raw material (12.5%) usage.

Artifact Transport and Reduction Strategies

Interpretations about artifact transport and reduction strategies were first assessed by analyzing the broad flake-to-core ratios from excavations M11, M12 and M5 (Figure 4.8). Again the sample sizes were much smaller therefore strength of results much weaker from M11 and M12 than they were from M5. In general, a trend favoring several more flakes than cores is apparent from each stratigraphic unit. Overall, this analysis is a fairly coarse representation for differences in transport and reduction strategies because it does not take into account more specific artifact characteristics such as raw material type, number of flake scars on cores, and artifact lithology, to name a few.

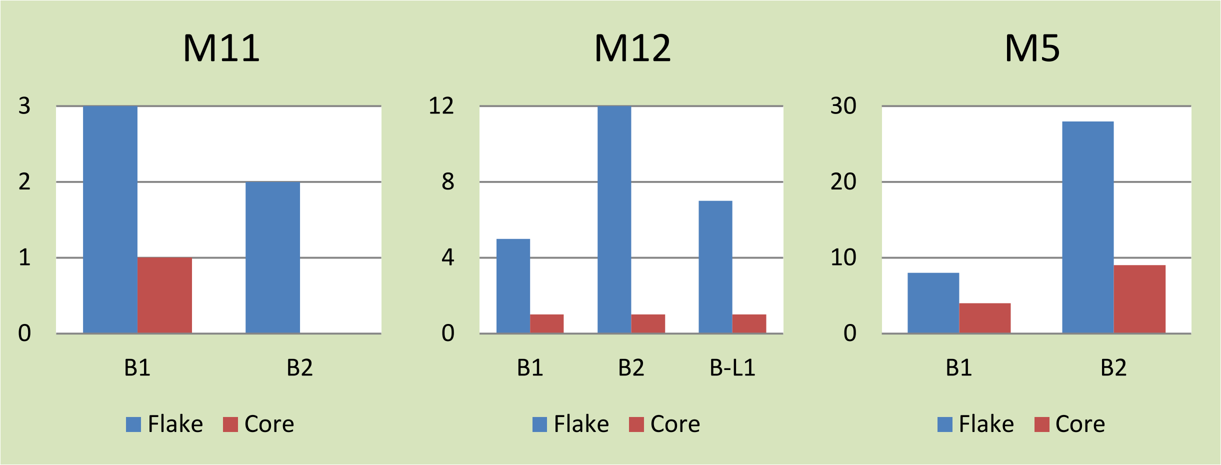


Figure 4.8. Flake-to-core ratio from each excavation.

The second flake-to-core analysis is concerned with changes in specific raw material transport and reduction strategies during each of these three stratigraphic units (Figure 4.9).

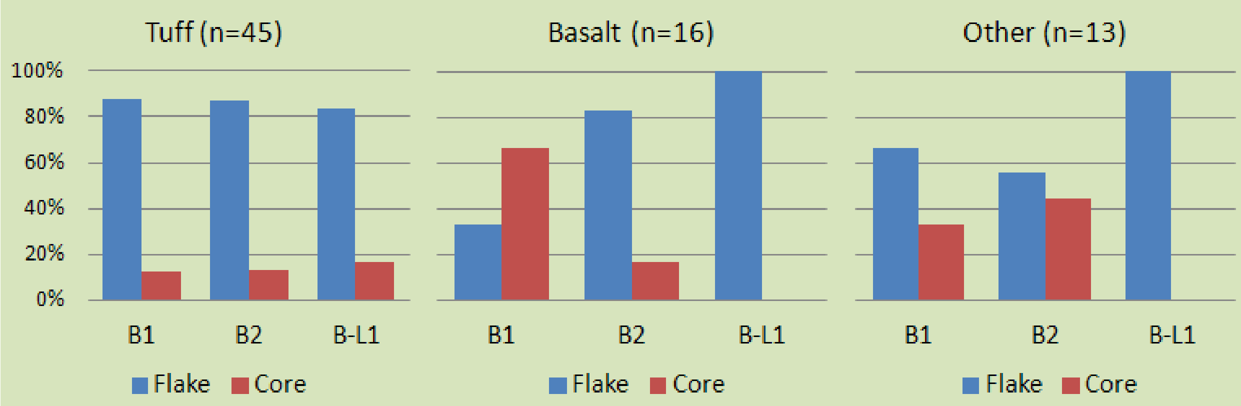


Figure 4.9. Flake-to-core ratio by raw material

The data here was pooled from M11, M12 and M5. In most cases there is still a clear preference of flakes to cores from the three raw material groups. The smaller sample size for basalt and*other* raw materials presents an issue for gathering stronger results. Again, more specific artifact characteristics such as the ratio between quantities of flake scars on a core of a specific raw material compared against the quantity of flakes showing dorsal cortex of that same raw material per stratigraphic unit provide the most precise measure of addressing likely artifact reduction locations. Unfortunately the current artifact sample size presented here is too small to gain any meaningful results from such an analysis.

In conjunction with flake and core ratios, artifact procurement and reduction strategies can further be diagnosed by the type and amount of cortex with respect to dorsal scar patterns. Artifacts from test pits M11 and M12 were pooled and divided between major stratigraphic Units B1, B2 and B-L1 (Table 4.5). In addition, artifacts with no cortex or unidentifiable cortex could not be included in this analysis.

Table 4.5.

Artifact lithology from M11 and M12

Raw Material	B1	B2	B-L1	TOTAL
Tan Tuff		4/1		4/1
Vit. Tan Tuff		-/3		-/3
Green Tuff	-/2	-/1	1/1	1/4
Vit. Green Tuff	1/-			1/-
Brown Tuff			-/1	-/1
Basalt	1/1			1/1
Fine Black Basalt		2/-		2/-
Andesite Porphry		1/-		1/-
Diorite	2/-			2/-
TOTAL	4/3	7/4	1/2	12/9

n/n shows counts of cobble/bedrock cortex

Between these two assemblages there are at least twelve artifacts represented by four different raw materials with cobble cortex, tuff, basalt, andesite, and diorite. These data indicate that these hominins were exploiting the heterogeneous distribution of cobbles naturally distributed in the Masavera and Pinasauri Rivers. In contrast, only nine artifacts from two different raw materials, tuff and basalt, were recovered with bedrock cortex. Given that the local bedrock is abundant in tuff and basalt it is not too surprising that these hominins would have primarily exploited their local resources.

Finally, reduction strategies were also measured both in terms of intensity as well as dorsal scar flaking patterns. Again, these artifact characteristics were combined from M11 and M12 but were not separated between major stratigraphic units because this analysis attempts to understand general behaviors of raw material and artifact reduction and shaping strategies. The results are shown in Table 4.6.

Table 4.6.

Stratum B cortex and dorsal scar patterns of flakes from M11 and M12

Dorsal scar pattern	Platform only	Dorsal Cortex				Sum
		None	1-50	50-99	100	
Cortex only					1	1
Unidirectional		7	8	2		17
Radial		1				1
Opposed				1		1
*CTE		2	4			6
Sum		10	12	3	1	26

*CTE = Core trimming element

These results show that unidirectional knapping was the most common dorsal scar pattern from artifacts at M11 and M12. In addition, these hominins also appear to have reduced their raw material enough so that less than half of the dorsal cortex remained on the flake.

Conclusion

These initial excavation results tentatively indicate that during Stratum B occupations artifact assemblage characteristics did not significantly change at Dmanisi although occupation intensity and periodicity may have changed. Overall, parts of the promontory do appear to have been occupied by hominins at least occasionally. Of course it should never be expected that every occupation period or location on the promontory should contain approximately identical assemblage characteristics especially given different rates of sediment deposition and erosion.

In addition, understanding hominin behaviors, especially from Lower Pleistocene sites outside of Africa, is critical for understanding how hominins adapted to these different environments. As a result, these results are compared against contemporaneous sites elsewhere.

The general lack of artifacts from Stratum A across much of the promontory further supports the idea that these sediments were rapidly deposited. It initially appears that fewer hominins were occupying this promontory during Stratum A than Stratum B given that Stratum A artifacts have so far only been recovered from one excavation location, M5 (Ferring et al. 2011). Although, this evidence does not necessarily indicate that hominin occupation intensity on the promontory changed much from Stratum A to Stratum B. Within Stratum A evidence for pedogenesis is strongest in Unit A2 which shows higher artifact densities than those units with less evidence for pedogenesis, such as A3 and A4 (Ferring et al. 2011). Therefore, if the temporal span for the deposition of Stratum A sediments is much shorter than Stratum B a similar expectation of less cultural debris should be found across the site at this time.

Broadly, the artifact density analysis from Stratum B may indicate that earlier occupations on the promontory were less intense than later periods. This again could be due to several factors including, 1) increasing intensity of hominin occupations on and across the site, 2) greater surface stability with increasing pedogenesis over time, 3) a combination of both those factors, or 4) coincidence which needs additional data from other excavations. An increase in pedogenesis may have influenced greater flora presence and diversity with could subsequently have attracted more and diverse fauna and ultimately hominins to the promontory. As a result, Strata B1 could have developed much more quickly than Strata B2, which could explain the lower artifact densities here.

Ultimately, the surrounding landforms, bedrock geology and basin systems directly impacted the raw material procurement decisions by the hominins who occupied the Dmanisi promontory. Each system acted as a repository of differing raw materials and forms which these hominins ultimately modified and occasionally transported to the promontory. The distribution of raw material stones visible in each system today would have been available to the Dmanisi hominins 1.8 Ma.

In general, the raw material distributions between the three Stratum B units showed very similar raw material preferences. Tuff is consistently represented by more than half the artifacts in each stratigraphic assemblage followed by less than a quarter of the artifacts on basalt and finally several different *other* raw materials are represented by less than a quarter of the artifact distribution. This initial result suggests that the hominins occupying the promontory between Strata B1 through Unit B-L1 consistently preferred the same type of raw materials.

The above evidence also tentatively suggests that the Dmanisi hominins manufactured many of their flakes from local bedrock and cobble sources and may have transported relatively few cores to the site. Archaeologists often assume that the closest source where that raw material is found relative to the site was the primary procurement location. In general, the flake-to-core ratios from these three stratigraphic units show similar frequencies of flakes and cores. Further, the majority of flakes exhibit little or no dorsal cortex suggesting moderate to heavy reduction. Unidirectional flaking was the dominant flaking pattern with very few flakes showing crossed or opposed flaking patterns. This is fairly indicative of the simple reduction style of Mode I artifact manufacture as a whole. These results corroborate the raw material analysis in that little or no changes in procurement and reduction patterns are visible archaeologically during this Stratum B period.

In addition to identifying raw material procurement locations, raw materials may have been transported to a site prior to reduction, such as in the form of manuports (Canell 2002). After reduction and over the course of the artifacts use-life, those artifacts may have been moved far from their original reduction location (Dibble 1995), possibly leading to a more even distribution of both artifacts and raw material types across a site and landscape.

The hominin behaviors inferred through the analysis of the Dmanisi artifacts are reminiscent of the interpretations made at contemporaneous sites in Africa. Changes in occupation intensity and periodicity, and therefore changes in procurement and provisioning behaviors have been identified at some Mode I assemblages. At Olduvai Gorge in Tanzania artifact characteristics have been shown to change over time (Tactikos 2005). It is well established from most Mode I assemblages that these hominins exploited just a couple specific types of raw materials, many of which tended to be igneous (Leakey 1971, Potts 1991, Torre and Mora 2005, Stout et al. 2005, Braun et al. 2008, 2009, Goldman-Neuman and Hovers 2011). Many African Mode I sites, such as Lokalalei 1 and 2C, Kokiselei 1, 5 and 4, Naiyena Engol 1, and Nadung'a 4, can fairly confidently trace their raw material provenance to local (<3 km) river cobble sources although in extreme cases sites at Olduvai (Leakey 1971, Hay 1976), Koobi Fora (Isaac and Isaac 1997) and Kanjera (Braun et al. 2008, 2009) contain raw materials transported from as far as 15 km from a source (Mgeladze et al. 2011). In addition, a scarcity of raw materials in the vicinity of locations where tools are most frequently used will result in comparatively intensive exploitation and re-use of artifacts; from Oldowan assemblages this could be identified from artifact re-sharpening and retouched edges. Although, due to the expediency by which Mode I artifacts are manufactured flakes and cores are not always fully reduced. Therefore these types of assemblages generally retain higher percentages of artifacts with cortex than later artifact industries (Bousman 1993).

CHAPTER 5

CONCLUSIONS

The following is a summary and interpretation of the main results of this study:

1. The excavation of these two test pits, M11 and M12, added to the documented excavation area of the Dmanisi site. It revealed variability in the formation of sediments and soils here. And most importantly, these excavations provide for the first time an extended north-south axis of site formation processes on the promontory.

2. Test pit M11 revealed a profile approximately two meters deep. The stratigraphy was limited to a Stratum A unit with unresolved chronostratigraphic association, as well as B1 and maybe B2. The sediments were particularly light colored, comparatively clay rich, and strongly calcareous throughout. The pedogenic features and clay-enriched sediments could be the result of increased soil development than at other parts of the site. Two pipe/gully features were uncovered within Stratum A (these are common features forming at the center of the promontory) with a high density of well-preserved fossils and which now demonstrates that these features were more numerous and extensive than previously observed. In addition, Strata B2 had a noticeably lower density of gravels than that observed further west at M12 as well as other excavations across the site maybe suggesting a gravel origin on the western side of the promontory.

3. Test pit M12 is located on the far southwestern end of the promontory. The stratigraphic profile was nearly complete up through Strata B2, and only missing A3. Two local Strata, B-L1 and B-L2, with so far uncertain chronostratigraphic association to the M5 type section, were uncovered at the top of this profile. The preserved strata showed similar

sediment depositional and soil development features characteristic of M5. The gravel deposits throughout the Stratum B sediments appear to be denser than those from M5 and possibly the densest per stratum so far uncovered on the promontory. This tentatively suggests that the source of these gravels was close to M12. Faunalturbation appears to have sorted many of the gravels within the Strata B2 sediments, which may subsequently have also disturbed artifacts.

4. The artifact data collected from each stratigraphic unit at test pits M11 and M12 are remarkably similar to both each other as well as the initial results from M5. With minor exception, artifact density, raw material selectivity, and artifact lithology do not appear to drastically change across space or time. Overall, only artifact density appears to change with an increase in abundance from Strata B1 to late B2. This increase in artifact density could be the result of increasingly more stable surfaces and/or more intensive occupation by hominins up until this point in time.

5. The results observed for this geoarchaeological analysis from Dmanisi broadly compare with contemporaneous Mode I assemblages in East Africa. The habitat around Dmanisi was dominated by grassland, shrubland and riparian zones similar to those of Africa. Coinciding with hominin occupations, southern Georgia was a volcanically active environment which rapidly buried multiple surfaces creating discrete occupation episodes which can be analyzed archaeologically. The Mode I artifacts characteristics from Dmanisi also suggest that hominin procurement and provisioning behaviors mimicked those from contemporaneous sites in Africa.

APPENDIX A

SEDIMENT-STRATIGRAPHIC PROFILE DESCRIPTIONS AND LAB DATA

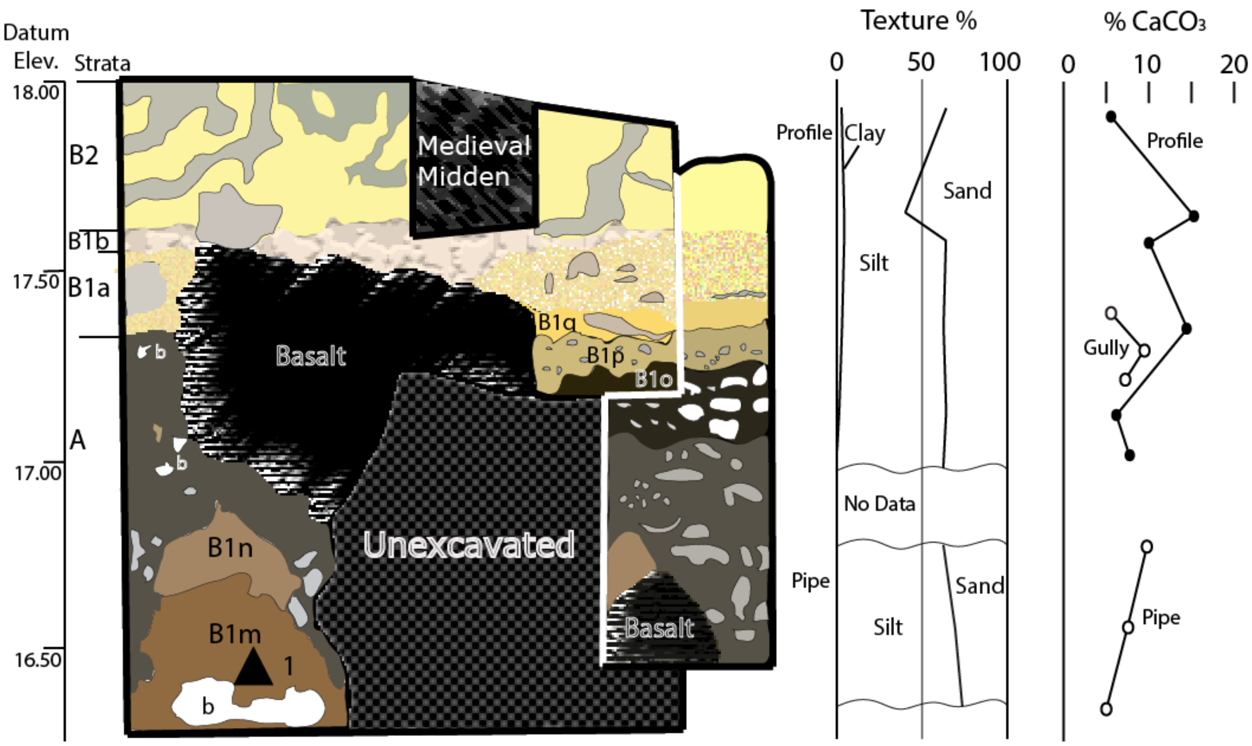


Figure A.1. Sediment Profile Test Pit M11
Bedrock Elevation = ~16.20m above datum
Western Profile

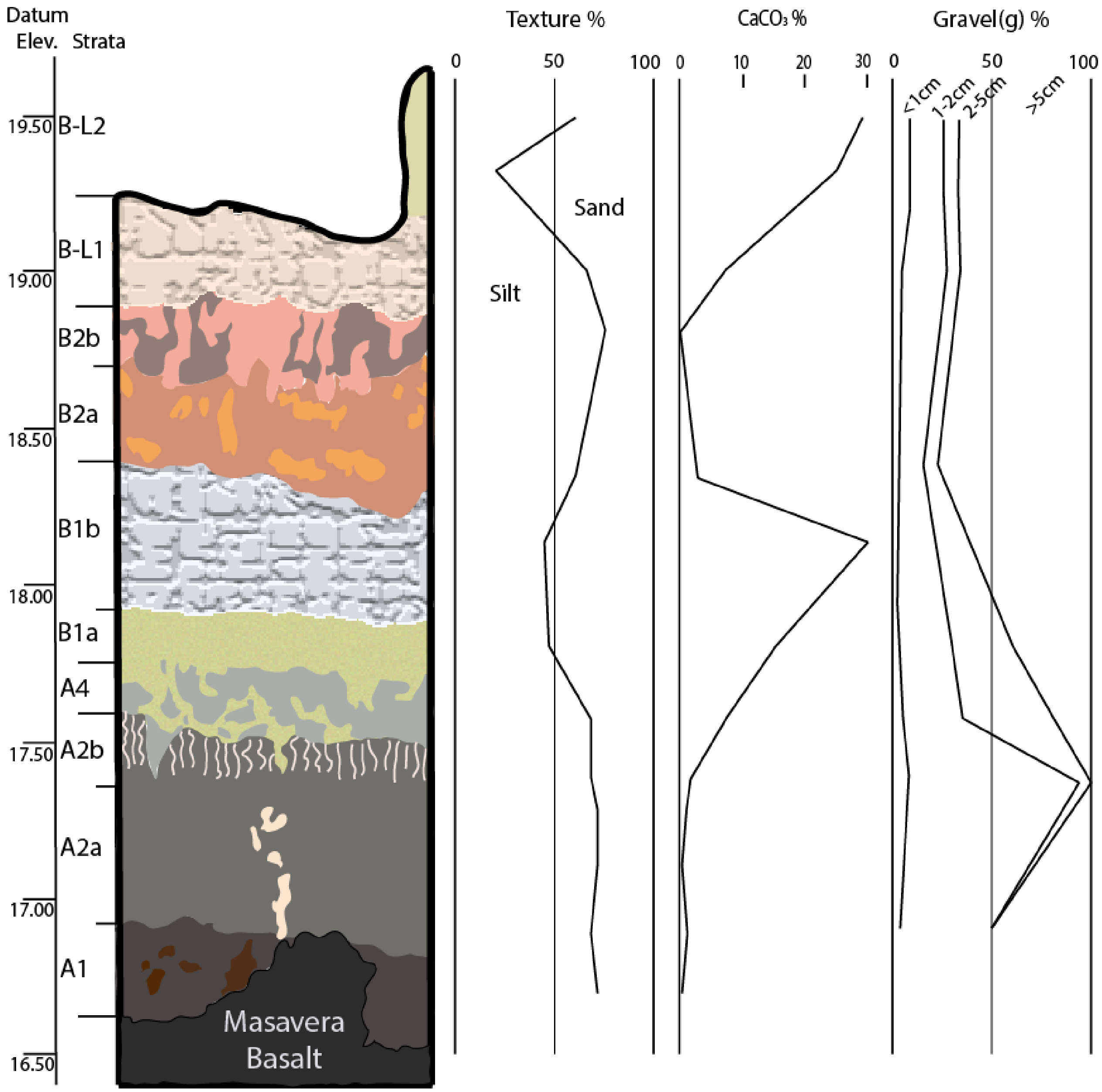


Figure A.2. Sediment Profile Test Pit M12
Bedrock Elevation = ~16.60m above datum
East Profile

Table A.1. Sediment Profile Description Key

COLOR all colors are Munsell dry, unless otherwise noted

TEXTURE

S	sand	SC	sandy clay	SCL	sandy clay loam
Sand Size:		vf	very fine	SL	sandy loam
		f	fine		
		m	medium		
		c	coarse		
		vc	very coarse		
s	silt	sC	silty clay	sCL	silty clay loam
		sL	silt loam		
C	clay	CL	clay loam		
L	loam	LS	loamy sand		
gr	gravelly				

CARBONATES

Abundance

f	few	<2%	c	common	5-10%
m	many	2-5%	a	abundant	>10%

Fabrics

fi	filament	ct	coatings
cc	concretions	rz	rhizoliths
po	pore linings		

BOUNDARIES

Distinctness

d	diffuse	>10 cm
g	gradual	5-10 cm
c	clear	2-5 cm
a	abrupt	<2 cm

Topography

s	smooth
w	wavy
i	irregular
b	bioturbated
u	unknown

GRAVEL

Size

very fine pebble	0.2-1.0 cm
medium pebble	1.0-2.0 cm
coarse pebble	2.0-5.0 cm
cobble and boulder	>5 cm

BIOTURBATION

Type

Burrows	<2 cm, insects
Krotovina	>2 cm, mammals

Abundance

I, Intense	>20%
M, Moderate	5-10%
L, Light	<5%
N, None	0%

OBSIDIAN

Abundance (in 1g sample)

ex. rare	1-2
few	3-5
common	>5

Color

clr.	clear
blk	black

Table A.2, Test Pit M11
Bedrock Elevation = ~16.20m above datum
Western Profile

UNIT	DEPTH (cm)	COLOR	TEXT	RCTN HCl	BNDY	BIOTURB	COMMENTS
B2	0-40	10YR 6/4 10YR 7/4	SL sL	c a	u	K, l	4.3% clay; few sm. obsid. grains
B1b	40-46	10YR 6/3.5	SL	a	a, i	N	6.1% clay; wk. dvp. Indur. calc. lam.; no obsid.
B1a	46-72	10YR 6/3	SL	a	a, i	N	3.5% clay; plug. calc. horiz.
B1q	62-72	10YR 5/3	SL	c	a, w	K, L	1.8% clay; few sm. obsid. grains
B1p	72-82	10YR 6/3	sL	c	a, w	K, M	1.8% clay; few tiny clr. obsid. grains
B1o	82-104	10YR 4.5/2	SL	c	a, w	K, L	2.4% clay; ex. rare obsid.; many *in situ* fossils
B1n	114-134	10YR 5/2.5	SL	c	a, w	N	0.2% clay; ex. rare sm. obsid.
B1m	134-176	10YR 5/2.5 10YR 4/1	SL LS	c m	a, w	N	<1% clay; few clr. and blk obsid
A	72-100	10YR 5.5/3	SL	m	a, s	K, L	2.3% clay; few sm. clr. obsid. grains; some *in situ* bone
A	100-150+?	10YR 5/2.5	SL	f	d, u	K, l	No clay; ex. rare tiny clr. obsid.

Table A.3, Test Pit M12
Bedrock Elevation = ~16.60m above datum
East Profile

UNIT	DEPTH (cm)	COLOR	TEXT	RCTN HCl	BNDY	BIOTURB	COMMENTS
B-L2	0-45	10YR 8/2	SL sL	a a	u	N	0.7-1.4% clay; few sm. clr. obsid.
B-L1	45-79	10YR 6.5/3	SL	c	a,u	N	0% clay; no obsid.
B2b	79-93	10YR 5.5/4	LS	f	a,b	K, I	0% clay; few sm. clr. and blk. obsid.
B2a	93-135	10YR 6/4	SL	m	a,w	K, I	0% clay; rare sm. clr. and blk. obsid
B1b	135-177	10YR 7/3	SL	a	a,w	N	1.2% clay; ex. rare sm. clr. obsid.
B1a	177-193	10YR 6/4	SL	a	a,w	I, L	0% clay; common sm. clr. obsid
A4	193-217	10YR 5.5/4	SL	c	a,w	K, I	0% clay; common sm. clr. and blk. obsid.
A2c	217-232	10YR 4.5/4	SL	m	a,w	K, M	0% clay; common sm. clr. obsid.
A2b	232-275	10YR 4/4 10YR 3.5/3	LS SL	f f	d,s	B, L	0% clay; common sm. clr. and blk. obsid.
A2a	275-305	10YR 2.5/2	LS	f	a,w	K, M	0% clay; unclear obsid. presence

Profile Analysis Data

Table A.4 Profile M11 Data

Unit	Depth (above datum)	% Clay	% Silt	% Sand	% Carb	pH
B2	17.90	4.31%	33.44%	62.25%	5.36%	8.88
B2	17.65	6.07%	52.57%	41.36%	15.66%	8.86
B1b	17.55	5.17%	30.14%	64.69%	10.01%	8.90
B1a	17.35	3.53%	34.23%	62.24%	14.08%	8.74
B1q	17.40	1.78%	29.67%	68.55%	5.63%	8.96
B1p	17.30	1.77%	52.73%	45.50%	9.14%	8.99
B1o	17.25	2.39%	38.94%	58.67%	7.19%	8.97
B1n	16.74	0.22%	37.59%	62.19%	9.40%	8.55
B1m	16.56	1.01%	30.55%	68.44%	7.62%	8.79
B1m	16.35	0.07%	28.54%	71.39%	4.89%	8.72
A	17.20	2.27%	30.81%	66.92%	6.09%	8.54
A	17.04	0.00%	34.80%	65.20%	7.26%	8.76

Table A.5 Profile M12 Data

Unit	Depth (above datum)	% Clay	% Silt	% Sand	% Carb	pH
B-L2	19.50	59.4%	39.9%	0.7%	27.06%	8.71
B-L2	19.30	21.2%	77.4%	1.4%	25.14%	9.13
B-L1	19.00	66.6%	33.4%	0.0%	7.16%	9.25
B2b	18.80	73.7%	26.3%	0.0%	0.36%	8.91
B2a	18.40	61.4%	38.6%	0.0%	3.29%	8.99
B1b	18.20	46.8%	52.0%	1.2%	30.79%	9.37
B1a	17.80	48.1%	51.9%	0.0%	15.95%	9.29
A4	17.55	67.7%	32.3%	0.0%	7.76%	9.23
A2c	17.40	67.2%	32.8%	0.0%	2.17%	9.06
A2b	17.30	72.2%	27.8%	0.0%	1.24%	8.87
A2b	17.10	72.6%	27.4%	0.0%	0.75%	9.19
A2b	16.90	67.8%	32.2%	0.0%	1.34%	8.74
A2a	16.70	72.8%	27.2%	0.0%	0.46%	9.15

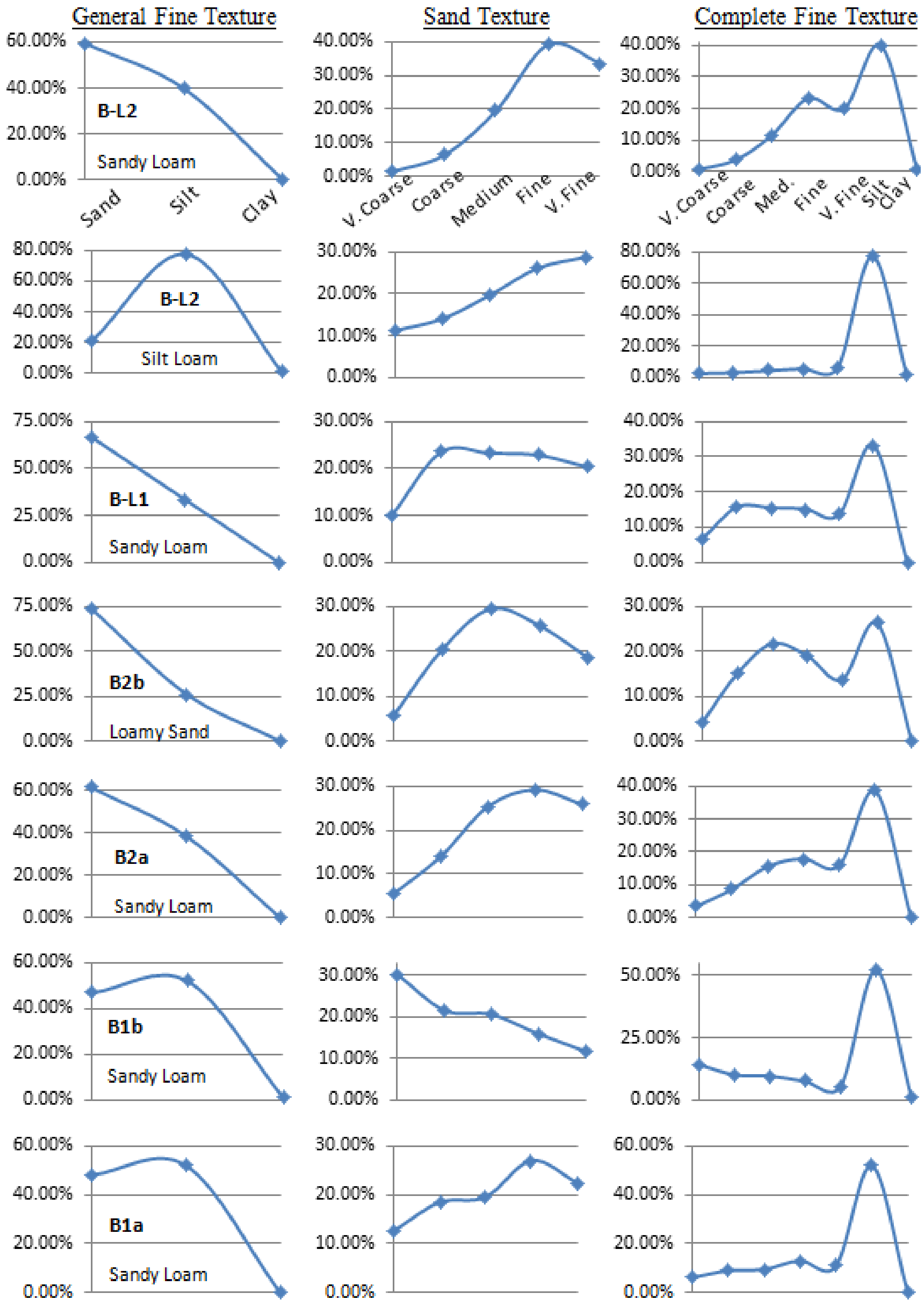
Sand Sieve Analysis

Table A.6 Profile M11 Data

Unit	Depth (above datum)	Very Fine Sand	Fine Sand	Medium Sand	Coarse Sand	Very Coarse Sand
B2	17.90	16.36%	22.65%	27.12%	28.71%	5.16%
B2	17.65	23.70%	27.99%	23.22%	16.94%	8.14%
B1b	17.55	22.96%	27.46%	23.51%	19.62%	6.45%
B1a	17.35	27.88%	32.31%	20.39%	13.97%	5.46%
B1q	17.40	29.91%	31.21%	19.28%	13.84%	5.76%
B1p	17.30	38.28%	35.02%	19.07%	6.78%	0.84%
B1o	17.25	39.75%	33.37%	15.19%	8.50%	3.18%
B1n	16.74	38.53%	34.12%	16.19%	8.75%	2.41%
B1m	16.56	29.54%	34.10%	19.31%	12.54%	4.51%
B1m	16.35	38.71%	40.45%	15.52%	4.40%	0.92%
A	17.20	32.73%	32.93%	19.64%	11.99%	2.71%
A	17.04	41.82%	33.81%	15.10%	7.16%	2.11%

Table A.7 Profile M12 Data

Unit	Depth (above datum)	Very Fine Sand	Fine Sand	Medium Sand	Coarse Sand	Very Coarse Sand
B-L2	19.50	20.01%	23.24%	11.56%	3.73%	0.81%
B-L2	19.30	6.09%	5.53%	4.18%	2.97%	2.38%
B-L1	19.00	13.54%	15.22%	15.50%	15.67%	6.70%
B2b	18.80	13.67%	18.99%	21.72%	15.09%	4.20%
B2a	18.40	15.91%	17.94%	15.57%	8.59%	3.39%
B1b	18.20	5.49%	7.46%	9.63%	10.09%	14.16%
B1a	17.80	10.77%	12.98%	9.39%	8.87%	6.05%
A4	17.55	18.76%	23.79%	16.87%	6.77%	1.48%
A2c	17.40	20.76%	25.19%	14.70%	5.36%	1.17%
A2b	17.30	19.96%	24.42%	15.84%	9.45%	2.53%
A2b	17.10	22.73%	25.28%	14.53%	7.96%	2.07%
A2b	16.90	27.40%	25.62%	10.22%	3.36%	1.24%
A2a	16.70	34.00%	31.91%	6.14%	0.60%	0.14%


General Fine Texture
Sand Texture
Complete Fine Texture
60.00%
40.00%
20.00%
0.00%
Sand
Silt
Clay
40.00%
30.00%
20.00%
10.00%
V. Coarse
Coarse
Medium
Fine
V. Fine
Med.
B-L2
Sandy Loam
80.00%
B-L2
Silt Loam
75.00%
50.00%
25.00%
B-L1
Sandy Loam
B2b
Loamy Sand
B2a
Sandy Loam
B1b
Sandy Loam
B1a
Sandy Loam

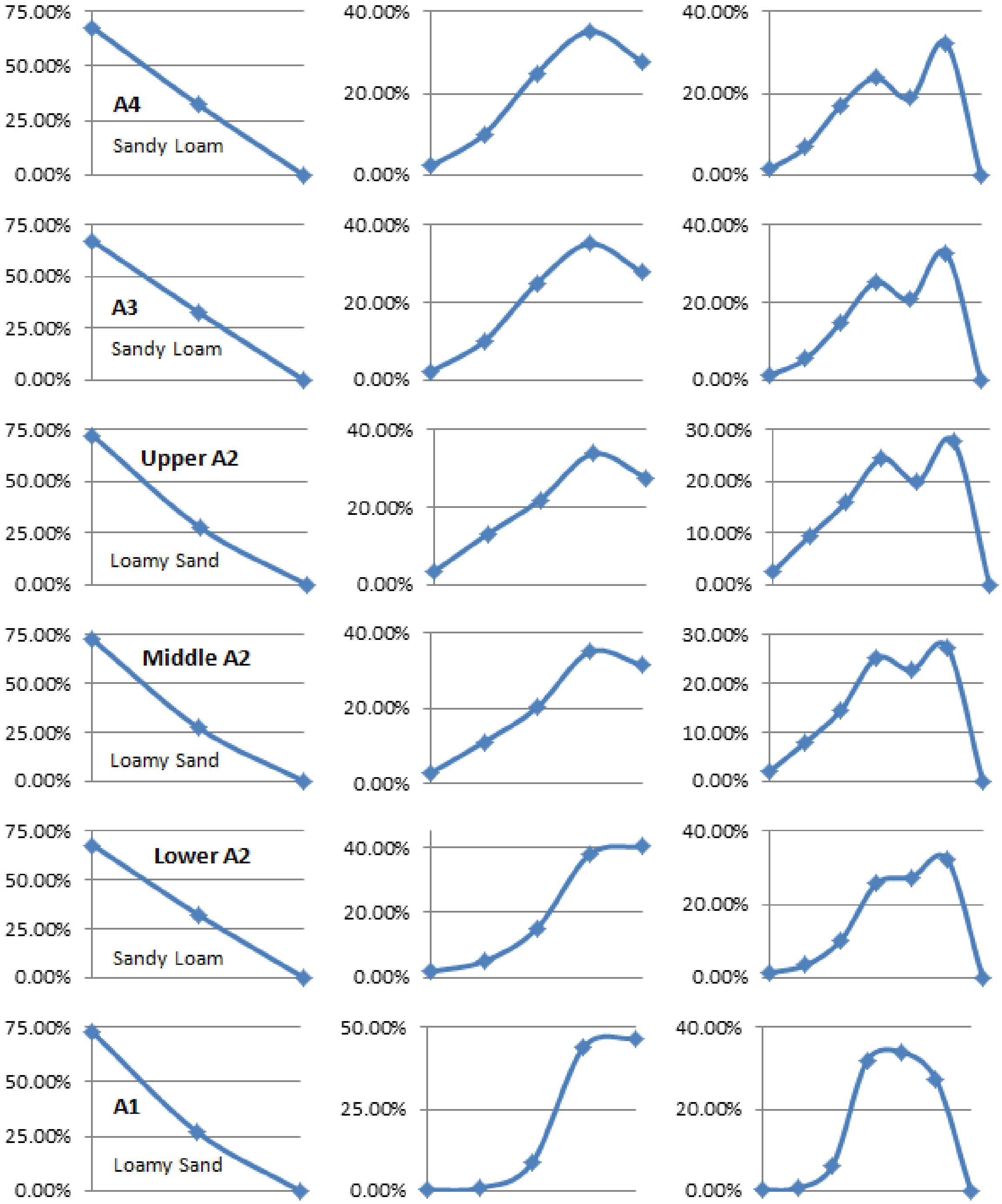


Figure A.3. M12 Complete Sediment Texture

Complete Texture Analysis

Table A.8 Profile M11 Data

M12													
Strata	Elevation	Very Coarse Sand	Coarse Sand	Medium Sand	Fine Sand	Very Fine Sand	Silt	Clay	Mean Particle Size (mm)	Standard Deviation	Skewness (+ right; - left)	Kurtosis	
B2	17.90	3.21%	17.87%	16.88%	14.10%	10.18%	33.44%	4.31%	0.390	0.436	1.523	2.352	Leptokurtic
B2	17.65	3.37%	7.01%	9.61%	11.58%	9.80%	52.57%	6.07%	0.249	0.167	0.166	-1.540	Platykurtic
B1b	17.55	4.22%	12.84%	15.38%	17.97%	15.02%	29.41%	5.17%	0.326	0.274	0.577	-0.736	Platykurtic
B1a	17.35	3.40%	8.70%	12.69%	20.11%	17.35%	34.23%	3.53%	0.271	0.173	-0.092	-1.546	Platykurtic
B1q	17.40	4.17%	10.02%	13.96%	22.60%	21.66%	25.81%	1.78%	0.328	0.222	-0.072	-1.643	Platykurtic
B1p	17.30	0.38%	3.09%	8.68%	15.94%	17.42%	52.73%	1.77%	0.172	0.095	-0.339	-1.014	Platykurtic
B1o	17.25	1.87%	4.99%	8.91%	19.58%	23.32%	38.93%	2.39%	0.215	0.084	-0.967	0.037	Leptokurtic
B1n	16.74	1.50%	5.44%	10.07%	21.22%	23.96%	37.59%	0.22%	0.235	0.110	-0.565	-0.801	Platykurtic
B1m	16.56	3.09%	8.58%	13.21%	23.34%	20.22%	30.54%	1.01%	0.335	0.205	-0.258	-1.526	Platykurtic
B1m	16.35	0.66%	3.14%	11.08%	28.88%	27.64%	28.54%	0.07%	0.222	0.167	0.541	-0.685	Platykurtic
A	17.20	1.81%	8.02%	13.15%	22.04%	21.91%	30.80%	2.27%	0.295	0.186	0.047	-1.207	Platykurtic
A	17.04	1.37%	4.67%	9.85%	22.04%	27.27%	34.80%	0.00%	0.289	0.114	-0.505	-1.031	Platykurtic

Table A.9 Profile M12 Data

M12													
Strata	Elevation	Very Coarse Sand	Coarse Sand	Medium Sand	Fine Sand	Very Fine Sand	Silt	Clay	Mean Particle Size (mm)	Standard Deviation	Skewness (+ right; - left)	Kurtosis	
B-L2	19.50	0.81%	3.73%	11.56%	23.24%	20.01%	39.90%	0.74%	0.187	0.135	0.217	-1.193	Platykurtic
B-L2	19.30	2.38%	2.97%	4.18%	5.53%	6.09%	77.41%	1.43%	0.133	0.099	0.255	-0.718	Platykurtic
B-L1	19.00	6.70%	15.67%	15.50%	15.22%	13.54%	33.37%	0.00%	0.512	0.427	0.530	-1.861	Platykurtic
B2b	18.80	4.20%	15.09%	21.72%	18.99%	13.67%	26.32%	0.00%	0.492	0.348	0.428	-1.172	Platykurtic
B2a	18.40	3.39%	8.59%	15.57%	17.94%	15.91%	38.60%	0.00%	0.389	0.220	-0.218	-2.215	Platykurtic
B1b	18.20	14.16%	10.09%	9.63%	7.46%	5.49%	51.96%	1.21%	0.317	0.464	2.095	4.507	Leptokurtic
B1a	17.80	6.05%	8.87%	9.39%	12.98%	10.77%	51.94%	0.00%	0.348	0.269	0.930	-0.564	Platykurtic
A4	17.55	1.48%	6.77%	16.87%	23.79%	18.76%	32.32%	0.00%	0.301	0.181	0.217	-1.978	Platykurtic
A2c	17.40	1.17%	5.36%	14.70%	25.19%	20.76%	32.80%	0.00%	0.287	0.164	0.164	-2.277	Platykurtic
A2b	17.30	2.53%	9.45%	15.84%	24.42%	19.96%	27.79%	0.00%	0.372	0.217	-0.108	-1.314	Platykurtic
A2b	17.10	2.07%	7.96%	14.53%	25.28%	22.73%	27.42%	0.00%	0.345	0.185	-0.329	-1.622	Platykurtic
A2b	16.90	1.24%	3.36%	10.22%	25.62%	27.40%	32.16%	0.00%	0.268	0.130	0.455	-0.462	Platykurtic
A2a	16.70	0.14%	0.60%	6.14%	31.91%	34.00%	27.20%	0.00%	0.221	0.223	1.186	0.972	Leptokurtic

Gravel Analysis

Table A.10 M11 Gravel Analysis

	Gravel (%)			
Unit	<1cm	1-2cm	2-5cm	>5cm
B2	3.2%	24.2%	12.6%	60.0%
B1	3.1%	11.6%	12.9%	72.4%
B1 Gully	3.1%	61.5%	35.4%	0.0%
A4 Gully	7.5%	92.5%	0.0%	0.0%
B1 Pipe	0.6%	10.7%	88.7%	0.0%
A4	0.4%	13.1%	0.0%	86.4%

Table A.11 M12 Gravel Analysis

	Gravel (%)			
Unit	<1cm	1-2cm	2-5cm	>5cm
B-L2	9.4%	15.5%	8.8%	66.3%
B-L1	3.7%	24.3%	5.7%	66.3%
B2	1.1%	14.6%	6.7%	77.6%
B1	1.3%	28.3%	30.5%	39.9%
A4	4.4%	31.0%	46.9%	17.6%
A2c	7.7%	86.6%	5.8%	0.0%
A2b	3.5%	47.3%	0.0%	49.2%
A2a	0.0%	0.0%	0.0%	0.0%

APPENDIX B

EXCAVATION RESULTS AND ARTIFACT ANALYSIS

Table B.1. Artifact Description Key

RAW MATERIAL

- 1. Tuff
  - 1.0 tuff
  - 1.1 tan tuff
  - 1.2 brown
  - 1.3 green
  - 1.4 red
  - 1.5 coarse volcarenite, tan
  - 1.6 coarse volcarenite, green
  - 1.7 gray tuff
- 2. Vitreous Tuff
  - 2.1 green
  - 2.2 gray
  - 2.3 red
  - 2.4 tan
  - 2.5 brown
  - 2.6 tan/green clasts
- 3. Rhyolite
  - 3.0 rhyolite
  - 3.1 brown banded
  - 3.2 brown
  - 3.3 tan
  - 3.4 red
  - 3.5 red scoria
- 4. Rhyolite Porphry
  - 4.0 rhyolite porphry
  - 4.1 red banded
  - 4.2 red
- 5. Andesite
  - 5.0 andesite
  - 5.1 andesite porphry
  - 5.2 pyroxene andes. porphry
  - 5.3 brown
  - 5.4 gray
  - 5.5 purple
- 6. Rhyodacite
  - 6.0 rhyodacite
  - 6.1 very fine black basalt
  - 6.2 rhyodacite porphry
- 7. Basalt
  - 7.0 basalt
  - 7.1 fine gray
  - 7.2 fine black
  - 7.3 coarse black
  - 7.4 vesicular
  - 7.5 olivine
  - 7.6 gnarly
  - 7.7 porphyritic
  - 7.8 black scoria
- 8. Plutonic
  - 8.0 granite
  - 8.1 aplite
  - 8.2 diorite
  - 8.3 quartz diorite
  - 8.4 hornblende diorite
  - 8.5 olivine diorite
- 9. Quartz
  - 9.0 milk quartz
  - 9.1 metaquartzite
  - 9.2 orthoquartzite
  - 9.3 micaceous quartzite
- 10. Chert
  - 10.0 chert
  - 10.1 gray
  - 10.2 green
  - 10.3 brown
  - 10.4 black
  - 10.5 red jasper
- 11. Metamorphic
  - 11.0 schist
  - 11.1 gneiss
  - 11.2 slate
  - 11.3 amphibolite
  - 11.4 phyllite
  - 11.5 green schist
- 12. Sedimentary
  - 12.0 arkose sandstone
  - 12.1 conglomerate
  - 12.2 volcarenite, vitreous
  - 12.3 volcarenite, coarse
  - 12.4 siltstone

Excavation Artifact Catalog, 2012

Table B.2 M11 Artifacts

Strata	Elevation (m above datum)	Specimen #	Raw Material	Platform	Dorsal Scar	# Scars	Cortex Type	% Cortex	Dorsal Hinge	Termination	Comments
FLAKES											
B2	18.05-17.80	600	1.3	cortex	unidirectional	2	bedrock	1-25	absent	hinged	
B2	17.84	20	8.2	unfacetted	unidirectional	1	cobble	none	absent	missing	
B1b	17.60	17	5.1	cortex	none	0	cobble	100	absent	feather	
B1b	17.56	16	1.1	unfacetted	opposed	1	cobble	51-75	present	feather	
B1a	17.43	22	2.4	unfacetted	unidirectional	1	bedrock	76-99	absent	hinged	
B1 Pipe	16.63	14	2.1	unfacetted	unidirectional	2	indeter.	none	absent	feather	
CORES											
B1b	17.58	4	7.2	mixed		9	cobble	26-50	N/A	N/A	1 distal scar from a 2nd platform; radially flaked

Table B.3 M12 Artifacts

Strata	Elevation (m above datum)	Spec. #	Raw Material	Platform	Dorsal Scar	# Scars	Cortex Type	Cortex %	Dorsal Hinge	Termination	Comments
<u>FLAKES</u>											
B-L1	19.13	40	7.2	missing	none	0	bedrock	100	N/A	feather	
B-L1	19.08	20	2.1	bifacial	unidirectional	1	indeter	51-75	absent	overpassed	
B-L1	19.04	11	1.3	cortex	cte	4	cobble	1-25	present	feather	Excavation damage
B-L1	19.03	15	1.3	missing	unidirectional	2	none	none	N/A	N/A	
B-L1	18.91	48	6.0	missing	unidirectional	2	none	none	absent	missing	Middle of flake
B2b	18.90-18.80	601	1.1	cortex	unidirectional	2	cobble	26-50	absent	feather	
B2b	18.90-18.80	603	1.1	cortex	unidirectional	1	cobble	1-25	absent	missing	
B2b	18.80-18.60	605	2.1	unfacetted	cte	4	none	none	absent	missing	
B2b	18.80-18.60	606	1.3	missing	cte	3	bedrock	26-50	present	feather	
B2b	18.80-18.60	608	1.3	missing	unidirectional	2	indeter	1-25	N/A	missing	
B2a	18.60	81	2.1	dihedral	unidirectional	3	none	none	present	feather	
B2a	18.46	105	7.2	unfacetted	unidirectional	4	cobble	26-50	absent	feather	
B2a	18.60-18.40	600	1.1	missing	unidirectional	3	bedrock	26-50	present	feather	
B2a	18.60-18.40	602	1.1	missing	unidirectional	3	none	none	present	hinged	
B1b	18.33	144	2.1	unfacetted	radial	4	indeter	none	absent	feather	

B1b	18.29	146	8.2	unfacetted	unidirectional	2	cobble	1-25	absent	feather	
B1b	18.20-18.00	607	1.3				bedrock	26-50			
B1a	18.00-17.80	604	2.1	cortex	cte	2	cobble	1-25	present	feather	
<u>RETOUCHED FLAKES</u>											
B-L1	19.05	7	1.1	missing	unidirectional	1	indeter	none	absent	missing	
B2b	18.70	70	2.4	unfacetted	cte	2	bedrock	1-25	absent	missing	rolled
B2b	18.67	71	2.4	crushed	cte	0	none	none	present	hinged	retouched?
B1b	18.40-18.20	609	7.0	cortex	unidirectional	0	bedrock	26-50	absent	missing	
<u>CORES</u>											
B-L1	19.06	8	1.3	cortex		1	bedrock	76-99	N/A	N/A	simple single platform
B2b	18.67	90	1.1	unfacetted		1	cobble	76-99	N/A	N/A	simple single platform
B1a	17.75	166	7.0	mixed		(Several)	cobble	26-50	N/A	N/A	multiple platforms
<u>DENTICULATE/NOTCH</u>											
B-L1	18.95	43	2.5	cortex	none		bedrock	1-25	N/A	N/A	thick dentic.; Karari scraper?
B2a	18.35	136	2.4	unfacetted	crossed	2	bedrock	51-75	absent	overpassed	

REFERENCE LIST

Agusti, J. and D. Lordkipanidze. 2011. How “African” was the early human dispersal out of Africa? *Quaternary Science Reviews* 30: 1338-1342.

Birkeland, P. W. 1999. *Soils and geomorphology*. Oxford, Oxford University Press.

Bousman, C.B. 1993. Hunter-Gatherer adaptations, economic risk and tool design. In *Lithic Technology* 18(1 and 2): 59-86.

Brady, N.C. and R.R. Weil. 2002. *The nature and properties of soils*. 13th edition. Upper Saddle River, N.J., Prentice Hall.

Braun, D.R., T. Plummer, J.V. Ferraro, P. Ditchfield, and L.C. Bishop. 2009. Raw material quality and Oldowan hominin toolstone preferences: evidence from Kanjera South, Kenya. *Journal of Archaeological Science* 36: 1605-1614.

Braun, D.R., T. Plummer, P. Ditchfield, J.V. Ferraro, D. Maina, L.C. Bishop, and R. Potts. 2008. Oldowan Behavior and raw material transport: perspectives from the Kanjera Formation. *Journal of Archaeological Science* 35: 2329-2345.

Buol, S.W., R.J. Southard, R.C. Graham, and P.A. McDaniel. 2003. *Soil genesis and classification*. 5th edition. Hoboken, N.J., Wiley-Blackwell.

Butzer, K. 1982. *Archaeology as human ecology*. Cambridge, Cambridge University Press.

Canell, A. 2002. Throwing behaviour and the mass distribution of geologic hand samples, hand grenades, and olduvian manuports. *Journal of Archaeological Science* 29: 335-339.

Courty, M.A., P. Goldberg, and R.I. Macphail. 1989. *Soil micromorphology and archaeology*. Cambridge, Cambridge University Press.

Dawson, J. 2010. *Impacts of volcanic ash originating from the April 2010 eruption of Eyjafjallajokull (Iceland) on the natural resources of Scotland*. The Macaulay Land Use Research Institute. Craigiebuckler, Aberdeen, AB15 8QH, UK., 1-25.

de Lumley, H., M. Nioradze, D. Barsky, D. Cauche, V. Celiberti, G. Nioradze, O. Notter, D. Zvania, and D. Lordkipanidze. 2005. Pre-Oldowan lithic industries from the early Pleistocene site of Dmanisi in Georgia (Translated from French). *Anthropologie* 109: 1-182.

Dibble, H.L. 1995. Middle Paleolithic Scraper Reduction: Background, Clarification, and Review of the Evidence to Date. *Journal of Archaeological Method and Theory* 2(4): 299-368.

Dreimanis, A. 1962. Quantitative gasometric determination of calcite and dolomite by using Chittick apparatus. *Journal of Sedimentology and Petrology* 32: 520-529.

Dzaparidze, V., G. Bosinski, T. Bugianisvilit, L. Gabunia, A. Justus, N. Klopotovskajan, E. Kvavadze, D. Lordkipanidze, G. Majsuradze, N. Mgeladze, M. Nioradze, E. Pavlenisvili, H.U. Schmincke, D. Sologasvili, D. Tusabramisvili, M. Tvalcrelidze, and A. Vekua. 1989. Der altpaläolithische Fundplatz Dmanisi in Georgian (Kaukasus). *Jahrbuch des Römisch-Germanischen Zentralmuseums Mainz*, 36: 67-116.

Faulkner, H., R. Alexander, and P. Zukowskyj. 2008. Slope-channel coupling between pipes, gullies and tributary channels in the Mocatan catchment badlands, Southeast Spain. *Earth Surface Processes and Landforms* 33: 1242-1260.

Ferring, R., O. Oms, J. Agusti, F. Berna, M. Nioradze, T. Shelia, M. Tappen, A. Vekua, D. Zhvania, and D. Lordkipanidze. 2011. Earliest human occupations at Dmanisi (Georgian Caucasus) dated to 1.85-1.78 Ma. *Proceedings of the National Academy of Science* 108(26): 10432-10436.

Gabunia, L., A. Vekua, D. Lordkipanidze, C.C. Swisher III, R. Ferring, A. Justus, M. Nioradze, M. Tvalchrelidze, S.C. Anton, G. Bosinski, O. Joris, M.-A. de Lumley, G. Majsuradze, and A. Mouskhelishvili. 2000. Earliest Pleistocene Hominid Cranial Remains from Dmanisi, Republic of Georgia: Taxonomy, Geologic Setting, and Age. *Science* 288: 1019-1025.

Gabunia, L. and A. Vekua. 1993. A Plio-Pleistocene hominid from Dmanissi, east Georgi, Caucasus. *Nature* 373: 509-512.

Gee, G.W. and K.H. Bauder. 1986. Particle-Size Analysis, Ch. 15. In *Methods of soil analysis: part 1 – Physical and mineralogican methods,* ed. A. Klute. Agronomy, No. 9, Part 1, 2nd edition, 383.

Goldberg, P., V.T. Holliday, and C.R. Ferring. 2001. *Earth sciences and archaeology*. New York: Springer.

Goldman-Neuman, T., and E. Hovers. 2011. Raw material selectivity in Late Pliocene Oldowan sites in the Makaamitalu Basin, Hadar, Ethiopia. *Journal of Human Evolution* 62(3): 353-366.

Hay, R.L. 1976. *Geology of the Olduvai Gorge: A study of sedimentation in a semi-arid basin.* Berkeley, CA, University of California Press.

Isaac, G. and B. Isaac. 1997. *Koobi Fora research project: Volume 5: Plio-Pleistocene archaeology*. Oxford, Oxford University Press.

Jenny, H. 1941. *Factors of soil formation*. New York, McGraw-Hill Book Company.

Johnson, D.L. 1989. Subsurface stone zones, artifact-manuport layers, and biomantles produced by bioturbation via pocket gophers (*Thomomys Bottae*). *American Antiquity* 54(2): 370-389.

Laity, J. 2008. *Deserts and desert environments*, 131-132. Hoboken, NJ, Wiley Blackwell.

Leakey, M. D. 1971. *Olduvai Gorge. Vol. 3, excavations in Beds I and II, 1960-1963*. Cambridge, Cambridge University Press.

Lordkipanidze, D., T. Jashashvili, A. Vekua, M.S. Ponce de Leon, C.P.E. Zollikofer, G.P. Rightmire, H. Pontzer, R. Ferring, O. Oms, M. Tappen, M. Bukhsianidze, J. Agusti, R. Kahlke, G. Kiladze, B. Martinez-Navarro, A. Mouskhelishvili, M. Nioradze, and L. Rook. 2007. Postcranial evidence from early *Homo* from Dmanisi, Georgia. *Nature* 449: 305-310.

Messager, E., S. Nomade, P. Voinchet, R. Ferring, A. Mgeladze, H. Guillou, and D. Lordkipanidze. 2011. ^{40}Ar/^{39}Ar Dating and phytolith analysis of the Early Pleistocene sequence of Kvemo-Orozmani (Republic of Georgia): chronological and palaeological implications for the hominin site of Dmanisi. *Quaternary Science Reviews* 30: 3099-3108.

Messager, E., D. Lordkipanidze, E. Kvavadze, C.R. Ferring, and P. Voinchet. 2010a. Palaeoenvironmental reconstruction of Dmanisi site (Georgia) based on palaeobotanical data. *Quaternary International* 223-224: 20-27.

Messager, E., D. Lordkipanidze, C. Delhon, and C.R. Ferring. 2010b. Palaeoecological implications of the Lower Pleistocene phytolith record from the Dmanisi Site (Georgia). *Palaeogeography, Palaeoclimatology, Palaeoecology* 288(1-4): 1-13.

Messager, E., D. Lordkipanidze, C.R. Ferring, and B. Deniaux. 2008. Fossil fruit identification by SEM investigations, a tool for palaeoenvironmental reconstruction of Dmanisi site, Georgia. *Journal of Archaeological Science* 35: 2715-2725.

Mgeladze, A., D. Lordkipanidze, M.-H. Moncel, J. Despiree, R. Chagelishvili, M. Nioradze, and G. Nioradze. 2011. Hominin occupations at the Dmanisi site, Georgia, Southern Caucasus: Raw materials and technical behaviours of Europe's first hominins. *Journal of Human Evolution* 60: 571-596.

Potts, R. 1991. Why the Oldowan? Plio-Pleistocene toolmaking and the transport of resources. *Journal of Anthropological Research* 47(2): 153-176.

Ryder, G. and S. Graham. 1996. *The Cretaceous-Tertiary event and other catastrophes in Earth history*. Geological Society of America.

Schick, K. and N. Toth. 2006. *The Oldowan: Case studies in the earliest stone-age*. Bloomington, IN, Stone Age Institute Press.

Schiffer, M. 2002. *Formation processes and the archaeological record*. Salt Lake City, UT, University of Utah Press.

Stout, D., J. Quade, S. Semaw, M.J. Rogers, and N.E. Levin. 2005. Raw material selectivity of the earliest stone toolmakers at Gona, Afar, Ethiopia. *Journal of Human Evolution* 48: 365-380.

Tactikos, J.C. 2005*. A landscape perspective on the Oldowan from Olduvai Gorge, Tanzania*. Dissertation.

Tappen, M., D. Lordkipanidze, M. Bukshianidze, A. Vekua, and C.R. Ferring. 2007. “Are you in or out (of Africa)? Site formation at Dmanisi and actualistic studies in Africa.” In *Breathing life into fossils: Taphonomic studies in honor of C.K. Brain*, ed. T.R. Pickering, K. Schick, and N. Toth, 119-135. Bloomington, IN, Stone Age Institute Press.

Tappen, M., D.S. Adler, C.R. Ferring, M. Gabunia, A. Vekua, and C.C. Swisher III. 2002. Akhalkalaki: The taphonomy of an Early Pleistocene locality in the Republic of Georgia. *Journal of Archaeological Science* 29: 1367-1391.

Torre, I. de la, and R. Mora. 2005. Unmodified lithic materials at Olduvai Bed I: Manuports or ecofacts. *Journal of Archaeological Science* 32: 273-285.

Vekua, A., and D. Lordkipanidze. 2008. The history of vertebrate fauna in Eastern Georgia. Paleobiology. *Bulletin of the Georgian National Academy of Sciences* 2(3): 149-155.

Verachtert, E., W. Maetens, M.V.D. Eeckhaut, J. Poesen, and J. Deckers. 2011. Soil loss due to piping erosion. *Earth Surface Processes and Landforms* 36: 1715-1725.

Verachtert, E., M.V.D. Eeckhaut, J. Poesen, and J. Deckers, J. 2010. Factors controlling the spatial distribution of soil piping erosion on loess-derived soils: A case study from central Belgium. *Geomorphology* 118: 339-348.

Walker, A. and R. Leakey. 1993. *The Nariokotome Homo erectus skeleton*. Cambridge, Mass., Harvard University Press.

Wood, W.R., and D.L. Johnson. 1978. A survey of disturbance processes in archaeological site formation. In, *Advances in archaeological theory and method, Vol. 1*. Waltham, Mass., Academic Press, Inc.