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The geoarchaeology of Dust Cave: a Late Paleoindian through Middle Archaic site in the western Middle Tennessee River Valley

Sarah C. Sherwood

To the Graduate Council:

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Jan F. Simek, Major Professor

We have read this dissertation and recommend its acceptance:

Steven G. Driese, Boyce N. Driskell, Paul Goldberg, Walter E. Klippel, Julie K. Stein

Accepted for the Council:

Carolyn R. Hodges

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

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THE GEOARCHAEOLOGY OF DUST CAVE: A LATE PALEOINDIAN THROUGH MIDDLE ARCHAIC SITE IN THE WESTERN MIDDLE TENNESSEE RIVER VALLEY

A Dissertation
Presented for the
Doctor of Philosophy Degree
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Sarah Catherine Sherwood
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Finally, I am grateful to my family for their love and support and for instilling in me the essentialness of curiosity and conservation. I thank them all for their cheers from the wings, and for forgiving my absences. To Hector Qirko, who endured the worst of it, I am in awe of your generous spirit, and fine heart.

ABSTRACT

This dissertation uses a geoarchaeological perspective in order to reconstruct the depositional history of Dust Cave. Dust Cave, located in the western Middle Tennessee River Valley, is a complex Late Paleoindian through Middle Archaic site. The cave contains uniquely well-preserved artifacts, and one of the earliest well-dated archaeological sequences in the southeastern US. The depositional history addresses the relationship of Dust Cave to the regional geomorphology and builds a contextual framework based on the cave's microenvironment. Microenviornmental conditions directly affected both the organization of human activity and its preservation.

The methodology employed consists of detailed macrostratigraphic field observations and micromorphological analyses of more than 130 sediment thin sections. Micromorphology is the most appropriate technique for the cave environment where fine-scale variation among the deposits is preserved and data from the anthropogenic sediments have the potential to inform about human activity. The zones are organized chronologically based on 46 radiocarbon ages and diagnostic artifacts.

When Late Paleoindian peoples began to occupy Dust Cave ca. 10,500 B.P. it had recently been flushed of sediment from a phreatic aquifer at the rear of the cave. The entrance chamber contained only a thin veneer of reworked alluvium overlying the bedrock floor in a ~10 m wide and nearly 8 m deep room with a 5 m high ceiling. Intermittent overbank deposition with limited reworked aeolian sediments and autochthonous sediments accumulated in the cave for the next ca. 2,000 years. During this time Late Paleoindian and Early Archaic peoples seasonally inhabited the cave. Microtopographic surface variation and the periodic resurgence of phreatic drainages controlled the organization and preservation of anthropogenic sediments. After ca. 8,500 B.P., when the floodplain began to stabilize, alluvial sediments were no longer actively contributing to the cave. Sedimentation over the next 3,000 years was primarily the result of human activity, which continues until ca. 5,200 B.P. when the cave is no longer habitable. Several interesting aspects of the depositional history are revealed including relic cold features deep in the sequence and the identification and distribution of prepared surfaces. These discrete anthropogenic structures have significant implications for technology and site formation.

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CHAPTER 1

INTRODUCTION AND OBJECTIVES

Introduction

Our knowledge of the human past is as much a result of *how* we look at the archaeological record as it is of the artifacts we find there. This dissertation approaches the archaeological record of one complex site from a geoarchaeological perspective at a range of scales in order to reconstruct its depositional history. The site, Dust Cave, is a late Paleoindian through Middle Archaic site in the western Middle Tennessee River Valley. The cave contains uniquely well-preserved bone and botanical materials, as well as microstratigraphy and intact occupation surfaces typically destroyed in open-air sites in the southeastern US.

Research questions regarding Paleoindian arrival and early prehistoric adaptations in eastern North America have moved to the forefront of North American archaeology (Anderson and Gillam 2000; Anderson and Sassaman 1996; Anderson and Faught 1998, Stanford 1991). The potential for caves and rockshelters to preserve early archaeological deposits and therefore play a significant role in this research is clear. Walthall (1998), states that the Late Paleoindian peoples, Dalton in particular, were the first to consistently frequent rockshelter and cave entrances. Based on changing site distributions, he suggests that initial Dalton occupations are the result of an increase in population density and a reorganization of hunter-gatherer seasonal rounds (Walthall 1998:231). This interpretation ignores the potential of the active geologic environment to both erase occupations prior to the early Holocene and directly affect the habitation potential of portions of the landscape. This geoarchaeological research demonstrates clearly the key role that the dynamic landscape played in early prehistoric settlement. The geomorphic transformations in this narrow section of the Middle Tennessee River Valley directly affected the timing of the occupation of Dust Cave and played a significant role in the cave's depositional history.

Within the cave, microenvironmental conditions influenced both the organization of human activity and its preservation. In the relatively new domain of anthropogenic sediment analysis, this study contributes to the identification and classification of these sediments in cave environments. The use of sediment composition and microstructure to infer microclimatic conditions within a cave has been successfully undertaken in numerous Old World sites (e.g., Courty 1989; Goldberg 1979a, 1979b, 1999; Farrand and McMahon 1997; Rigaud et al. 1995). The following chapters will describe the manner in which the application of this approach is undertaken at Dust Cave, effectively providing a comprehensive understanding of the processes that occurred within the cave, as well as their direct and indirect affects on our interpretation of human activity there.

Dust Cave

Archaeological sites in the western Middle Tennessee River Valley dating from the Pleistocene/Holocene transition through the early Holocene are typically poorly preserved and deflated and therefore provide only limited contextual, environmental, and subsistence data. Dust Cave contains one of the oldest and most complete archaeological sequences in the eastern US, including some of the earliest well-dated evidence for human occupation in the Southeast. This dissertation provides a stratigraphic framework through which to organize the artifactual data from the cave. The fine-scale variation among the deposits can be used to inform about human activity and the nature of the artifact distribution. Ultimately, the multi-disciplinary investigation of Dust Cave will enable construction of interpretive models relevant to human adaptive strategies from the Pleistocene/Holocene transition through the mid-Holocene.

Dust Cave (1Lu492) is a habitation site in a karstic cave vestibule in the Tennessee River Valley, in the southern Interior Low Plateau of Northern Alabama (Driskell 1996; Goldman-Finn and Driskell 1994) (Figure 1.1). Humans first occupied the cave around 10,500 years ago, at which time the entrance chamber consisted of patches of relic sediments on a bedrock floor.

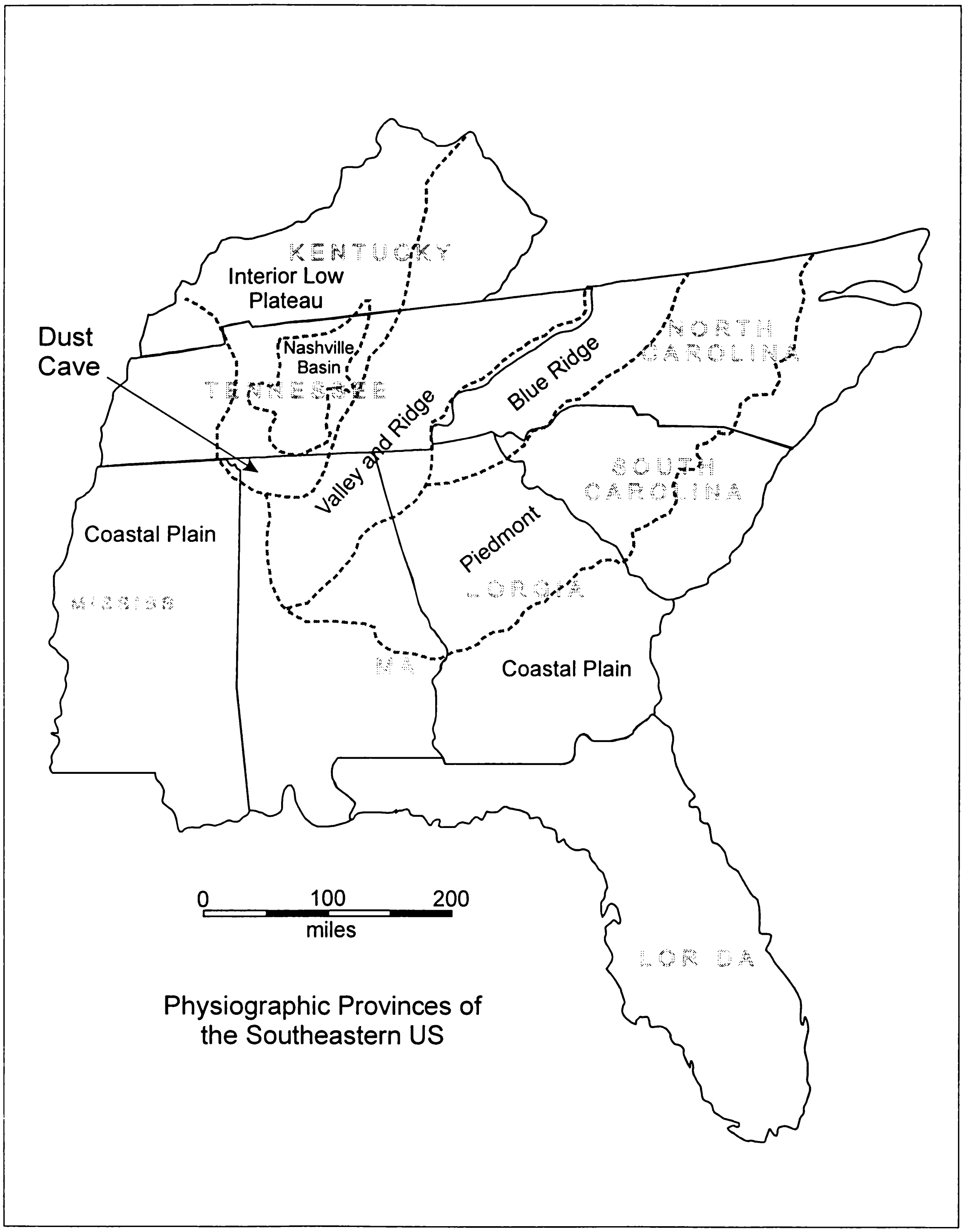

Figure 1.1. The Location of Dust Cave.

The ceiling was then over 4 m high. After approximately 5,000 years of seasonal human occupation, headroom in the entrance chamber was reduced to less than 1 m and the cave was abandoned. The cave vestibule contains as much as 4 vertical meters of sediment generated through anthropogenic, biogenic, and geogenic processes, with human occupation being the overwhelming process responsible for these deep deposits (Goldberg and Sherwood 1994).

Dust Cave was first recorded and mapped in the Alabama Cave Survey, and reported to the Alabama State Site File by Richard Cobb in 1984. Then, in 1989, as part of the ongoing research agenda focusing on the regional caves, the University of Alabama and the University of Northern Alabama conducted limited testing, involving five small test units (50 x 50 cm). In 1990, based on these initial findings, Boyce Driskell of the University of Alabama launched what has become a multi-year, interdisciplinary field project centering on an intensive archaeological field school, which meets each summer for an 8 to 10 week dig season.

The 1990 through 1994 seasons focused on the excavation of several test units in an effort to define the extent and nature of archaeological deposits in the cave (Figure 1.2). Also during this time a 2 m x 12 m north-south trench (Test Trench) was excavated in contiguous 2 m squares, extending from outside the entrance toward the back of the entrance

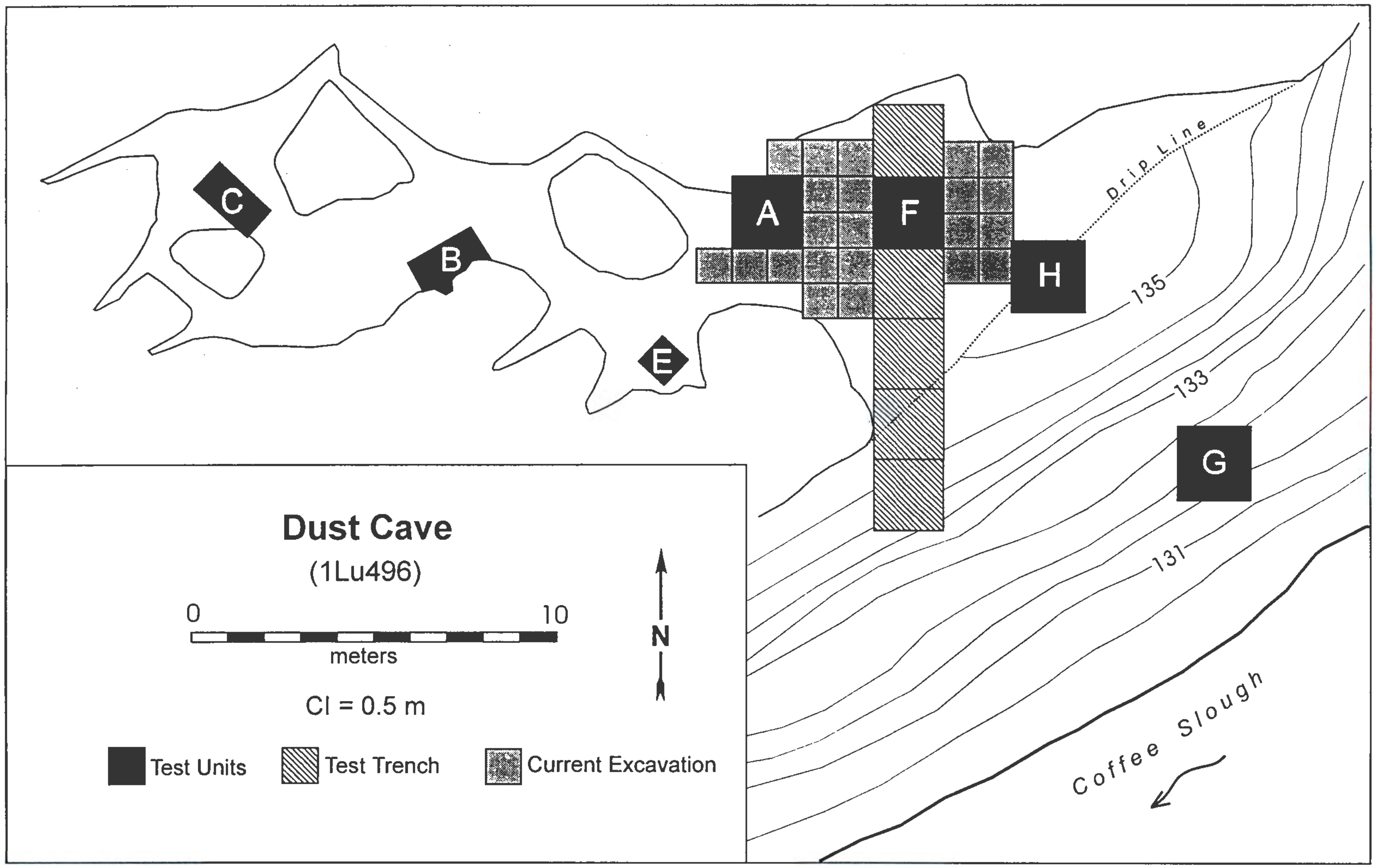

Figure 1.2. Dust Cave Plan Map Illustrating Excavation Stages.

chamber (incorporating Test Unit F). This test trench was completed in 1994. In 1994, Nurit Goldmann-Finn and Boyce Driskell edited a comprehensive volume of the *Journal of Alabama Archaeology* that presented preliminary results on every aspect of the test excavation, including chronometric dates, diagnostic artifacts, botanical and faunal materials, and geologic interpretations. Most of the papers focused on artifacts derived from the on-going Test Trench excavations, specifically Test Unit F, located near the center of the entrance chamber (Figure 1.2).

Currently, the chronosequence in the cave is composed of five superimposed prehistoric components organized by 48 radiocarbon age determinations (Table 1.1). These components begin with the late Paleoindian (10,500 to 10,000 BP), and continue through the Early Archaic with Early Side Notched (10,000 to 9,000 BP) and Kirk Stemmed (8,500 to 7,000 BP) components, to the Middle Archaic with Eva/Morrow Mountain (7,000 to 6,000 BP) and Seven Mile Island (6,000 to 5,200 BP) components (Driskell 1994, 1996).

The testing phase analyses (concentrating on Test Unit F) suggest several trends among the artifacts representing the cultural components. Analysis of the faunal data indicates a shift through time from exploitation of aquatic habitats (as indicated by water birds and fish) to terrestrial habitats (deer, rabbit, etc.) (Grover 1994; Walker 1998). Of particular interest is the

Table 1.1. Conventional Radiocarbon Dates for Dust Cave Organized by Zone.

Zone	Convent. 14C Age (BP)	+/-	Beta No.	TU	N	W	Lev	Depth (top)	Depth (bot)	Fea.	Context Comment
D4	5,280	130	65168		60.00	64.00	6	160	178	42	basin shaped, intersecting feature complex Fea.47, 136 (hearths)
D4	5,000	80	100508		60.00	65.00	11	173		136a	Intersecting basin shaped features, 136a originates at the base of D4, intrudes into E1, Fea.47 adjacent and same temporal placement
D4	5,590	50	58895		62.00	64.00	6	175	185	15	base of D4, intersecting shallow basin pits
D4/E1	5,380	90	48753	H	60.20	60.10	7	150	160		
E1*	5,400	80	100509		59.20	64.60	15	196		150b	series of intersecting shallow basins of ash and cc with variable amount of burned gastropods, intrusive into E5. *could be intrusive into E1
E1	6,700	100	48752	H	60.00	59.60	12	200	210		Benton and Morrow Mt projectile points immediately above
E1	5,670	120	58898		58.00	64.00	11	200	208	56	small pit intruding into E8, (E8d zones).
E4	5,910	70	65169		62.60	62.90	11	215	220	69	small basin shaped sparse rock lined pit, originated in E1/E4, intrudes into J1/J3
X10	6,560	140	48751	B			2	327	347		back passage level w/ bone needles, Benton & Big Sandy base
J/K	6,660	100	58899		58.00	64.00	14	240			base of J/top of K (spit D), prior to zone designations
J1a	6,480	90	100510		62.00	64.50	23	245		177	shallow elongated rock feature (cc & ash beneath rock) originates in J1a intrudes into J3
J3	6,280	90	65171		63.50	63.50	11	222	225		Upper J3, material intruded by Fea.69, excav from '92-'93 possible contamination
J3	6,790	120	58897	H	60.00	59.60	16	240	250	38	Top of Fea.38 in Zone J1/J3 (fea. above or intruding into zone containing Kirk Serrated & Eva projectile points), at cave entrance
J3d	6,350	90	65174		62.70	62.80	16	245	251	88	small cc & ash filled basin with red clay base, Fea.88 originates in J3d, intrudes into K2
K3	7,040	80	65173		60.00	64.00	18	259			base of K3, transition to N, complex zones with intruding features
K3	7,480	120	65170		58.00	64.00	18	270	275	71	base of K, outside entrance
K3-K5/N2	6,570	190	65175		60.00	64.00	21	270	275		Exact zone not clear (assoc. w/ 93013)

Table 1.1. (Continued)

Zone	Convent. 14C Age (BP)	+/-	Beta No.	TU	N	W	Lev	Depth (top)	Depth (bot)	Fea.	Context Comment
L1	7,040	110	65178		59.10	62.50	24	283	293	98	rock lined shallow elongated pit w/ ashy silt and cc and red clay inclusions, intrudes into P1, just inside drip line at the N/L1 transition
L4	9,190	130	65183		58.00	64.00	35	385	390		transition entrance to talus, under R (L3), adjacent to R and R3/S2
N	6,840	90	65182		63.50	63.20	22	275	280		top of N2, cc concentration in NE quad of unit, associated with possible reworked Kirk projectile point into scraper (#73)
P1	6,050	100	48755		61.00	63.00	13	280	286	34	burial fill, intrusive into P3, part of zone P1, top depth ~246
P1	7,680	170	48756		60.20	62.20	17	285	295		
P2	7,010	90	65180		60.00	64.00	25	290			compact ash & cc zone, intrusive, may be part of a feature complex associated with Fea. 98
P3/~ P14	8,330	170	65184		60.00	64.00	36	345			red silty clay, (bioturbated), just above Q1
Q1	8,470	50	81608		64.00	64.00	38	359			top of Q, below P5b
R1*	9,720	70	81606		63.00	63.00	43	380	385		cc concentration in silty clay *possible intrusive pit
R3f	10,140	40	16273		60.00	65.00		405	410		Early Side-Notched component
R9	10,050	60	81602		59.00	64.00	46	400			soft red zone, associated with Big Sandy (material from top of 98058)
S1a	8,720	90	65176		58.00	64.00	25	306	313	94	cave entrance S1a or P3, basin shape shallow pit with artifacts
S2	10,450	50	81600		56.00	64.00	29	437			related to drip line just outside entrance, same material as 93020, above bedrock
T	10,070	70	81610		64.00	63.00	48	409			rock concentration, Beaver Lake projectile point in zone T, 50 cm to the south of sample
T1/T 2?	9,990	140	65177		60.40	63.60	33	430	435		Zone T1 associated with uniface & Big Sandy projectile points
T2/T 3?*	10,490	360	40681	A	60.85	66.60	22	381	391	33	*Problematic sample?, Fea.33 intrusive into zone containing Big Sandy projectile point (near sample 98014)
T2	9,950	50	133788		61.95	65.63	55	384			cc concentration reddish brown, silty "loam" w/ éboulis, >15 cm above large bird humeri concentration

Table 1.1. (Continued)

Zone	Convent. 14C Age (BP)	+/-	Beta No.	TU	N	W	Lev	Depth (top)	Depth (bot)	Fea.	Context Comment
T2c	10,020	40	16274		60.00	66.00		410	415		Late Paleoindian component
T2?T3	10,330	120	41063	A	60.50	67.00	23	391	401		*Problematic Sample, Big Sandy projectile point found above (SE, SW corner of TU A)
T8 (T2)	9,890	70	81611		64.00	64.00	47	403			cc ash concentration in red micaceous clay
T8	10,100	50	133791		63.00	65.00	61	420			micaceous clay with cc and éboulis <10 cm above U3
U1	10,340	130	81609		60.00	64.00	58	460			
U1a	10,390	80	65179		62.00	64.00	36	450	455		concentration of cc beneath a rock identified as lens U1a, originates in U2, just above bedrock, assoc. w/ unifacial tools, ~98041 (E. wall Test Trench)
U1a	10,310	230	65181		60.25	62.16	39	461	463		silty clay zone w/ cc, directly below #1000, intrudes or overlies basal U2, ~98074 (E. wall Test Trench)
U2	10,480	60	81599		60.24	62.20	40	476			micaceous silty clay on bedrock w/ cc flecks, still contains bone and lithics, underlying #1000 and 1037, (E. wall Test Trench)
U3	10,290	60	133790		61.00	66.00	59	428			brown silty clay w/ éboulis, associated w/ flot column #5678
U3	10,345	80	40680	A	60.20	66.20	27	431	441		silty clay (uniface tools, bone, flakes, etc.), ~10 cm above bedrock
U3	10,470	60	81613		64.00	64.00	55	445			excavated as T (west wall Test Tench), micaceous silty clay among weathered bedrock & éboulis
Y1	10,570	60	81603		55.00	63.36	35	460			silty clay at base of cave over bedrock

high relative frequency of ducks during the Late Paleoindian. The botanical data so far are very preliminary and indicate that nuts, specifically hickory, were important throughout the sequence, especially in the Early and Middle Archaic Periods (Gardner 1994). Recent botanical analyses focusing on the Late Paleoindian component also indicate hickory as important both as a subsistence resource and a fuel during this time (Detwiler 2000). Other floral resources utilized during the Late Paleoindian included wild fruits. The Late Paleoindian component has, at the time of this writing, undergone the most extensive analyses, with flora and faunal results suggesting a late summer and autumn occupancy (Walker, et al. 2001). Preliminary lithic analyses suggest an overall emphasis on late stage biface production and tool maintenance strategies (Meeks 1994). Nearly all of the resource material, consistent throughout the temporal sequence, is locally available, high quality, blue/gray Fort Payne chert.

Excavation Protocol

As in all multi-year projects, the Dust Cave excavation and recording methods were developed and refined from the project's initial prospective phase to today's intensive, detailed excavation (Figure 1.2). The test units (A, B, C, F, G, H) were exploratory, so the resolution of the excavation levels shifted from 20 to 5 cm as the excavation progressed, and the quality of the recorded profiles varies. In particular, the profile resolution and attention to detail vary significantly depending on the period of excavation.

All of the elevations within the cave are reported as centimeters below datum (cmbd), and are derived from a point outside the cave designated as zero. The grid system in which all the horizontal measurements are recorded is oriented to magnetic north and is centered on a hypothetical 0,0 point outside the cave (Figure 1.2). The test units in the back passage of the cave, B and C, are not tied to the grid system, so they are consistently referred to by their Test Unit designations.

In 1996 a projected ten year program caused the investigators to expand the excavations east and west of the Test Trench, focusing on a more detailed excavation strategy. The new strategy uses 1 x 1 m units, excavating by 5 cm levels within lithologic units called "zones". An intensive sampling program was also implemented for micromorphology and flotation (representative samples from each zone and all "feature" fills are floated). The remaining sediments are water screened through ¼ in (6.25 mm) mesh and all artifacts are collected.

Dissertation Objectives and Organization

The primary objective of the geoarchaeological analysis is to describe and interpret the depositional history of Dust Cave. In order to accomplish this goal, a methodological framework had to be implemented that was appropriate to the complex stratigraphy typically identified in cave sites, while also providing a chronostratigraphic structure. This framework had to provide a context for the interpretation of the artifacts and at the same time describe the anthropogenic sediments to allow inferences about both human activity and site formation. I used a geoarchaeological framework that relied on macrostratigraphic and microstratigraphic observation.

The macrostratigraphic aspect of the study centers on seven years of summer excavations in the cave (1991-1994, 1996-1998). During this time, first Paul Goldberg and then I delineated, described, and correlated zones. The zones are organized into a relational database that is specifically designed to encompass all the data from the site (e.g., stone tools, plant and animal remains, sediment descriptions). The relational database uses the stratigraphic context as its structural foundation (Sherwood and Riley 1998). The zones are organized chronologically based on 48 radiocarbon ages (Table 1.1).

The microstratigraphic study, based on the micromorphology of approximately 130 thin sections, is the primary technique used in the interpretation of the cave sediments. This technique is the most appropriate for a cave environment in which fine scale variation among deposits is preserved and data from anthropogenic sediments have the potential to inform about human activity.

In Chapter 2 use a geoarchaeological perspective to construct a methodological framework for the study of karstic deep cave sites and their subaerial entrances. This includes a review of the depositional environments of caves and the processes that generate and affect the sediments found there. I briefly discuss the techniques traditionally applied to cave sediments in an archaeological context and examine micromorphology as the best technique to decipher cave deposits.

In Chapter 3 I define the regional landscape (the western Middle Tennessee River Valley), and the project area (the Seven Mile Island Archaeological District). Included is an overview of the Quaternary history for the area, beginning with the current landscape, examining the regional geology, climate, vegetation, soils, and geomorphology. Models for the Quaternary geomorphology proposed by Delcourt (1980), Brakenridge (1982, 1984), and others are briefly reviewed as they pertain to the regional geomorphic history. Additional data are derived from local archaeological stratigraphy, site distributions, and radiocarbon dates. Finally, I refine a model originally developed by Collins and Goldberg (1995) as the general outline for the project area geomorphic history.

Chapter 4 describes the archaeology and early prehistory of the western Middle Tennessee River Valley. I begin with the history of archaeology in the region, and the constraints and theoretical orientations under which it was undertaken. I also submit additional discussion on the development of cave and rockshelter archaeology in the region. This is followed by a synthesis of the region's early prehistoric periods, beginning with the Paleoindian and continuing through the Archaic. I emphasize the western portion of the Middle Valley with general summaries of the components present at Dust Cave.

In Chapter 5, I explain the methodology used for the macro- and microstratigraphic analyses at Dust Cave. While the types of field data collected are also briefly reviewed, the description of the Zone Database, along with the actual data, are presented in Appendix A. The majority of the chapter focuses on the microstratigraphic analysis, describing the laboratory procedures and nomenclature employed in thin section description. The sample locations and field descriptions are presented in Appendix C. Appendix D (CD Rom) provides the individual thin section descriptions, accompanied with a digital image of each sample.

In Chapter 6, I describe and discuss sediment signatures that are unique to Dust Cave or to the region. Sediment signatures refer to specific combinations and/or distributions of clasts that are derived from a particular source or are related to a specific transport mechanism or depositional environment. While the processes themselves may be universal, the resulting character of the sediment is unique. I assign descriptive terms to the signature features and constituents, discussing their significance in the Dust Cave context. These signatures include both single processes and combinations. I also discuss anthropogenic sediments, focusing on prepared surfaces and burning deposits.

Chapters 7, 8, and 9 present narrative descriptions and interpretations of the stratigraphy observed at Dust Cave. Chapter 7 includes the back passage (dark zone) stratigraphy represented in Test Units B and C. Color plates begin in Chapter 7 and continue through Chapter 9. These plates are located on the accompanying CD Rom and are in jpg format. The plate captions are listed in Appendix E.

Chapter 8 contains the entrance chamber stratigraphy, a very complex series of superimposed lithostratigraphic units. The discussion begins with the zones resting on bedrock and continues upward to the latest deposits that followed the abandonment of the cave. Lateral as well as vertical variation is discussed. In Chapter 9, I present the stratigraphy outside the cave represented in the sequence observed beyond the drip line in the Test Trench.

Chapter 10 contains the summary of the previous three chapters where I submit a final interpretation of the data and the depositional history of Dust Cave. I also discuss the significance of the relic cold features in the cave, the stratigraphic trends, and the prepared surfaces. This discussion is followed with suggestions for future research directions.

CHAPTER 2

A GEOARCHAEOLOGICAL FRAMEWORK FOR THE STUDY OF KARSTIC CAVE SITES IN EASTERN NORTH AMERICA

Introduction

Caves have been described as highly efficient sediment traps where accumulation characteristically excels over erosion -- as sources of continuous sedimentological records that are absent in open air sites where erosion and soil formation otherwise prevail (Collcutt 1979, Straus 1990). As such, the stratigraphic record in cave entrances is traditionally targeted by geologists and prehistorians as indicators of regional paleoclimate (Butzer 1981; Laville et al. 1980). The original sedimentological criteria proposed for paleoenvironmental reconstruction in caves (e.g., Butzer 1981; Laville 1976; Laville et al. 1980), although generally suitable for the periglacial environment of Pleistocene West Europe, were ultimately deemed inappropriate for many environments (Goldberg 1979b; Schnurrenberger 1991). These criteria focused on clast size and morphology as a result of variation in physical weathering or changes in local chemical weathering. No new criteria have been or probably will be developed that are appropriate for a regional scale.

It is extremely difficult to distinguish between local factors (microclimate) and broader climatic factors (macroclimate) as the dominant influence of sediment infilling (Campy and Chaline 1993; Funk 1989). For example, moisture content affecting the morphology and porosity of limestone clasts may not be the product of warm humid climates as originally thought, but the result of large quantities of organic matter absorbing and retaining moisture. Sufficient CO_2 or acids produced from biological decay can substantially alter the post-depositional environment (Bögli 1975; Foreman and Miller 1984). This post-depositional alteration has been mistaken for the basal enrichment of secondary carbonates resulting from warm humid conditions. This effect is not necessarily the result of a warm humid climate increasing chemical weathering, but the same alteration can occur in cold climates, or basically anywhere calcium carbonate-enriched groundwater emerges from cave walls and ceilings (Schnurrenberger 1991). The variables of physical weathering are not understood well enough to permit regional climatic inferences (Farrand 1985; Goldberg 1979a; Straus 1990).

In actuality, cave sediment sequences are strongly controlled by their microenvironment rather than regional climatic change. Microenvironmental conditions are the result of numerous factors, including bedrock lithology, elevation, aspect, relation to local drainage, tectonic events, and human activity (Bonifay 1962; Campy and Chaline 1993; Farrand 1985; Goldberg 1979a; Goldberg and Bar-Yosef 1998; Schnurrenberger 1991).

Despite the absence of an interpretive model for cave sediments, there is a general geoarchaeological methodological framework that guides our observations and the nature of the data we extract from archaeological sites in these complicated depositional environments. The goals of such a geoarchaeological framework are to render a depositional history of the cave while providing a context and chronology for the artifacts in the depositional environment. One must also keep in mind that sediments in archaeological sites, especially those in caves, are themselves typically artifacts of human activity.

In this chapter I outline a geoarchaeological perspective and methodological framework for the study of karstic deep cave sites and their subaerial entrances. I focus on the type of karstic caves typical to eastern North American cave sites. Much of the geoarchaeological framework presented here originated in Old World archaeology and Quaternary studies, which are characterized by a long tradition of geological and archaeological collaboration (Stein 2000). First, I will review the environments of deep caves and their entrances and the kinds of processes that generate and affect the sediments they contain. The techniques traditionally applied to cave sediments will be briefly discussed, underscoring micromorphology as a technique to best address contextual questions.

Rockshelters *vs.* Caves

I distinguish between deep caves and cave entrances or vestibules, based on their often divergent archaeological and depositional histories. Deep caves can be defined as subterranean passages and chambers formed in bedrock that reach beyond the limits of natural light. The lithology of the bedrock can vary from basalt to sandstone and various carbonate rocks, but most caves (and the focus of this chapter), form through the dissolution of limestone. These karst cavities form as conduits for water flow between input and output points (Gillieson 1996). The entrance(s) from the ground surface into a cave system can take many different forms, including vertical shafts, fissures, and lateral openings. Archaeologists exploring cave habitation sites typically deal with lateral openings, which provide horizontal surfaces under roofed shelters, affording stable and predictable refuge on the landscape.

Rockshelters, rock overhangs and shallow rock recesses can also contain rich habitation sites. These depositional environments, unlike caves, exist completely within the reaches of natural light and ambient temperature and moisture conditions (Collins 1990). They can be similar to cave entrances in morphology and content, but lack contiguous subterranean passages and the effects of these environments. The subterranean environment adds new processes that create and affect the archaeological site not typically dealt with in the rockshelter literature. Some of the processes and methods discussed here are appropriate to rockshelters, but these sites are not specifically addressed. The geoarchaeology of rockshelter sites is the focus of many previous publications by Farrand (1985), Collins (1990), Laville (1976), and Straus (1990).

In geoarchaeology texts (e.g., Stein and Farrand 1985; Rapp and Hill 1998; Waters 1992) where cave environments are discussed, authors typically focus on rockshelters and cave entrances and regularly refer the reader to standard geologic texts for information on deep cave environments. Such resources as Ford (1976) and White (1998) are important geologic references, but these rarely include humans as a contribution or process to consider in cave sedimentation. These geoscience-oriented resources lack sufficient information in the face of increasing interest in cave archaeology.

Cave Environments

Unlike cave entrances, deep caves do not generally contain habitation debris and thick stratigraphic sequences, but rather an ephemeral record of human exploration, ritual, burial, and mining (Carstens and Watson 1996; Watson 1986). While there has historically been an interest in the archaeological and paleontological deposits of cave entrances and rockshelters, deep cave sites have remained more enigmatic. This trend is changing however, due to the archaeological research pioneered by Patty Jo Watson in the Salts and Mammoth Cave systems (Watson 1969, 1974, 1996; Watson and

Yarnell 1966), as well as the increasing threat to these subterranean cultural and natural resources by ever-increasing recreational traffic and urban expansion.

Deep cave sites fall into two categories at the end of the hydrological energy spectrum -- "the active or dynamic cave passage, and abandoned or arrested cave passage" (Crothers and Watson 1993:53). These wet vs. dry environments greatly affect original human use, the preservation of the material record, and ultimately, how archaeologists investigate these environments. Hydrologically abandoned cave passages are the targets of most underground Eastern North American archaeological research (e.g., Simek et al. 1998; Watson 1969, 1974, 1996). Typically these passages are relatively dry (with only localized drip water), and maintain a near constant temperature and humidity. Archaeological studies in active or wet cave passages are far less common.

The deposits in hydrologically active passages are usually generated by geologic processes, fluvial in nature, and remain both wet and active. As a result, archaeological deposits in these active environments are difficult to recover, and materials are rarely found in their behavioral context. These factors, however, do not diminish their archaeological significance, because the simple presence of artifacts and human remains in these environments can be informative. For example, one of the most extensive cave archaeology projects conducted in an active cave system is the Petexbatum Regional Cave Survey in the Mayan area of Guatemala. Here, researchers have grappled with the methodological issues of processing buried saturated clay deposits where meaningful diagnostic artifacts are recovered (Brady and Scott 1997). The laborious extrication of these finds has been worthwhile, as the work suggests ritual activities in the Petexbatum caves that previously underrepresented in open-air Mayan assemblages (Brady 1994; Brady and Scott 1997).

The wet environment of some deep caves is often the norm for pit caves used for prehistoric human "burial" in the Eastern Woodlands. Like the Petexbatum examples, the dynamic nature of this context does not diminish the significance of important archaeological burial sites. However, the implementation of unique methodologies for taphonomic considerations is required when interpreting these deposits (e.g., Cook and Munson 1997; Crothers and Watson 1993; Willey et al. 1988).

In dry or arrested cave passages, the groundwater that once shaped the system has abandoned that elevation, leaving behind a sediment or breakdown surface that typically far predates human occupation in the Americas. Paleomagnetic dating of clastic sedimentary deposits has been used successfully to establish minimum ages of regional karstic systems (e.g., Noel and Thistlewood 1989; Sasowsky et al. 1995). Sediments from several of the inactive archaeological caves in the Eastern Woodlands indicate a minimum age of deposition at the Pliocene/Pleistocene boundary (Sasowsky et al. 1995).

The paleosurface, therefore, is usually the same as the modern surface, posing contextual problems as we try to identify temporal variability among artifacts resting on the same surface (Crothers and Watson 1993). The sedimentation rate can be exceedingly slow in deep cave environments (there are catastrophic exceptions, but these generally occurred before human occupation in the Americas), making the identification and interpretation of artifact palimpsests very difficult. Stratigraphic distinctions in deep caves become obvious when the paleosurface is disturbed, typically as a result of prehistoric and historic human activity, which can result in the inundation of paleosurfaces and associated archaeological materials.

Stratified or buried deposits in hydrologically abandoned or arrested cave passages are usually anthropogenically or biologically derived. For example, prehistoric mining activity for chert, aragonite, and gypsum are common prehistoric disturbances observed in caves (Munson and Munson 1990, Munson et al. 1989; Simek, et al. 1998; Watson 1969, 1974). This prehistoric activity created archaeological sediments through scraping and battering the cave walls or digging for these mineral resources. In order to interpret the archaeological significance of these sediments, they must be studied in the context of the geological and biological cave environment. These deposits may not be composed specifically of anthropogenic material, but their existence is the result of human activity. Thus, the artifacts within the sediment, as well as the sediments themselves, are relics of human activity.

Deciphering palimpsests in cave entrances is equally difficult, but for slightly different reasons. Here the depositional environment is typically more dynamic, with a higher rate of sedimentation. We must consider the cave entrance as an interface between deep cave processes and subaerial processes where more varied types of sediments can accumulate at varying rates.

Cave Sediments

Nearly all cave deposits are complicated sequences derived from multiple sources and numerous processes. Diagenesis (the geologic transformation of sediments), predominates over pedogenesis and represents the principal weathering in deep caves and their entrances. This mechanical or chemical post-depositional alteration is greatly influenced by the porosity and mean grain size of the cave sediments. In order to decipher diagenesis and understand the depositional history of these complex deposits, the sediments should be classified and observed at a variety of scales. This requires looking at the sediments composing the strata and not just at the layer as a unit or a group of units. Sediment description and classification provides an understanding of their source(s) and transport agent(s), as well as the nature of their depositional environment.

White (1988) proposed a generalized classification of cave sediments that I modified slightly to include anthropogenic sediments (Table 2.1). Cave sediments are composed of clastic and chemical sediments. Clastic sediments include both autochthonous (endogenous) sediments originating inside the cave system, and allochthonous (exogenous) sediments, originating outside the cave system. Clastic sediment types can be found in both deep caves and their entrances. Chemical sediments also exist in both depositional environments; however, they are more active in deep cave environments where long-term constant temperature and high relative humidity encourage the chemical deposition of various minerals.

Autochthonous sediments include clasts of bedrock, travertine or other detritus produced from chemical weathering of carbonate walls, ceilings and floors. These sediments can vary greatly in size, from mechanically weathered angular blocks referred to as breakdown - measuring several meters in size - to water-lain silt-size and clay-size materials. As carbonate rocks weather, their insoluble components are added to the cave deposits. These fractions vary according to the composition of the bedrock but generally consist of various siliceous minerals including clay minerals, quartz, chert or chalcedony nodules, and heavy minerals (White 1988).

Autochthonous minerals resulting from chemical weathering vary depending on the bedrock and microenvironment, but most commonly include

Table 2.1. The Classification of Cave Sediments (Based on Table 8.1 in White 1988).

Classification	Cave Sediment
Clastic Sediments	
Endogenous or Autochthonous	Weathering detritus
	Breakdown
	Organically derived minerals
Exogenous or Allochthonous	Entrance talus
	Infiltrates
	Fluvial deposits
	Glacial deposits
	Aeolian deposits
	Organic debris
	Biogenic (non-organic) debris
	Anthropogenic sediments
Chemical Sediments	Travertines
	Evaporites
	Phosphate and nitrate minerals
	Resistates
	Ice

calcite and aragonite. They result in speleothems, and locally cemented sediments (secondary chemical crystallization), that are of limited interest to the archaeologist except where their formation overlies or incorporates archaeological deposits. Such instances suggest specific microenvironmental conditions and/or the quarrying or extraction of these minerals by prehistoric peoples. One such extraction study looks at the removal, caching, and ritual use of speleothems in a number of Mayan caves (Brady et al. 1997). Speleothem deposits can also be used as chronostratigraphic dating tools applying techniques such as radiocarbon, Uranium-series and trapped electron methods (Aitken 1990; Schwartz 1980; Henning et al. 1985).

Chemical evaporite deposits in caves commonly consist of sulfates and halides (White 1976, 1988; Hill and Forti 1997). These minerals form within the sediment as delicate crystals and cements on the walls and more rarely, as stalactites and stalagmites. Chemical evaporites should be examined by archeologists, as prehistoric peoples mined these minerals and typically targeted specific sulfate crystallite forms including gypsum, epsomite, and mirabilite (Tankersley 1996; Watson 1974; Watson et al. 1969). Finally, phosphate and nitrate minerals - organic and authigenic in origin - appear both in cave entrances and deep in the interior. In keeping with White's (1988) classification, I will regard them as autochthonous chemical sediments when considering deep cave mineral deposits. These minerals occur in caves primarily as crusts on breakdown material and on bedrock walls, or as layers (e.g., massive phosphates produced by large-scale reaction products, Karkanas et al. 2000) or nodules within clastic sediments or guano piles (Gillieson 1996; Hill and Forti, 1997).

Nitrate minerals were the focus of 19^{th} century saltpeter operations when these nitrate rich sediments were mined to produce gun powder. These operations often resulted in extensive disturbance to dry deposits in cave entrances and the adjacent dark zones, resulting in archaeological deposits (Hill 1981; Duncan 1997; Smith 1990).

Allochthonous sediments enter the cave system through a number of processes, including aeolian, fluvial, colluvial, biogenic, glacial, marine, and human activity. Aeolian processes are generally restricted to the entrances of caves. Wind-blown (loess) deposits are regionally limited to those areas affected directly and indirectly during the Pleistocene glacial maxima. Glacial deposits in the form of tills often occur in glaciated regions and can appear in cave entrances (e.g., Dixon et al. 1997; Bobrowsky et al. 1990). Loess and glacial sediments are also reworked by fluvial processes. Fluvial processes generate the majority of material in cave sediment sequences and are often derived from numerous sources inside and outside the cave environment (White 1988:238). These water-transported sediments can appear anywhere within the cave system, and can be moved through small fissures and conduits or through large open channels. Fluvial deposits can vary from cobble to clay sizes, often appearing as highly variable interbedded strata resulting from annual fluctuations and shifts in source areas. Fluvial deposits and their flow conditions in caves are typically interpreted from sediment transport theory or by relating empirical or theoretical relationships between sedimentary structures and the hydrologic regime (Gillieson 1996:155).

Gravitational sediments can enter a cave system in the form of entrance talus material or colluvium, roof fall, and phreatic infiltrates. Talus materials can be very complex and are derived generally from numerous sources such as soil, rock debris and, in the case of archaeological sites, sediments generated through human activity. This material is unsorted, and usually mixed with other transported material from the same sources including slopewash, solifluction, and trampling. As a result, the transport processes are often difficult to identify. Talus sediments are deposited at the cave entrance but can be transported a short distance into the cave interior. Gravitational infiltrate sediments can also occur when karstic sinks open into the system, resulting in an almost catastrophic influx of surface sediments, including residual soils. These sediments often include paleontological bones derived from animals once attracted to subaerial water sources that these sinks sometimes provided (e.g., Parmalee 1992).

Biogenic Sediments

Biogenic sediments can include organic and inorganic material. The inorganic material can consist of mud nests of mud from insects (mud daubers) or birds (swallows). Faunal fecal materials are primarily composed of organic materials. The fauna that produce them not only contribute to the sediment of archaeological cave sites with their waste, but through the actions of macro and micro fauna they can also bury or turbate archaeological sediments. Sediments, which can be linked to the activity of specific fauna, can provide microenvironmental information: cave species may be highly sensitive to temperature, humidity or substrate conditions, and therefore reside only in certain subterranean habitats.

Organic debris in caves is primarily derived from animal wastes such as guano, but can also include plants. This organic debris is considered the original source for some chemical cave minerals (Table 2.1), but it is also associated with the generation of autochthonous clastic sediments. The natural appearance of specific plant and/or animal species depends on highly variable habitats arranged along a gradient of decreasing light and increasing humidity from the entrance towards the deep cave (Howarth 1983). In the entrance there is the potential for greater diversity of plant and animal habitats, resulting in a far greater frequency and diversity of organic sediments. Organic matter brought into a cave system by humans can be thought of as constituting part of the anthropogenic sediment. Distinguishing between these transport agents requires knowledge of the regional flora and fauna, and consideration of the nature of the other sediments and their structure in the same deposit. Non-anthropogenic plant material is typically limited to cave entrances except for that which enters as fluvial sediment; the latter is usually distinguished by the presence of fluvial structures.

Plants also have the effect of modifying pre-existing sediments. For example, plant rhizome structures can disturb the arrangement of a deposit by changing the void structure and mixing strata. Roots can also act as pathways for groundwater movement affecting the geochemistry. For example, in Dust Cave, roots penetrated several meters into the archaeological sediments, serving as conduits for calcium carbonate-rich waters that resulted in localized calcite precipitation. Roots can also provide organic materials that attract biological activity, resulting in post-depositional mixing of the strata.

Fauna contributing to and affecting deep cave sediments are restricted by their ability to thrive in dark, constant, microclimatic conditions, often with high CO_2 levels. These animals subsist on limited organic nutrients that enter the system through percolating water, seasonal floods, or guano (Gillieson 1996; Holsinger 1988). Fauna include Traglophiles, or cave loving species that can live in or out of caves (e.g., several varieties of spiders and crickets), Tragloxens or temporary residents (e.g., bats, cave-nesting birds), and Troglodytes, typically blind cave dwellers who can only reside in this dark stable environment (e.g., cave fish, some salamanders). Burrowing and the accumulation of feces by some of these cave occupants, such as crickets and beetles, can affect archaeological deposits in caves by mixing sediment within and between deposits. The same is true of Tragloxenes, such as bears, raccoons and coyotes who are known in the eastern woodland to seasonally venture deep into the dark zone. These fauna can disturb sediments through digging and burrowing and can also introduce allochthonous clastic material through fecal material and food waste (raccoons in particular).

Anthropogenic Sediments

Anthropogenic sediments are defined as any sediment affected or generated by human activity. These sediments include ash, charcoal, organic materials from vegetable materials introduced by people for subsistence, fuel or for bedding, and microartifacts (artifacts that bypass traditional collection techniques of < 6mm mesh) (Stein and Teltser 1989; Sherwood 2001). This anthropogenic material can also include geologic clastic material transported by people and introduced into a new context. Such sediments might include those removed to dig a subterranean pit, clay used to line a hearth or prepared surfaces, sediment burned at the base of a hearth pit, or soil material either trampled in or brought in adhering to game or plant food (Goldberg and Bar-Yosef, 1998; Macphail and Goldberg 1995). The only way to identify these materials is through a thorough understanding of the environment of deposition, microstructure variability, and the contents and morphology of a deposit.

Anthropogenic and biogenic contributions to the infilling of caves and rockshelters, although recognized as sedimentologically significant (Butzer 1981, 1982; Goldberg 1979a), have often been overlooked in North American archaeological cave site descriptions. In assessing the volumetric consequence of anthropogenic sediments, consider Gillieson's (1996:145) estimates that people contribute several tons per year of lint and skin cells in heavily used tourist caves.

In Table 2.1 anthropogenic sediments are classified as allochthonous, however they can also be considered autochthonous in specific circumstances. For example, wood brought into a cave entrance and burned to ash results in silt-size ash sediments produced inside the cave. They do not fit a strict definition of material originating from within the cave system, but when considering their source, transport mechanism, and the *in situ* transformation of the calcium oxalate crystals to $CaC0_3$ (Karkanas et al. 2000) they are derived from activity that occurred inside the cave.

Approaches to cave sediments by archaeologists and geoarchaeologists have been borrowed directly from sedimentology and soil science (Farrand 1985; Laville et al. 1980). These techniques often do not permit the distinction of different sources and processes in complex depositional and diagenetic environments and sequences. In order to interpret these sequences more effectively a geoarchaeological approach must combine intensive field observation and a problem-oriented combination of analytical methods centered on the *in situ* microscopic or micromorphological analysis of cave sediments.

Methodology

Observation and description are the simplest but most important tools for understanding the context of cave sites (Collcutt 1979). Descriptions generated through laboratory analyses cannot substitute for first hand field observations, and laboratory analyses should not supply data on samples from poorly documented contexts (Farrand 1985; Goldberg 1980, 1988). The initial recording and subsequent reporting of thorough field descriptions based on standardized criteria and terminology are requisite tools of archaeological investigation. Standardized descriptions are absent in reports detailing New World cave sites, or they are replaced with interpretations such as paleoclimatic conditions. There are clear, concise, standardized nomenclatures published for soils and sediments (Birkeland 1984; Folk 1980; Soil Survey Staff 1975), and they should be systematically used by archaeologists.

Soils, in the pedological sense, are rarely present in cave systems. The distinction between sediments and soils affects how we observe sections in the field and how we describe stratigraphy, the properties we observe, measure, and the processes we interpret. Soil formation typically results in the development of horizons, diagnostic entities parallel to the stable ground surface that have characteristics which reflect upon the physical and chemical modification of minerals and their translocation within the soil body (Buol et al. 1997; Holliday 1992). Many of our traditional excavation techniques, developed for open-air sites, use "levels" and "layers" associated with soil horizonation and soil description. Soil horizons are rarely identified in caves, yet some practitioners often use methodological approaches that are oriented towards soil characterization and landscape reconstruction (e.g., Moody and Dort 1990).

To communicate the complexities of cave stratigraphy, standardized terminology must be implemented. As an excavation progresses, distinct lithostratigraphic units are defined and described. Important field observations are texture, sedimentary structures, color relations, boundaries, and facies constituents and relationships (Farrand 1985; Gladfelter 1977; Hassan 1978; Stein 1987). Simple aspects like boundaries must be observed and reported. The nature of the contact between strata is instrumental for interpreting processes that actively create and affect the deposits. Unconformable contacts are frequent in cave strata and can be tied to both geological and anthropogenic causes. In either case, these contacts are vital in the correlation of lateral facies changes, often frequent in cave sites (Courty 2001). Contacts are also crucial in the reconstruction of microclimates, distinguishing artifact palimpsests, and in the construction of chronosequences.

Standardized soil characterization techniques such as grain-size distribution, pH, total phosphorus, clay mineralogy, grain morphology and calcium carbonate equivalence are considered standard procedures for the characterization of stratigraphic sequences and deposits in archaeological sites (Hassan 1978; Mandel and Simmons 1997; Shackley 1975; Stein 1985). All or combinations of these techniques are traditionally applied in geoarchaeological studies of cave entrances. Due to the uniqueness of the cave environment and the general absence of pedogenic weathering profiles, not all of these techniques are appropriate for the characterization or interpretation of cave sediments. Problem-oriented research dictates the sedimentological methods that best address specific questions (Quine 1995). Problem-oriented analyses target broad objectives, such as characterization of lithology, identification of depositional and post-depositional processes, and more specific questions including taphonomic conditions, the identification and temporal assessment of disconformities, or the nature and origin of specific anthropogenic sediments.

As noted above, cave deposits are complicated, with numerous sources, depositional environments and post-depositional processes operating simultaneously (Farrand 1985, 1999; Farrand and McMahon 1997, Mandel and Simmons 1997). Thus, standard analytical techniques are limited in their ability to reveal a complicated succession of pedological, geological, or anthropogenic events superimposed upon the same depositional sequence. For example, calcium carbonate analysis will not distinguish between primary (depositional) or secondary (pedogenic) carbonates (Goldberg 1979a). Grain-size analysis also has specific limitations when applied to archaeological sediments. The technique is universally applied in geoarchaeological studies and first requires samples to be disaggregated into their (supposedly) original individual particles. Pretreatment can destroy organic matter, wood ash and some microartifacts, all of which are major components of anthropogenic deposits and integral parts of the archaeological record (Sherwood et al. 1995). Grain-size analyses typically do not discriminate between translocated silt, clay or transported fine materials that were transported as sand-size aggregates (Courty et al. 1989).

Micromorphology

A technique that is increasingly valuable to avoid many of the above-mentioned limitations is micromorphology, the study of undisturbed soils, sediments and other archaeological materials (including ceramics, bricks, mortars) at a microscopic scale. Micromorphology employs undisturbed, oriented samples in which the original components and their geometric relationships are conserved (Courty et al. 1989). Micromorphological analysis allows the observation of composition (mineral and organic), texture (size, sorting), and fabric (the geometric relationships among the constituents). Within an individual thin section one can observe micro-stratigraphic sequences that reflect temporal changes in depositional and post-depositional processes. Sediment attributes such as size, roundness, sorting and clast composition, which require several procedures to record (including dispersal of the sediment, sieving of grain sizes, and microscopic observation), can be described semi-quantitatively through microscopic observation made on micromorphological thin sections.

This technique of using micromorphology to study the depositional and contextual relationships of archaeological deposits and to generate data about both environmental conditions and human activity has been successfully applied to numerous archaeological contexts. In particular, the study of anthropogenic sediments in thin section is contributing to a more comprehensive understanding of the archaeological record and an appreciation for sediments as products of human behavior (e.g., Gé et al. 1993; Gebhardt and Langohr 1999; Matthews 1995; Matthews et al. 1997; Simpson et al. 1999). Experimental and ethnoarchaeological studies are providing both baseline studies and comparative materials in the study of hearths, earthwork construction, agricultural practices, and other various occupational activities (Gebhardt 1992; Goldberg and Whitbread 1993; Macphail et al. 1987; Macphail and Goldberg 1995; Quine 1995).

The study of caves, with their unique depositional environments and confined space, and the nature of the anthropogenic deposits recovered there, has benefited greatly from thin-section analyses in the study of spatial organization and site formation processes, especially in the Old World (Courty et al. 1989; Goldberg 1999; Goldberg and Arpin 2000; Laville and Goldberg 1989; Sherwood and Goldberg 1997; Weiner et al. 1993). Due to the limited degree of weathering, microstratigraphic lenses are much more likely to be present in caves than in open-air sites, at least in Holocene caves from the New World. These layers are so small that it is typically impossible to isolate them during excavation. Micromorphology allows a sample of these sediments to be observed *in situ*, at a variety of scales.

Sampling should be as systematic as possible within a specific problem-orientated framework, and as such need not involve huge amounts of sediment taken in bulk sampling techniques. Micromorphological samples require removal of oriented, *in situ* blocks of sediment (Courty et al. 1989; Murphy 1986).

Ancillary methods should be implemented after micromorphological analysis, in order to clarify observations or identify microscopic elements (Macphail and Goldberg 1995). These methods may include physical analyses like grain-size analysis or SEM to identify surface morphologies, or the identification of buried surfaces with magnetic susceptibility. Methods addressing elemental distributions include infrared spectrometry or inductively coupled plasma spectroscopy (ICP) (to identify elemental composition), x-ray diffraction (to identify clay mineralogy), or SEM/EDAX (to identify elemental variation). Fourier Transform Infrared Spectrometry (FTIR) has been very successful in documenting diagenetic changes in cave sediments, with implications for bone preservation and dating (Karkanas et al. 2000; Schiegl et al. 1996; Weiner et al. 1993, 1998). The combination of rigorous field observation and micromorphology with ancillary techniques is an approach that has been successfully implemented in numerous cave sequences in the Old World (e.g., Bar-Yosef et al. 1992; Courty et al. 1989; Gé et al. 1995; Goldberg 1979a, 1979b, 1999; Schiegl, et al. 1996), and a growing number of sites in North America (e.g., Goldberg and Arpin 2000; Goldberg and Sherwood 1994; Simek et al. 1997).

Conclusions

Cave environments (especially in deep caves) offer exceptional opportunities for preservation of residues of prehistoric human activity. Numerous processes generate and transport sediment from within and outside the cave system, resulting in complex deposits commonly derived from several sources. These sediments can include both autochthonous and allochthonous clastic elements as well as chemical precipitates. Cave entrances in particular are even more complex due to the direct impact of exogenous processes (e.g., temperature shifts, rainfall, pedogenesis, plant growth, and faunal turbations) that typically do not influence deep cave stratigraphy. Deep cave environments and their slow sedimentation rates offer their own unique challenges, specifically the identification of artifact palimpsests and their association with ancient surfaces. Thus, karstic cave sediments, and the stratigraphic units they represent, require careful classification and interpretation in order to reconstruct their complex depositional histories.

Micromorphology, in combination with detailed field observation and problem-oriented ancillary techniques, is the best approach to accomplish this task. Specifically, micromorphology provides the scale at which sediments (often associated with anthropogenic processes) can be studied in context. Micromorphology requires minimal sediment removal and provides a permanent record of the site stratigraphy. The geoarchaeological research from Dust Cave, presented in the following chapters, is organized within this methodological framework. This framework provides the basis of the interpretation of the depositional history of the cave, while at the same time furnishing the context and chronology for the artifacts recovered from this deeply stratified site.

CHAPTER 3

QUATERNARY HISTORY OF THE WESTERN MIDDLE TENNESSEE RIVER VALLEY

Introduction

The geomorphic history of a region can have a profound effect on both the spatial and temporal distribution of archaeological sites and the geologic processes of site formation that influence their preservation and discovery (Butzer 1982; Goldberg et al. 1993; Leach and Jackson 1987; Schiffer 1987). Therefore, to reconstruct the depositional history of Dust Cave, we must first position the site in the context of the geomorphic history of the regional landscape. I define the regional landscape as the western Middle Tennessee River valley in northwestern Alabama, which today contains Wheeler, Wilson and Pickwick lakes (Figure 3.1). More specifically I focus on the local landscape of Dust Cave, referred to as the project area. The project area is situated in the easternmost reaches of the Pickwick basin associated with the Seven Mile Island Archaeological District (Figure 3.2).

This chapter begins with a basic overview of the current landscape including the regional geology, climate, vegetation, soils, and geomorphology. I integrate the few existing regional Quaternary history models with additional data to construct a general model for the geomorphic history of the project area.

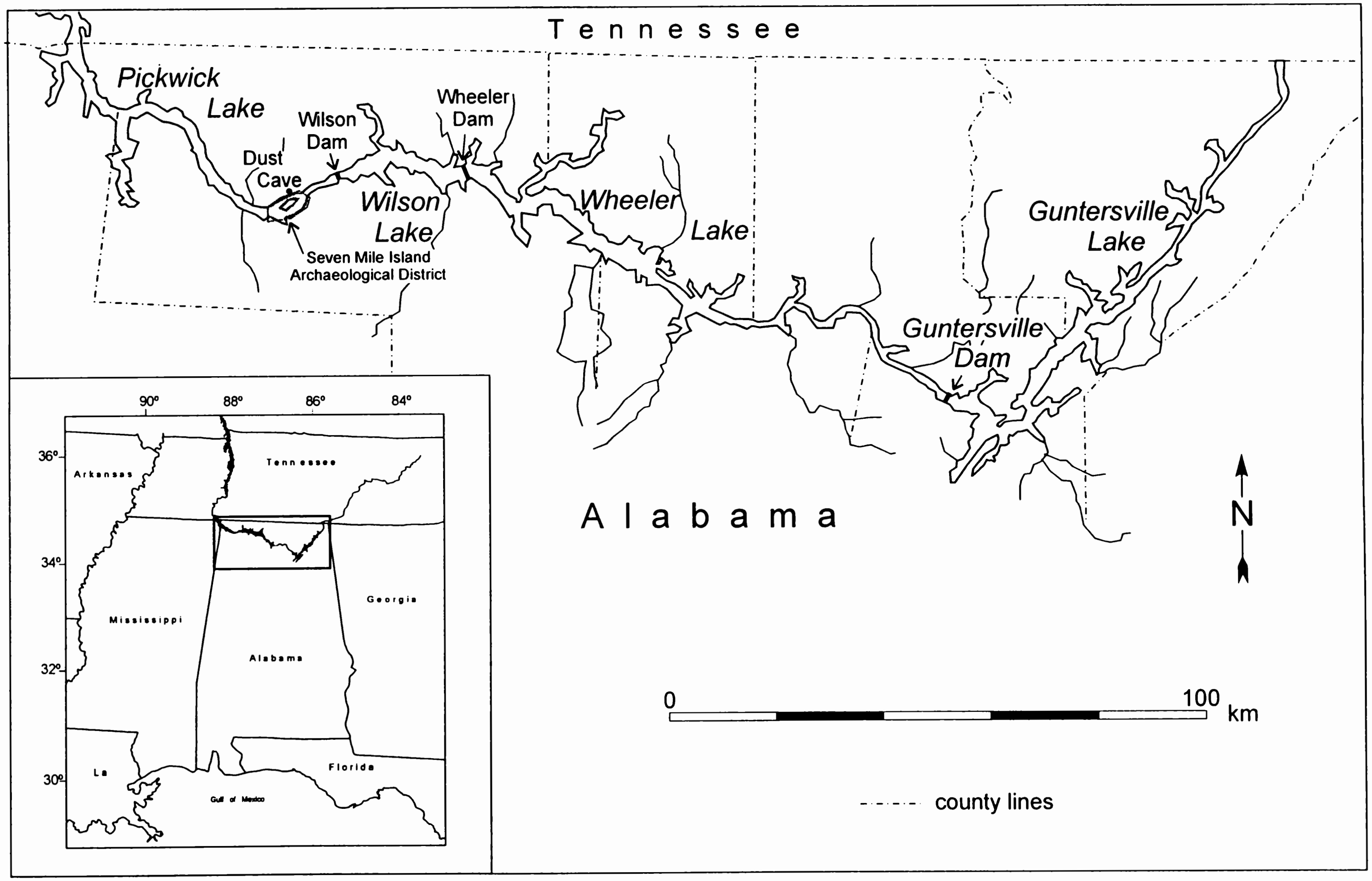

Figure 3.1. Locations of the TVA Dams and Lakes in the Alabama Portion of the Middle Tennessee River Valley. Insert Indicates the Position of the Figure in the Southeastern US.

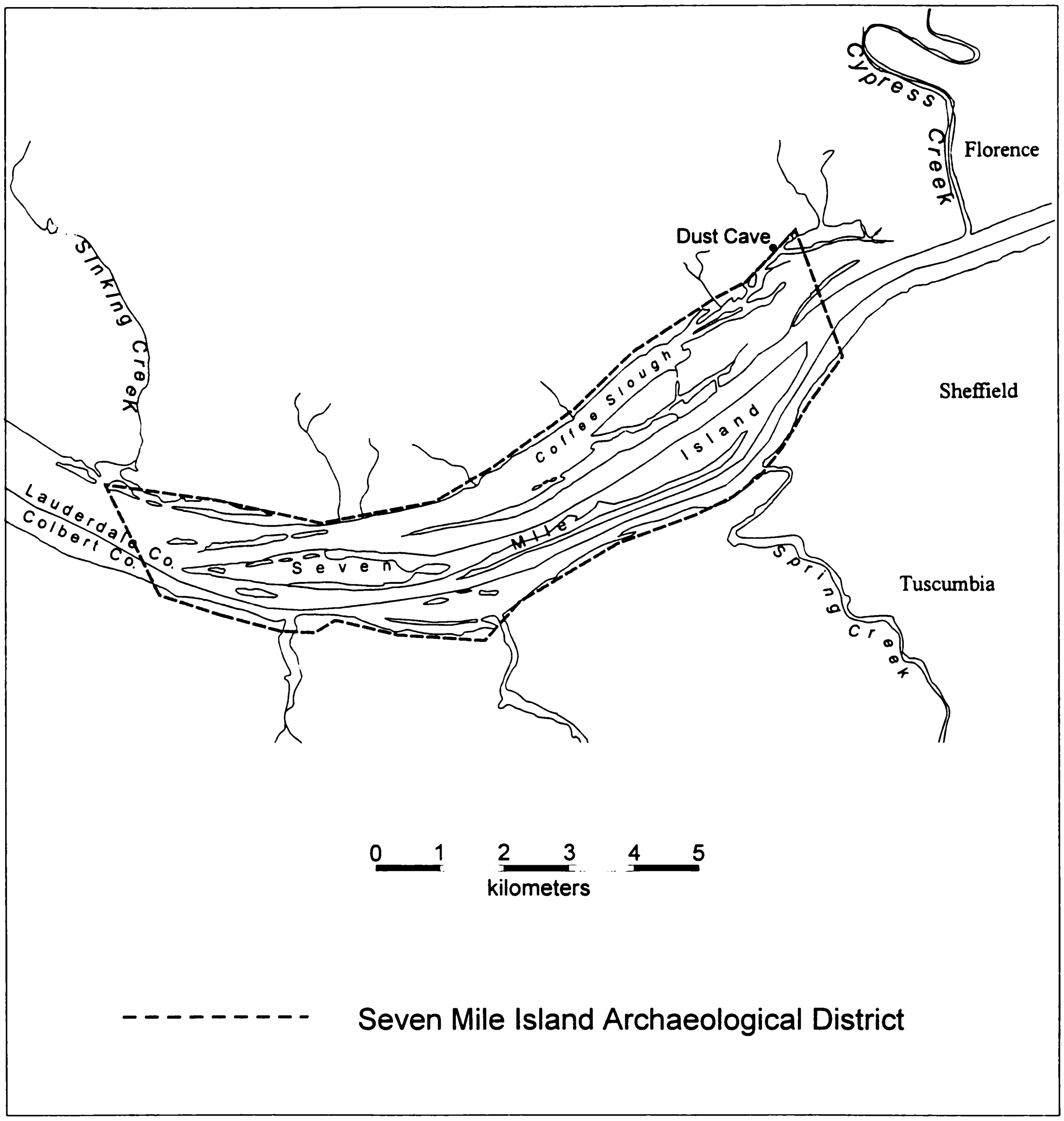

Figure 3.2. Seven Mile Island Archaeological District.

The existing models are not derived from the project area or even from the western Middle Tennessee River valley but are primarily based on regional pollen and alluvial stratigraphic records to the north on the Cumberland Plateau and to the east in the Upper Tennessee River Valley. The additional data are derived from known local archaeological stratigraphy, site distributions, and radiocarbon dates. I refine a model originally developed by Collins and Goldberg (1995) as the general outline for the geomorphic history within the project area. In Chapter 10, I relate the regional landscape transformations suggested in this model to my interpretation of the depositional history of Dust Cave.

The Middle Tennessee River Valley Today

The Tennessee River is the fifth largest river system in the US. Its length of 1,040 km is now completely controlled by the Tennessee Valley Authority, raising water levels high above the original channel morphology. The river is divided into three sections - the Upper, Middle, and Lower (Figure 3.3). The Upper Tennessee River Valley begins in East Tennessee with its headwaters (Clinch, Powel, Holston, French Broad, and the Little Tennessee Rivers) draining the folded and faulted metamorphic and sedimentary rocks of the Appalachian Highlands and the Appalachian Plateau Provinces. The river flows due south down the Ridge and Valley until it joins the Sequatchie Anticline in what is called the Narrows. The Middle Tennessee River begins as

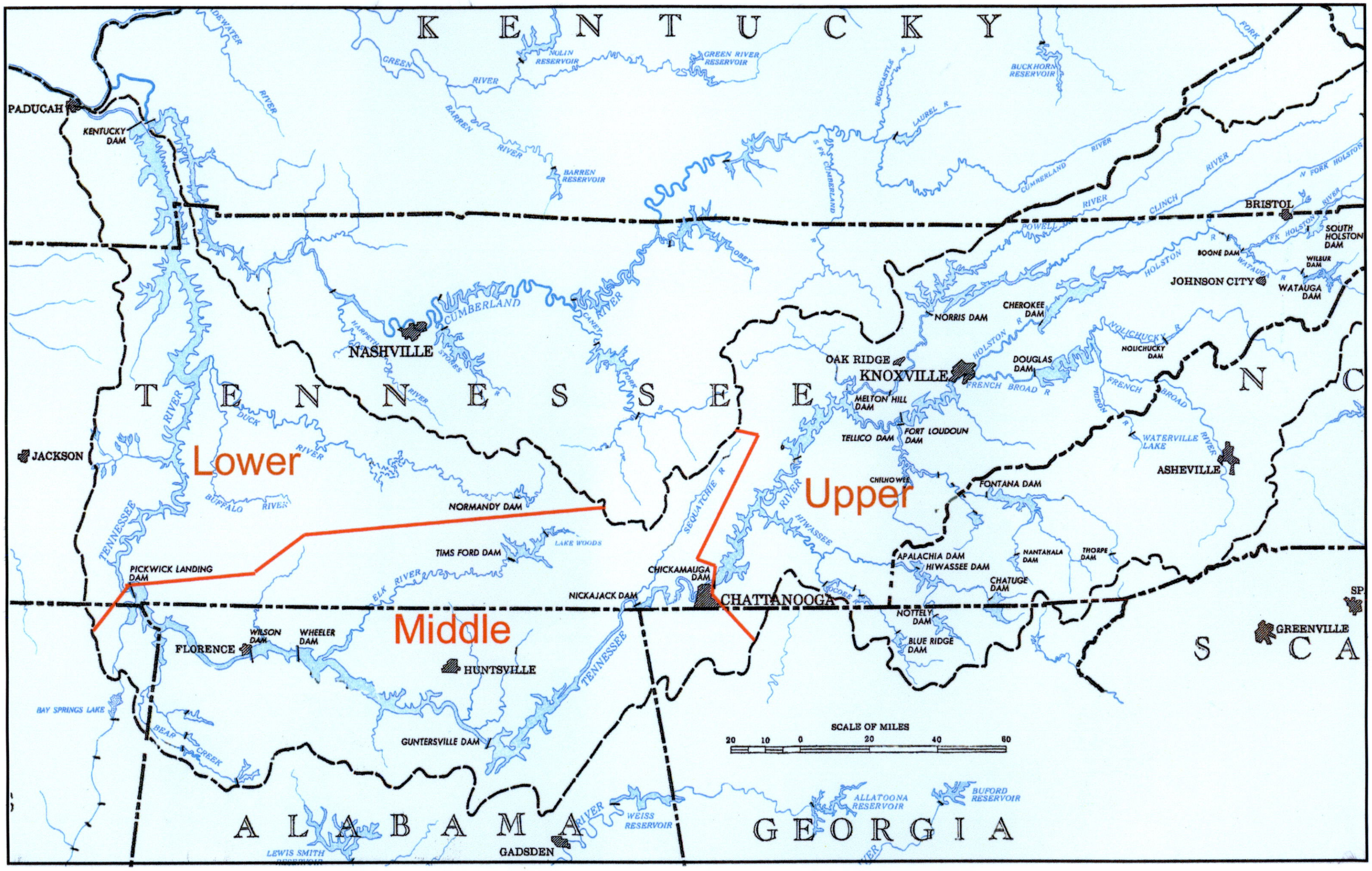

Figure 3.3. The Upper, Middle and Lower Tennessee River.

the river leaves Chattanooga and follows the Sequatchie Anticline south across the Cumberland Plateau. At the edge of the Plateau, in Guntersville, the river turns northwest and travels through the karstic terrain of North Alabama along the southern edge of the Plateau. The Lower Valley begins after the river turns northward at the Alabama/Mississippi border incising through displaced strata of Upper Mississippian and Lower Cretaceous sediments associated with subsidence structures along the limits of the Mississippi Embayment (Stearns and Marcher 1962; Szabo 1992). The river flows northward off the Plateau and onto the Upper Cretaceous Coastal Plain sediments to the Pickwick Landing Dam. North of Pickwick Lake the river flows along the edge of the Interior Low Plateau just above the Coastal Plain, through western Tennessee and Kentucky where it finally meets the Ohio River in Paducah, Kentucky.

The western Middle Tennessee River Valley consists of two general valley morphologies reflecting two different Late Pleistocene histories. The Wheeler basin (32 to 150 km east of the project area) and the Pickwick Basin (the project area). Both sections of the valley appear to contain variable alluvial stratigraphy and different valley morphologies. These variable landscape histories directly influence both the distribution of archaeological sites and their preservation and identification.

Project Area

The project area, including the Seven Mile Island Archaeological District (defined below), is in the western portion of the Middle Tennessee River valley (Figure 3.1). This portion of the valley is located in the Interior Low Plateau province in the Highland Rim section traditionally referred to as the Western Valley Proper (Harper 1942). Here the horizontal Mississippian rocks create a rolling karstic plateau on either side of the river and its floodplain.

The Seven Mile Island Archaeological District encompasses approximately 25 km^2 and includes Seven Mile Island, several other smaller islands, the south bank in Colbert County Alabama and the North Bank in Lauderdale County Alabama (Waselkov and Morgan 1993) (Figure 3.2). The north bank incorporates Coffee Slough, a drowned spring-fed creek bed that trends west paralleling the river for 7 km until it meets the Tennessee River at River Mile 249 (Figure 3.4). Coffee Slough probably originated as the ancestral bed of Cypress Creek, which now channels directly into the River to the north (Womochel 1983). The Coffee Slough has probably been independent since the early Holocene, when the Tennessee River prograded to the south (see below), resulting in the stream channel (Coffee Slough) relying on intermittent upland drainages and springs located along the base of the escarpment. These springs are generally no longer visible due to raised water levels but were identified and mapped by TVA in the preinundation land maps ca. 1935.

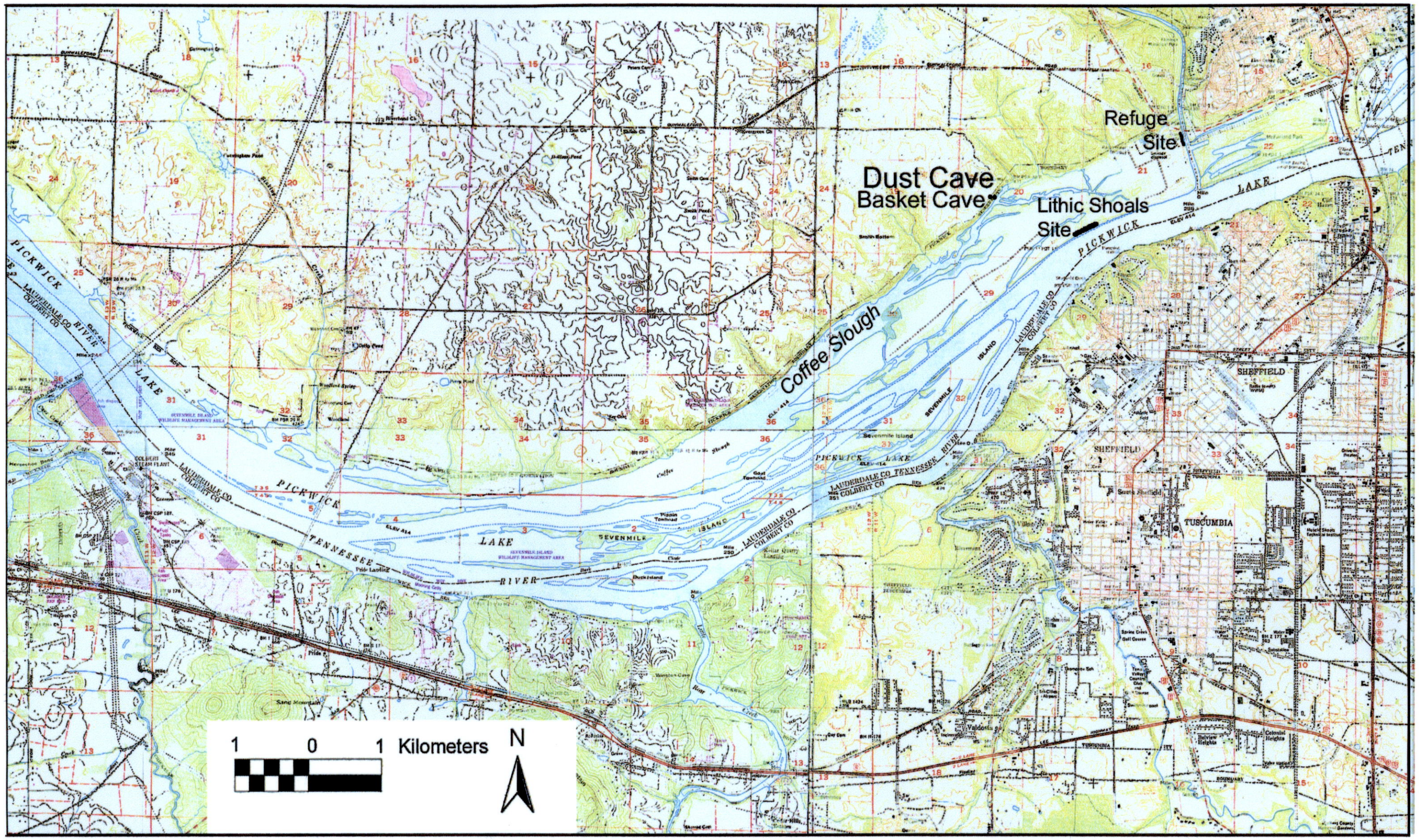

Figure 3.4. Topographic Map of the Project area and Vicinity, with Select Site Locations. USGS Topographic Quadrangles: Florence, Sinking Creek, Tuscumbia and Pride, Alabama. Contour interval = 10 ft.

The elevation of the valley floor in the project area ranges from approximately 126 m amsl (lake elevation) to 134 m amsl. Escarpments bounding the floodplain rise sharply over 30 m from the valley floor to elevations as high as 216 m amsl. There are caves and numerous springs associated with these bluffs, several of which feed into Coffee Slough. Cypress Creek, which drains the uplands to the north, marks the eastern extent of the district (Figure 3.4). Dust Cave, located on Coffee Slough, is one of nearly 275 sites recorded in the district, 27 of which reportedly contain Paleoindian components (Meyer 1995; Waselkov and Morgan 1993).

Regional Geology

The basic geology of the southernmost limits of the Interior Low Plateau along the Highland Rim area consists of Mississippian limestones and bedded Cretaceous sand, clay and gravel (Mancini 1989; Jones 1942). The river cuts down through the Plateau into the more resistant Fort Payne chert. The Fort Payne Formation marks the base of the local Mississippian sequence. The strata regionally dip slightly south - southwest. In ascending order, the local Mississippian strata incorporate the Fort Payne, Tuscumbia, Pride Mountain, and Hartselle Formations. The chert and cherty limestone of the Fort Payne Formation is made up of massive, thick-bedded, compact dark clayey or siliceous limestones interbedded with some crystalline pure nondolomitic limestone with dark shale at its base (La Moreaux 1949). The formation is known as a prolific prehistoric chert source as light-colored, stratified residual chert can be found close to the surface (Meeks 1998). This formation marks much of the river bottom in this portion of the valley, specifically the infamous unnavigable Muscle Shoals, a several kilometer stretch of the river east of the project area above Wilson Dam.

Next up the sequence is the Tuscumbia Limestone, a thick-bedded, coarsely crystalline, highly fossiliferous (crinoid plates and bryozoans) cherty limestone that crops out on either side of the Tennessee River (Johnson 1978; McMaster and Harris 1975). Dust Cave and numerous other karstic features are associated with the Tuscumbia Formation. Interbedded shale, sandstone and limestone of the Pride Mountain Formation are situated above, followed by remnants of the Hartselle Sandstone (Harris 1957). The Hartselle Sandstone is thick bedded to massive, quartzose sandstone, containing interbeds of dark-gray shale (Osborne et al. 1989). The Hartselle crops out in the uplands (but is not present in the immediate vicinity of the project area) and is often associated with rock shelters, particularly to the east.

Soils and Geomorphology

Floodplain. The valley floor in the project area is composed of a narrow floodplain between the steep escarpments of the Tuscumbia Limestone. The river can be described as ingrown and meandering with asymmetric cross-valley profiles (Lewin 1978). The river splits into two channels around Seven

Mile Island (Figure 3.4). These channels are referred to as the main channel, flowing against the south side of the valley escarpment, and the back channel, which flows on the north side of the Seven Mile Island, against the remnants of the floodplain. The floodplain is made up of discontinuous progradational ridges or levees paralleling the river. Between these so-called levees are drainages, some maintained for farm use and others probably relic meander scars and spring drainages. The soils on the valley floor are mapped as Choccolocco, Staser, and Chenneby Series (Sherard 1977). These alluvial soils are typically deep, well drained silt loams to fine sandy loams classified as Hapludolls, Dystrochrepts and Hapludults. Buried incipient A horizons are visible in some of the cutbanks along the river. Recent archaeological investigations at 1Lu356 and 1Lu347 (Meeks 1997a, 1997b) suggest that these surfaces are buried under approximately 50 to 100 cm of alluvium. Radiocarbon ages associated with these buried surfaces range from 4,800 B.P. to as early as 9,000 B.P.

At the base of the escarpment, along the northern edge of the floodplain, the soils are primarily a mixture of cherty silt loam residuum and colluvium. These soils rest on narrow benches and are mapped as the Bodine series and classified as Paleudults (Sherard 1977). In the vicinity of Dust Cave these soils are composed of a combination of colluvially transported upland loessial soils and remnants of reworked ancient alluvium.

In contrast to the narrow floodplain of the project area, Wheeler Basin to the east, is characterized by a broad valley floor averaging 19 km in width, with numerous progradational ridge and swale sequences (Collins and Goldberg 1996; Womochel 1983). This change in floodplain character is primarily a response to bedrock. Up river of the project area, above Wilson Dam, the river descends about 40 meters over a distance of 55 km, nearly half of the river's total fall (Womochel 1983) (Figure 3.5). This is the steepest gradient by far in the middle valley, and one of the steepest in the entire length of the river. Near Dust Cave the valley narrows to 1.6 to 2.5 km wide. This constriction and steep gradient make the terrace or levee sequence to be poorly developed and difficult to follow. The distribution of archaeological sites is therefore not as well understood as it is in the wider portions of the valley, up or down river of the project area.

Uplands. Escarpments mark the transition from the valley floor to the uplands. The uplands are characterized by rolling karstic topography with elevations that average 450 to 480 m amsl. Incised creeks flow north or south (depending on the side of the river) to drain the plateau and meet the Tennessee River. Groundwater discharges from springs and maintains stream flows during much of the year (Harris 1957). Sinkholes and solution caves are common throughout the Tuscumbia Formation. Sinkholes of various sizes dot the uplands, and those that contain water generally reflect seasonal

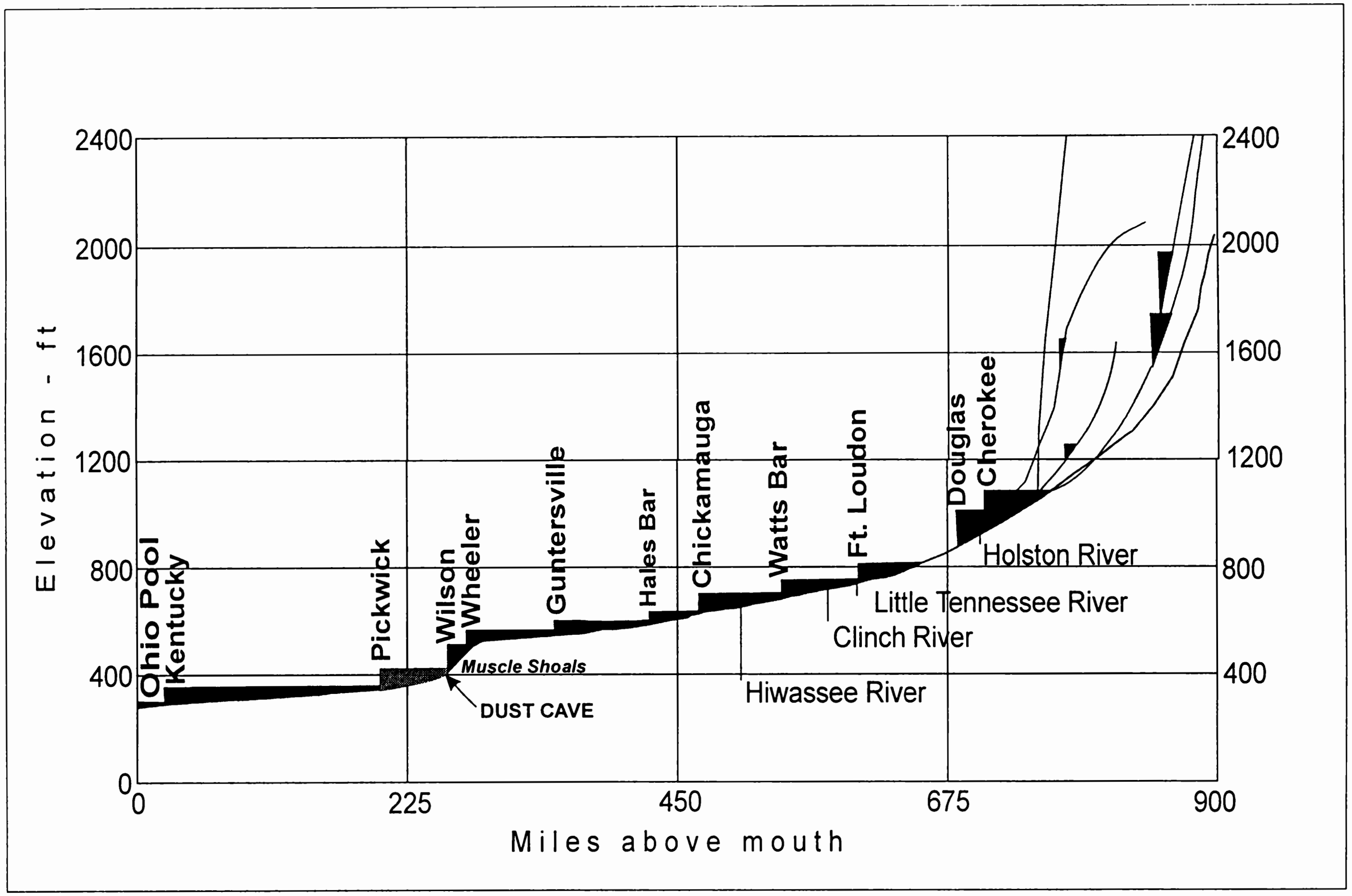

Figure 3.5. Tennessee River System Illustrating the Descent Related to the Reservoirs. Note the Greatest Descent for the Middle River Valley is just up River from Dust Cave in the Vicinity of Muscle Shoals.

precipitation and are characterized by fluctuating water tables. The caves, opening along the base of the cliffs at the edge of the floodplain, act as springheads and conduits for underground streams draining the karstic uplands.

The upland soils are primarily composed of Paleoudults with brown cherty silt loams over red cherty silty clays related to the Bodine-Fullerton-Decatur general mapping units (Bowen 1994; Sherard 1977). Due to deleterious agricultural practices in the early twentieth century, upland soils are extensively eroded, reduced to cherty residuum and deflated lag surfaces. Along the edges of the plateau, in the wooded areas out of reach of agricultural implements, remnants of the brown cherty silt loams occur. These upper horizons, absent from much of the plateau today, contain loess or well sorted aeolian silts. Re-deposited loess also contributes to the soil series on the narrow floodplain along the present day Cypress Creek (Sherrard 1977). These upland margins and remnants are possibly all that remain of old aeolian deposits probably derived from the Pleistocene Tennessee River floodplain. The loess is lithologically distinct as well-sorted angular silt quartz and mica.

Climate and Vegetation

Modern climatic conditions in the region are humid and temperate. Based on data from a 72 year period from 1884-1955, rainfall constitutes nearly all the precipitation, with snowfall occurring rarely (Harris 1957). The average annual precipitation for Florence, Alabama is 131 cm. The climate is mild with moderate monthly average temperatures of 26.4°C (79.6°F) in summer and 5.5°C (41.9°F) in winter (Hambridge 1941; Harris 1957; Sherard 1977). Freezing temperatures are sporadic and do not last more than two days.

The native vegetation in the uplands is dominated by deciduous hardwoods, mainly oak, hickory, and chestnut mixed with some pine. The bottomlands contain lowland hardwoods, including yellow-poplar, sweetgum, ash, dogwood, oak and wetland trees such as willow birch, blackgum, beech, water oaks and willow oaks (Sherard 1977). Much of the bottomlands is cleared, and where the land is not cultivated or urbanized it is dense with secondary growth, including shrubs and herbaceous plants. Coffee Slough is classified as a Cypress Swamp with Bald Cypress throughout the area.

Quaternary History

Introduction

Despite the historic interest in resource development throughout the Tennessee River Valley, very little work has been done to trace the Quaternary geomorphic history of the middle section of this valley. This is due in part to difficulties in identifying past geomorphic processes and establishing exact ages for surficial deposits, since the depositional history of an alluvial valley is typically reconstructed based on the chronometric, morphologic and lithologic correlation of stream terraces (Mills and Delcourt 1991). Throughout the

Tennessee River Valley, terrace correlation is difficult due to the present-day erosion and flooding of the valley floor. The raised water levels from inundation have covered the lowest portions of the original floodplain and other early erosional and depositional features. Terrace surfaces rarely continue longitudinally, making it difficult to correlate such features across the valley. In addition, exposures that could aid in such correlations are rare in this richly vegetated region.

The following quaternary history is an extrapolation from several sources. The earliest are engineering geology studies associated with TVA dam construction and other work along major Tennessee River tributaries proposed for inundation. More recent engineering geology data include drill logs from the construction of the Florence waste water treatment facility expansion (Gallet and Associates 1997) and the locks on Wilson Dam (Kellberg and Benziger 1956). Preinundation studies include the Lower Tennessee River (Leach and Jackson 1987; Nance 1987a, 1987b), the Little Tennessee River in the upper valley by Chapman and Delcourt (Chapman 1980), and Brakenridge's (1982, 1984) work on the Duck River in the Nashville Basin and Highland Rim.

The current models for the early depositional history of the valley focus on landscape response to cycles of Quaternary climatic change. Delcourt (1980) developed one such model while conducting alluvial geomorphic work along the lower Little Tennessee River valley, a large Tennessee River tributary located 400 km east of the project area, at the boundary between the Ridge and Valley and the Blue Ridge Provinces in East Tennessee. This work was performed in conjunction with the Tellico Reservoir archaeological investigation to offer a strategy for the identification of deeply stratified sites within the terrace system. Though developed for the Little Tennessee River, this model is probably applicable to the Upper Tennessee River Valley in general.

Collins et al. (1994, 1995) outlined a model for the project area to explain Tennessee River alluvial deposition in caves located high above the valley floor. What follows is a refinement of that model, looking to those studies noted above and using data from two recent excavations within the project area, the Refuge site (1Lu356) located on Cypress Creek close to the base of the escarpment (Ensor et al. n.d.; Meeks et al. 1997b), and the Lithic Shoals Site (1Lu492) located on the present-day north bank of the river across from Seven Mile Island (Meeks et al. 1997a).

Regional Pleistocene/Early Holocene Geomorphology

During the Cenozoic Era, the Tennessee River progressively cut down along the edge of the interior low plateau, creating the initial valley. The landscape reflected the impact of full glacial conditions far to the north, influencing both the local geomorphology and the vegetation. The interior low plateau of the project area was covered with boreal-like climax forests dominated by jack pine, spruce and fir, with deep open ponds attracting megafauna and other animals (Delcourt 1979; Delcourt and Delcourt 1985). The valley aggraded during the late glacial/interglacial cycles of the Quaternary as periglacial conditions (Denny 1940) in the tundra of the Southern Appalachians mechanically weathered bedrock and promoted the movement of sediment down slope. The freeze-thaw conditions of the Late Pleistocene interglacial periods extensively weathered the exposed bedrock, resulting in massive colluvial fans extending down the slopes and foothills of the Appalachian boreal forests (Braun 1989; Daniels et al. 1987; Eaton 1999; Shafer 1988). Sediment weathered from the bedrock and these colluvial fans were transported down slope by gravity and slopewash, rapidly aggrading the valleys below (Delcourt 1980).

Today, and prehistorically, the lithology of the Tennessee River alluvium is a direct result of this periglacial weathering of the original igneous and metamorphic rocks composing the Southern Appalachians. Sand size micas and pyroxene/amphibole are signature minerals in the alluvial lithology. This signature is observed today in the Upper Valley sediments (Delcourt 1980; Simek et al. 1997) and in the Middle Valley alluvium (Collins et al. 1994; Meeks et al. 1997b).

Radiocarbon dates from terraces in the Little Tennessee River valley place the peak sediment accumulation during the Late Pleistocene just over

30,000 BP, and Delcourt (1980:121) associates these accumulations with the transition from the Late Altonian Stadial to the Early Farmdalian Interglacial. There are no known early Late Pleistocene radiocarbon dates for terraces in the Middle Tennessee River Valley, primarily because few studies have targeted Quaternary Research. The remnants of alluvial lithostratigraphic units derived from this phase in the river's history are deeply buried in the current floodplain. The only descriptions of this material can be found in engineering drill logs (e.g., Gallet and Associates 1997; Kellberg and Benziger 1956). These sediments consist of massive to moderately bedded deposits of micaceous, quartzose silts and fine sands, manifesting an accretional topography composed of fining upward sequences that are suggestive of overbank deposition. At the base of the sequence, approximately 8 m from the current surface at an elevation of ca. 120 m amsl, the alluvial sequence overlies Early Mississippian Fort Payne Limestone. Resting on the bedrock is a series of channel lag deposits ranging in size from boulders and gravel to sand. The fluvial sediments above these channel lag deposits consist of fluvial micaceous sediments. Also resting over the channel lag are gray micaceous coarse sediments grading upward into brown sandy silt and sandy clay with minor lenses of fine sand. The top of this sequence consists of dark brown clayey silts in which soils are actively forming.

Within these buried alluvial deposits lie narrow channels identified at different depths across the valley floor. These extinct channels are filled with organic clay and suggest abandoned sloughs and braided channels (Kellberg and Benziger 1956). During the Pleistocene the river most likely consisted of a braided drainage pattern with relatively steep gradient and increased sediment load (Leopold and Wolman 1957).

The vegetation patterns during the Late Pleistocene also reflect the changing environment. The Pleistocene boreal-like climax forests changed to mixed coniferous-deciduous forests with the ecological conditions of the late Wisconsinan lasting up to the Pleistocene/Holocene transition (Delcourt 1979; Parmalee 1992; Parmalee and Klippel 1981). Pollen data also provide evidence for vegetation related to prairie or grassland microenvironments in the Midsouth (Delcourt et al. 1982), while Parmalee and Klippel (1981) identified grassland species to the north in the inner Nashville Basin.

Valley aggradation continued in the Upper Valley into the early Holocene. Precipitation was greater and temperatures cooler than today (Delcourt and Delcourt 1985), and as a result, the Tennessee River in general probably flooded frequently. Delcourt (1980:121) surmises that the further aggradation of the floodplain in the Little Tennessee River Valley occurred relatively rapidly from 15,000 to 7,000 years BP, burying a nearly continuous archaeological record in the first terrace. Leach and Jackson (1987:104-5) report elevated base levels in the Ohio River system after 15,000 BP, corresponding to melt water draining down the Ohio River system due to a re-advancement of ice. This elevated base level "down stream" resulted in the Lower Tennessee and Cumberland Rivers aggrading until approximately 11,000 B.P., when they adjusted to lowered local base levels and began downcutting.

Schumm and Brakenridge (1987), referring to the Duck River of the Nashville Basin region of central Tennessee, see geomorphic conditions similar to the Tennessee River Valley for the Late Pleistocene. The responses they observed, however, were not due to glacial outwash but to direct and indirect effects of climate change in the watershed, and are therefore probably directly relevant to the project area. In the Duck River Valley, around 30,000 years ago (as in the Little Tennessee River valley), peak sediment accumulation resulted in the formation of the T2, with the bedrock floor of the valley about 5 m higher than it is today (Figure 3.6). At the end of the Pleistocene, extensive fluvial erosion resulted in further entrenchment of the valley and the removal of much of this Late Wisconsin sedimentary record (Brakenridge 1982, 1984; Schumm and Brakenridge 1987). In the Duck River Valley, Brakenridge (1982, 1984) reports remnants of the now partially buried Late Pleistocene floodplain (T2b) along the T2 containing artifacts associated with 12,000 to 10,000 years ago (Figure 3.6). Following the terminal Pleistocene erosion, a lower (T1) terrace

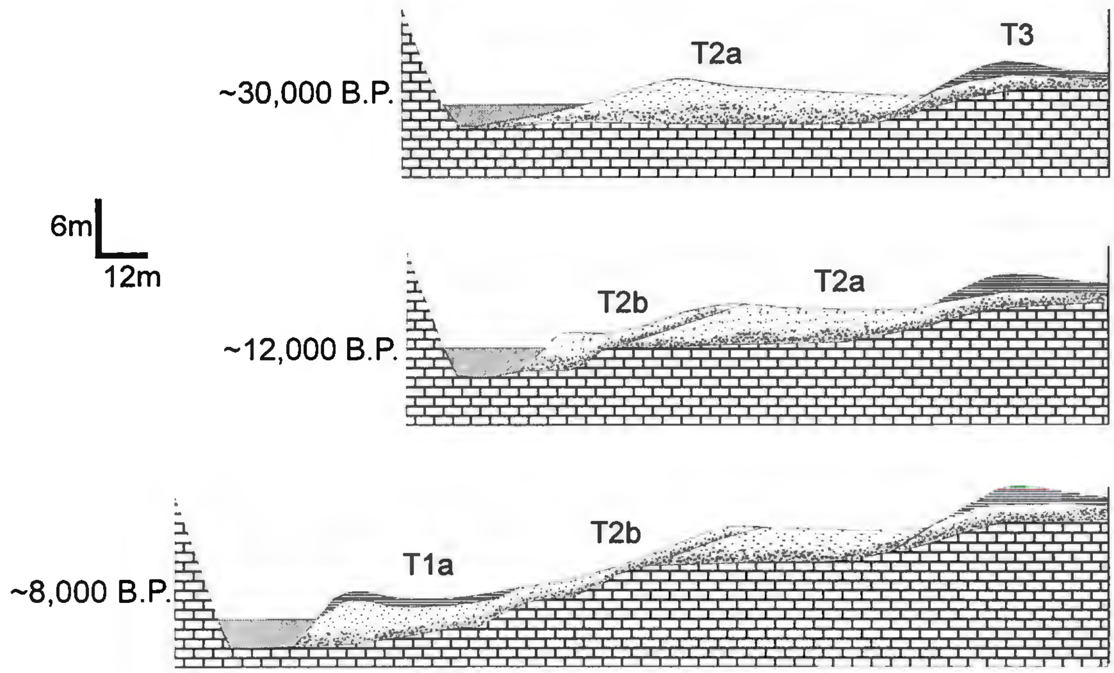

Figure 3.6. Sedimentary History of the Middle Reaches of the Duck River Valley, Central Tennessee, During the Time Period of Continental Deglaciation. T2b is the Terminal Pleistocene-age Wedge-shaped Unit. (Modified from Brakenridge 1984, and Schumm and Brakenridge 1987, Figure 232).

formed, with artifacts and radiocarbon dates suggesting stability as early as 10,000 years ago.

The Middle Tennessee River Valley appears to have undergone similar transformations during the Pleistocene/Holocene transition that were probably in response to climate change. In the relatively wide portion of the eastern Middle Valley the increased precipitation and rising sea levels during this time and the resulting adjustments in the load and flow characteristics initiated Incision, followed by a reduced flow that resulted in lateral progradation (Collins and Goldberg 1996).

This response is clearly visible in the Wheeler Basin as progradational sequences discernible in the eastern portion of the basin with limited elevation differences (the western basin sequences are primarily inundated) (Collins and Goldberg 1996:202). Current research at the Whitesburg Bridge Site, south of Huntsville AL, documents this geomorphic progression, with dates of ca 3,000 BP derived from the base of the first terrace. This is further documented in archaeological surveys in the Wheeler and Pickwick Reservoirs where site distributions on first terraces are restricted to later component sites (Middle and Late Archaic, Woodland and Mississippian Periods), while early period sites are located on the second and third levees (Meyer 1995; Shaw 1996). In some instances Paleoindian and Early Archaic Period deposits dating to the Pleistocene/Holocene transition ca. 12,000 – 10,000 B.P. are buried in the second terraces (where these geologic features are discernable). The well-known Late Paleoindian sites referred to as the Quad Locale (see Chapter 4) suggest that the second levee, located approximately 200 m from the first levee, represents the river bank at the end of the Pleistocene (Hubbert 1989). These data further support a progradational sequence for this relatively broad portion of the Middle Tennessee River Valley. In the western Middle Valley the geomorphic alluvial history manifests itself slightly differently and is discussed below in the context of the Project Area.

By the beginning of the Holocene, warmer and wetter climatic conditions allowed the initial northern expansion of deciduous forests into the Southern Appalachians (Delcourt 1979). Deciduous tree species, including mast producers, spread beyond their Pleistocene refuges across the Tennessee River Valley and up into the tributary valleys (Delcourt, et al. 1982). As the Pleistocene forests moved to the north, the Midsouth vegetation patterns characterized by the spread of dense mixed oak/hickory deciduous forests were established (Jacobson et al. 1987).

Project Area Pleistocene/Early Holocene Geomorphology

Stratigraphy and radiocarbon dates from the project area suggest a slightly different scenario associated with the Pleistocene/Holocene transition in the portion of the western Middle Tennessee River Valley west of Muscle Shoals. Here, the increase in precipitation resulted in adjustments in the river's load and flow characteristics along a comparatively steep gradient in the narrow valley. A relatively rapid degradation of this section of the valley occurred, resulting in the probable removal of most of the Late Pleistocene surfaces.

A key in the interpretation of the geomorphic history of the Pleistocene Holocene transition in the project area is Basket Cave (Figure 3.7). This cave, located in the northern escarpment approximately 6 m above Dust Cave at an elevation of approximately 136 m, was initially tested in 1991 by the University of Alabama as part of the larger Pickwick Reservoir Survey (see Meyer 1995). In test Unit X, placed approximately 12 m from the entrance of the cave, a 3.5 m sequence of Tennessee River alluvium was identified (Collins et al. 1994; Collins et al. 1995; Goldberg 1994, Sherwood and Goldberg 2000) (Figure 3.7). These deposits produced dates of ca. 17,000 and 15,600 BP associated with Stratum II (Figure 3.7) (Collins et al. 1994). This fluvial sequence is capped by slack water deposits followed by 2.2 m of autochthonous red clay and éboulis, probably derived from the solution dome over the test unit. The Basket Cave sequence clearly indicates that at the end of the Pleistocene, the Tennessee River actively deposited fluvial sediments high up in the valley, suggesting both a higher valley floor and the presence of upper terraces.

On the River's southern bank along Little Bear Creek is Winston Cave, located at an elevation comparable to that of Basket Cave. Winston Cave

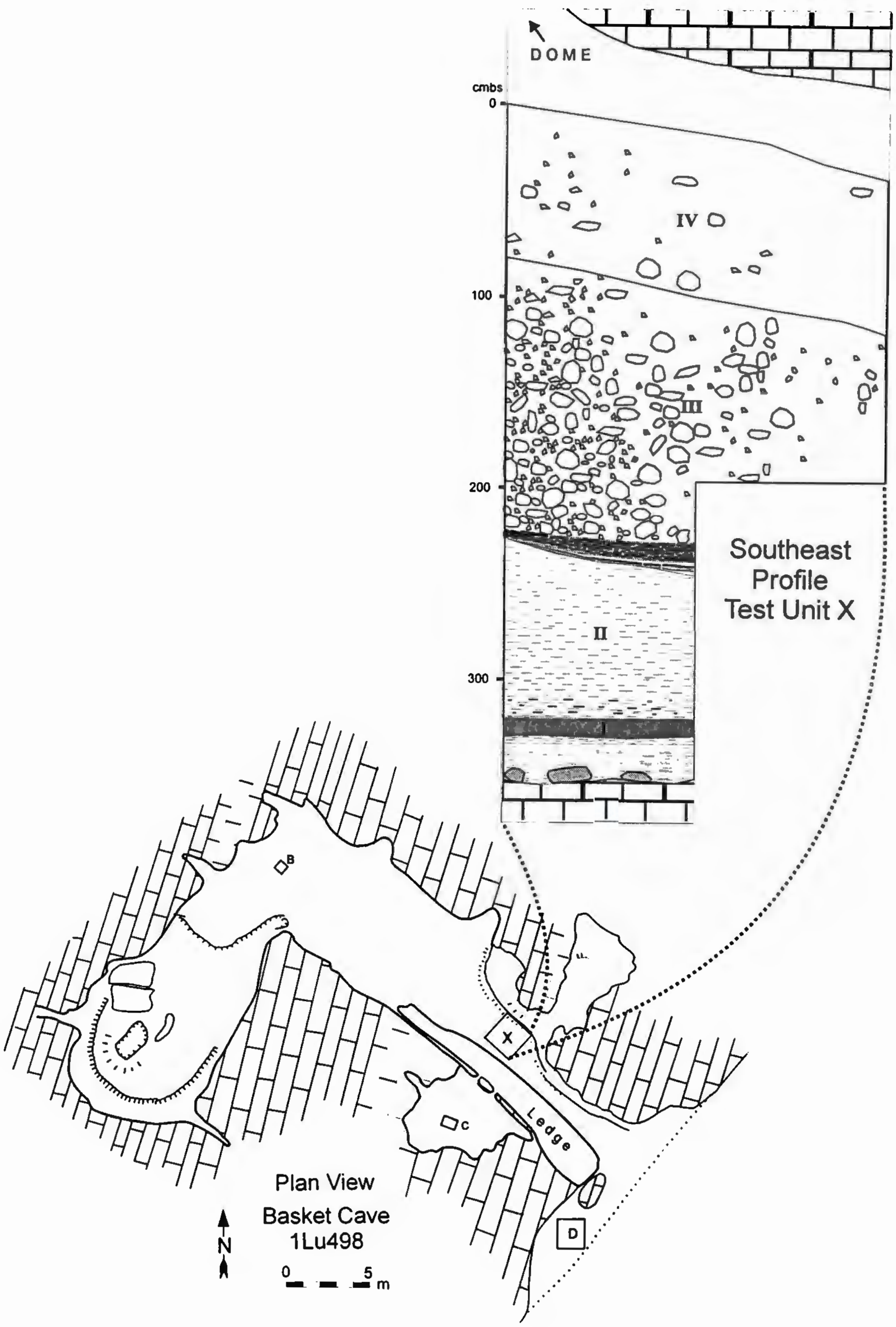

Figure 3.7. Basket Cave Plan View with Test Units and Southeast Profile of Test Unit X.

further supports a Late Pleistocene terrace surface high above the modern valley floor. Womochel and Barnett (1980) note travertine shelves that appear to be remnants of former floors and suggest the cave may have been subject to considerable erosion and dripstone formation during more humid Pleistocene times. The paleontological assemblage from the cave dates to at least 8,000 years ago and is probably much older based on the presence of *Equus* and *Mylohyus*. I have also observed remnants of cemented sediment outside Colliers Cave approximately 4 km downstream from Dust and Basket Caves. The ancient sediment is adhering to the escarpment around 10 m above current lake level, far above the current ground surface, comparable to the Basket Cave elevation.

There are no other known terrace remnants visible along the valley walls, suggesting that at the end of the Pleistocene, as in the Duck River basin, extensive fluvial erosion resulted in further entrenchment of the valley and removal of this early sedimentary record. There may be remnants preserved under steep colluvial deposits along the escarpment, but at this point the micaceous alluvial deposits in Basket Cave appear to represent one of the only subaerial remnants of the highest reaches of late Pleistocene alluviation and subsequent terrace development.

During the late Pleistocene, Dust Cave, located approximately 130.5 m amsl, would have been completely full of sediment and below the floodplain level. Between 15,000 and 10,500 BP the river cut down through this restricted valley, extensively eroding much of the upper portions of the valley floor. With this downcutting, the base level of the karstic water table dropped below 134 m across the uplands. Collins et al. (1995) refer to this process as the dewatering of the Cumberland Plateau. With the lowering of the water table the caves in the valley wall, including Dust Cave, became major spring conduits flushing sediments from their entrances onto talus slopes below (Collins et al. 1994). As the Late Pleistocene spring system became active in Dust Cave it cut down towards the mouth of the cave, leaving remnant alluvial deposits in the back of the cave and eroding the sediments in the entrance chamber nearly to bedrock. Meanwhile, the Basket Cave sequence, located above this downcutting, experienced inundation from ponding and slack water, followed by extensive endogenous sediment deposition. In Dust Cave, at least one spring channel remained active for some time as the water table continued to drop in the valley. A seasonally active spring conduit is still present in the cave floor today.

The lowering base level, as well as the increased precipitation at the end of the Pleistocene (Delcourt and Delcourt 1985), directly affected both the karstic drainage system and the surges at the base of the escarpment. These surges would have seasonally raised the levels of Cypress Creek and directed slope wash into the cave that transported soil, colluvium and remnant Tennessee River alluvium from the large talus outside the cave.

The Late Paleoindian deposits at the base of the Dust Cave sequence, primarily composed of Tennessee River alluvium and autochthonous slack water deposits, indicate that the cave was not habitable until the end of the Pleistocene/Holocene transition ca. 10,500 BP. This observation can be extended to the remainder of the valley floor during this phase in the River's history. Yet to be explained, however, is the exact context of the numerous diagnostic Paleoindian artifacts recovered along the floodplain margins. These concentrations are used to support the idea that the Middle Tennessee River Valley was a major staging area for Paleoindian migration and colonization (Anderson 1996). The Basket and Dust Cave sequences suggest that Pleistocene terrace remnants in the field likely exist but they are fairly high above today's valley floor, calling into question the context of the Paleoindian artifacts recovered there. Paleoindian artifacts are also recovered in high numbers in the uplands adjacent to the escarpment. The upland sites are reduced to gravel lag deposits primarily caused by deleterious farming practices (Goldman-Finn 1995). The potential exists, however, for finding intact deposits along the edges of large dolines above the escarpment where eroded sediments may have buried Pleistocene deposits. Thus far no such deposits have been recovered (see Waselkov and Hite 1987).

Elsewhere in the project area recent data suggests that landscapes were stable along a prograding floodplain beginning in the early Holocene (see Hubbert et al. 1978 and Waselkov and Morgan 1983). On Cypress Creek at the base of the escarpment, the Refuge Site (1Lu356) is identified as an Early Archaic site dating to ca. 9,400 BP and is buried under only 50 cm of alluvium at an elevation of about 127 m amsl (Ensor et al. n.d.) (Figures 3.4). A small portion of the Lithic Shoals Site (1Lu342) (Figure 3.4) is located on the north bank of the back channel with radiocarbon dates indicating a > 1m deep Middle Archaic component (~8,000 BP), beneath a Late Archaic component (~3,700 BP) approximately 50 cm from the surface. The temporal distributions of sites within the Seven Mile Island Archaeological District and the general morphology of the landforms suggest a southward progradational sequence. The poorly defined levee and overbank deposition began on the north side, against the escarpment in the vicinity of Coffee Slough, and the associated channel prograded toward the south wall until it settled in its current location against the steep southern escarpment. The sites reporting Paleoindian components on the valley floor are located primarily against the north escarpment along Coffee Slough (Figure 3.8).

Conclusions

Admittedly the current state of the data pertaining to the Quaternary history of the Middle Tennessee River Valley is a patchwork of dispersed

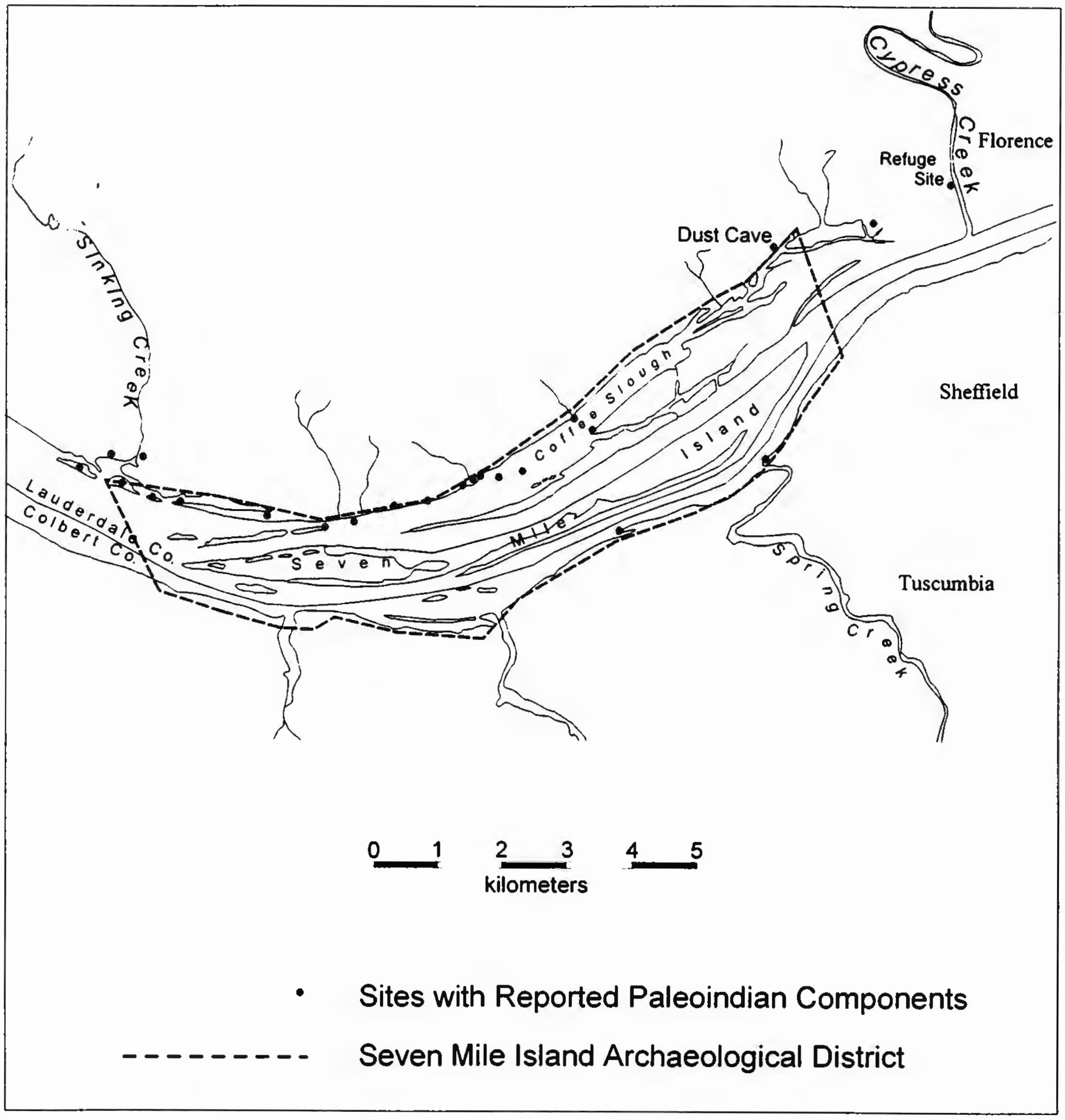

Figure 3.8. Sites with Reported Paleoindian Components within the Seven Mile Island Archaeological District.

sources (pollen, microfauna, river basin climatic responses and regional bedrock geology), all from various locations in the Midsouth. There are certainly variations within the western Middle Tennessee River Valley that are not detected in these discrete studies. In addition, the effects of reservoir inundation generally dissuade modern local geomorphic analyses of the valley floor. However, based on this patchwork data set, a general picture of the landscape since the late Pleistocene begins to emerge.

Perhaps the narrow valley and the descent associated with Muscle Shoals accelerated the major Terminal Pleistocene erosional phase, suggested by the Basket and Dust Cave sequences. Following this phase, as in the Duck River Basin (Brakenridge 1984), the river stabilized at the onset of the Holocene climatic conditions, with progradation and minor aggradation within the valley. This scenario varies from the broader, eastern portion of the Western Valley in the vicinity of Wheeler Basin. There the valley is composed of numerous progradational ridge and swale sequences potentially preserving Late Pleistocene surfaces associated with the T2. In the project area, however, these alluvial surfaces seem to be preserved only in the caves of the steep valley walls and perhaps beneath protective colluvial deposits. Obviously far more geoarchaeologically-oriented research is needed in the project area to resolve the issue of the high frequency of Paleoindian diagnostic artifacts in the context of the dynamic late Pleistocene landscape. But in the meantime, Dust Cave provides a rare opportunity to address the depositional history of an archaeological site within the Western Valley occupied from the end of the Pleistocene/Holocene transition through the Mid Holocene.

CHAPTER 4

THE ARCHAEOLOGY AND EARLY PREHISTORY OF THE WESTERN MIDDLE TENNESSEE RIVER VALLEY

Introduction

The Tennessee River Valley has a rich prehistory that begins with Paleoindian migration and colonization and ends with the florescence and decline of large Mississippian towns. This discussion focuses on the early prehistoric periods beginning with the Paleoindian and continuing through the Archaic. Much of what archaeologists have reconstructed of these cultural periods - their technology, subsistence, social organization, and chronology - is as much an artifact of the history of archaeology in the region, the constraints and orientations under which it operated, as it is what was recovered. Therefore I begin with a brief review of the history of archaeological investigation in the area, with additional discussion of the development of cave and rockshelter archaeology. I emphasize the western portion of the Middle Valley but refer to sites from the eastern Valley as well. The historical review is followed by a synthesis of the region's early prehistory, with general summaries of the components present at Dust Cave. The region's current research directions are highlighted with the preliminary results from Dust Cave.

Archaeological History

Before the New Deal Archaeology

The post WWI New Deal era marks the advent of large-scale archaeological investigations in the Middle Tennessee River Valley. This New Deal archaeology is what shaped our understanding of the region's prehistory. Prior to this time archaeological expeditions were carried out in the Valley, but within a classificatory-descriptive approach (*sensu* Willey and Sabloff 1980), bordering on an antiquarian interest that contributed little to our contextual understanding of the region's prehistory. These early expeditions did address, however, specific questions and drew the attention of the professional community to the archaeological richness of this region. The intensive mound exploration carried out by Cyrus Thomas, (working in the late 19th century), and C. B. Moore (at the beginning of the 20th century), resulted in surveys or excavations of several sites in the Tennessee River Valley (Willey and Sabloff 1980). Thomas, targeted mounds and other types of archaeological deposits throughout the eastern US and finally quieted the Mound Builder debate with his conclusion that Native Americans were responsible for the mound construction (Thomas 1894). Moore's (1915) work specifically focused on burial practices and the associated impressive artifacts represented in the region's mounds. He is recognized for his pioneering multi-disciplinary efforts (in human osteology in particular), but his archaeological techniques and reporting addressed only specific aspects of the archaeological record, and as a result we know little of the context of his finds.

During the first quarter of the 20th century the archaeology of the Tennessee River Valley did not include interest in trait lists and taxonomy which was anxiously being incorporated into American Archaeology (Dunnell 1986, 1990). Funding was extremely limited; the South and its various institutions were generally poor. The majority of "archaeological" endeavors were the work of looters who typically continued a tradition of focusing on unique or exquisite artifacts as objects to be acquired or sold (Lyon 1996:51). This practice is documented well into the Depression, and in spite of efforts to curb this largely illegal industry it continues in the Valley today.

The only professional archaeology conducted during the first quarter of the 20th century was supported by the fledgling Alabama Anthropological Society and the Alabama Museum of Natural History. Amateurs, directed by professionals associated with the Museum, carried out most of this work. Their primary goal was to locate sites. The Museum carried out some notable excavations including Winston Cave, Hobb's Island and the Florence Mound, all in the western Middle Tennessee Valley (Waselkov 1994). One of the most fortuitous actions of the Museum during this time was an intermittent survey of the Middle Tennessee River Valley under the direction of the Alabama State Geologist and amateur archaeologist Walter B. Jones (Lyon 1996). It was this survey and one conducted earlier in the present-day Wilson Reservoir (Fowke 1928) that alerted archaeologists to the certain destruction of numerous cultural resources by new dam construction along the Tennessee River.

The New Deal Archaeology

By the second quarter of the 20th century southeastern archaeology significantly changed both in how and why it was conducted. Franklin D. Roosevelt created the Tennessee Valley Authority (TVA) in 1933 to jumpstart the socially and economically deprived valley with jobs while improving the navigation of this major river route. The first major dam on the Tennessee River, Wilson Dam, was completed in 1925. Wilson dam allowed river traffic to pass over the largest navigation hazard in the Tennessee Valley, Muscle Shoals. Over the next 50 years the TVA would construct 53 more dams and 3 nuclear plants for hydroelectric power, navigation, flood and malaria control, leaving nearly the entire Tennessee River Valley and the lower reaches of many tributaries inundated in a series of interconnected lakes. The construction of these major dams divided the Middle Tennessee River Valley into 4 distinct units: Guntersville Basin, Wheeler Basin, Wilson Lake (actually part of the Wheeler Basin), and Pickwick Basin (Figure 4.1). These are the units under which the valley is typically organized archaeologically, each with their own research history. The majority of the Middle Tennessee River Valley thus

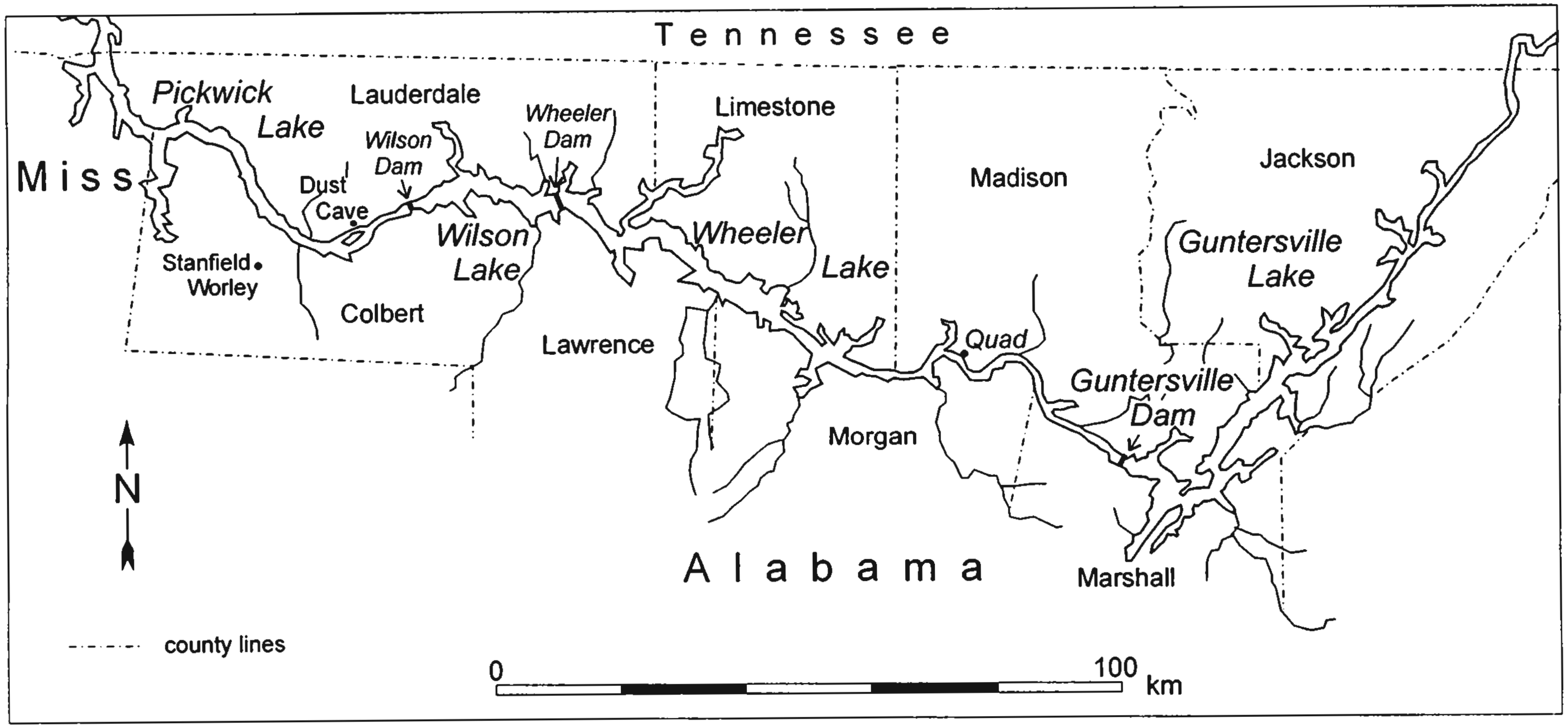

Figure 4.1. Middle Tennessee River Valley with the Locations of Significant Archaeological Sites mentioned in Chapter 4.

became federal property, and as a result, the archaeology of the region is largely conducted under the auspices of federal mandates.

It was the actions of TVA and the creation of work relief institutions like the Federal Emergency Relief Administration (FERA), Civil Works Administration (CWA), and Works Progress Administration (WPA) that redirected the archaeology of the Southeast, and in particular the Middle Tennessee River Valley. Beginning in the 1930's, this federal archaeology came to be known as New Deal Archaeology (Haag 1985; Lyon 1996) and sustained large-scale excavations with huge crews, the like of which had never been conducted before or since in the Southeast. Archaeology was beginning to shift from an antiquarian interest in specific sites and their ability to produce large quantities of high quality artifacts, to salvage efforts targeting large sites in specific areas.

But with the benefit of a large work force came logistical problems, organizing inexperienced government relief labor, unpredictable structural changes in the federal system, and variability in state procedures. Political expediency in place of scientific precision was often the rule in much of the New Deal Archaeology (Lyon 1996). Reports were selective in the kind and amount of information they presented (often due to immediate report submission requirements), while some of the excavations were never recounted in report form at all. With its origins in antiquarianism, the New Deal

Archaeology focused on the most obvious sites including earthworks, shell mounds and large villages, steering this early work towards the study of the region's later prehistory. These excavations were often constrained both by the sheer size of the sites investigated and the limited time frame forced by the advancing water levels as construction of the dams progressed. Many bottomland sites had to be overlooked while others underwent hurried excavation. For example, in the initial Pickwick Basin survey, only 20 sites of the original 323 surveyed could be excavated as the lake levels quickly rose (Meyer 1995).

Though New Deal Archaeology was a salvage effort, there were research objectives behind this early work. Most of these objectives revolved around culture history and a combination of defining cultures based on trait presence/absence and the transition to recording the frequencies of the trait variants (Lyman et al. 1997). These frequency or seriation studies concentrated on the development of ceramic types and the use of pottery as time markers (e.g., Griffin 1939; Haag 1942; Heimlich 1952).

Those that oversaw these large-scale excavations and directed the field work were products of the northern universities training new anthropological Americanist Archaeologists. They brought with them the "stratigraphic revolution", referring to superposition and classification (not physical strata as "stratigraphic" might imply). They also brought ways to organize and interpret the enormous amounts of material generated from these large-scale excavations. They represented both sides of the anthropological issues - the heavy influence of ethnography in Americanist Archaeology (the Direct Historical Approach) (Steward 1942, 1977), and the efforts to break away from this perspective (Taxonomic Approach) (Fisher 1997; McKern 1939). Southeastern archaeology in the 1930's was acutely influenced by the direct historical approach using ethnology and historic observations. In particular, there was a strong connection to the ethnology of Swanton (1917, 1922, 1946), and others (Lyon 1996). McKern's (1939) Midwestern Taxonomic System amassed trait lists and organized artifacts into foci and components, excluding aspects of regional variation and stratigraphic divisions. This system largely influenced the way cultures are sequenced and organized in the Middle Tennessee Valley, even after stratigraphic distinctions began to suggest otherwise (Lyon 1996). More often than not, stratigraphy was treated purely as a construct of culture and changing artifact use.

For example in the Mulberry Creek Shell Mound (1CT27), variable sand and shell layers were documented and recognized for their significance as zones of changing river activity and changing artifact use over time. Even so, the authors state

> "Finally, while it seems certain that stratigraphy of a kind is demonstrated at the site, yet it does not seem possible to consider these cultural changes as the result of a shifting population. The removal of one people and their replacement by another might account for the

> abrupt introduction of new customs somewhat as observed at this site, but it could hardly account for the retention of older traits by later people. It would be especially difficult to see how a later people could retain a series of cultural associations in the same proportions as existed before their advent" (Webb and DeJarnette 1942:265-66)

The authors go on to relate the stratigraphic changes, both in terms of the sediment and the changing artifact types at the site, as "wholly owing to the changes in material culture of a single people over a long time" (p.266). The implications for adaptation around local environmental change were not an aspect of this "stratigraphic revolution" and not incorporated into the consideration of culture change.

The Close of the New Deal Archaeology

As New Deal Archaeology progressed into the early 1940's things began to change. Feuding over research objectives in the TVA jurisdiction (e.g., Kentucky Basin), funding, and territory, developed among different individuals representing different state institutions (Lyon 1996). The WPA support for archaeology finally began to decline with American involvement in World War II. The conduct of archaeology in Northern Alabama during this time seems to have come under two, sometimes overlapping, groups. The University of Alabama, with David DeJarnette at the helm, and amateur based archaeology, primarily what was to become the Alabama Archaeological Society. Most of the work by DeJarnette and his crew required the labor force that only TVA and the WPA could provide. The focus of this work had shifted from the Middle

Tennessee Basins to the Tombigbee and Alabama Rivers as well as Moundville. The most notable efforts of the time, in terms of advancing our knowledge of the prehistory of the Western Middle Tennessee region, came from the Alabama Archaeological Society.

The early salvage work in the Middle Valley focused on the most obvious sites and as a result overlooked the older, less conspicuous occupations. The Shell Mound Archaic was considered the earliest manifestation of native peoples in the eastern US (Ford and Willey 1941). It was not until the 1950s, with the work of Lewis and Kneberg and the organization of the Tennessee Archaeological Society, that it became evident that the Tennessee River Valley was occupied prior to the Archaic Period (Walthall 1980). There was a growing interest in fluted point finds in the east and their similarities to Paleoindian projectile points in the American West (Kleine 1953; Lewis 1953; Witthoft 1952; Wormington 1939). Lewis and Kneberg started a campaign in the Tennessee River Valley for professionals and amateurs alike to record fluted point in an attempt to identify their position in the East, temporally and spatially. Some of the first dates derived from the new radiocarbon technique were erratic. As a result, the initial backward push in chronology was fraught with speculation and confusion in conjunction with the advent of radiocarbon aging (see Cambron 1956; Soday 1954; Time Magazine 1956). It was not until the 1960s that the new early chronology was secure and the Alabama Archaeological Society discovered and reported sites such as the well-known Quad, Stone Pipe, and the Pine Tree sites (see below), revealing the Middle Tennessee River Valley as a concentration of Paleoindian activity.

Meanwhile Americanist Archaeology hashed out the meaning and definitions of types, refined classification systems, and worked towards anthropological explanations. The Southeast, however, continued to conduct basic culture-history oriented excavations through the 1950s and early 1960s, albeit on a much smaller scale than did the New Deal Archaeology.

With the advent of cultural resource federal legislation in the 1960's and 1970's, the era of Cultural Resource Management (CRM) was born, and the archaeology of the region again underwent another major change. Processual questions began to creep into research designs along with the refinement of culture history sequences. Cultural resources within the Wheeler, Wilson and Pickwick reservoir reservations were now protected and administered by the TVA. As of the year 2000, numerous federally mandated projects have been conducted throughout the Middle Tennessee River Valley, refining the regional chronologies (e.g., Futato 1980, 1983; Meyer 1995; Shaw 1996; Waselkov and Morgan 1983). Beyond surveys, excavations have approached the region's sites with new environmental techniques and explanatory research designs, seeking to refine the analytical units defined under the culture history paradigm (e.g. Dye 1980; Goldman-Finn and Driskell 1994; Meeks et al. 1997a).

Development Of Regional Cave Archaeology

In the earliest known published survey of possible archaeological cave sites in Northern Alabama Fowke (1928:435) states

> "It is useless to search in this part of Alabama for caves presenting indications that they may have been habitable, or the reverse, in ages past. The native rock is a cherty or flinty limestone, crumbling easily, and readily susceptible to changes from atmospheric influences, and especially so to the action of water."

Fowke may have overestimated the rate at which cave environments weather. His attitude about the futile nature of archaeological endeavors in caves and rockshelters, however, reflected the marginal interest in such sites by the region's early 20th century professional archaeologists.

For example, only one cave, Georgetown Cave (1CT42), was excavated during the initial Pickwick Basin survey. Even then the excavation was an attempt to maintain the work schedule due to a crisis brought on by premature flooding of larger sites in the Basin (Webb and DeJarnette 1942:268). Very little is written about the cave excavations other than noting burials and associated finely worked artifacts. Most of the caves targeted in the early excavations were related to what became known as Copena, a mortuary complex in the Middle Valley, recognized for its use of burial caves and associated elaborate artifacts (Walthall and DeJarnette 1974; Webb and DeJarnette 1942; Webb and Wilder 1951). The association of elaborate burial accouterments was well known among the general populace. Many caves, therefore, were extensively looted since the nineteenth century. This practice contributed to the lack of interest in caves and rockshelters by the TVA basin surveys. One early survey report remarks, "huntsmen, idlers, and treasure seekers have destroyed or rendered intangible the evidence contained in caves along the valley" (Jones 1939:14). Nevertheless, nearly all the early surveys did record at least a few caves (e.g., Fowke 1928; Webb 1939; Webb and DeJarnette 1942). Very few of these early surveys and excavations, however, recognized the potential for multicomponent aspects and deep temporal sequences in cave sites. One exception appears to be Bettye Broyles (1958:27) who noted that the small number of artifacts observed in many of the early excavations might have been because "the cultural debris was hidden by large rocks which covered most of the cave floors".

The discovery of Russell Cave (Broyles 1958; Griffin 1974) and Stanfield-Worley Bluff Shelter (DeJarnette et al. 1962) demonstrated the promise of ancient deposits buried in caves. As interest grew in the pre-pottery prehistory of the region and the development of cultural chronologies, it became more important to identify early tools that were stratigraphically associated with other materials. Protected stratified cave deposits provided such an opportunity.

As the New Deal Archaeology waned, the region's caves continued to be of interest to amateur archaeologists, who excavated numerous cave entrances and rockshelters in the tradition of Stanfield-Worley. These excavations often involved professional archaeologists, and expanded analytically to include other data sources such as animal bone (e.g., Curren 1976). These sites include the Cave Springs Site in Morgan County (Moebes 1974), LaGrange Bluff Shelter in Colbert (DeJarnette and Knight 1976), several rock shelters and caves tested in the Bear Creek and Cedar Creek area (Futato 1983), and the bluff shelter excavations on Sand Mountain in Marshall County (Clayton 1965). These studies are important contributions to the understanding of Late Paleoindian/Early Archaic occupation in the Midsouth. Dust Cave in particular is revealing new details on the economy and environment relating to these early occupations.

In general, the regional cave excavations have been instrumental in devising the region's cultural chronology. These stratified sites have also provided a more detailed comprehension of the numerous open-air sites that, while typically lacking the deep stratigraphic sequences, are intricate parts of the region's early prehistory.

Early Prehistory

Paleoindian

Much of what we know about the Paleoindian period is based on the recovery of fluted points, artifacts generally considered unambiguous diagnostic indicators of Paleoindian occupation. Efforts are underway to synthesize the limited data generated from the growing inventory of fluted points across North America (e.g. Faught et al. 1994; Futato at al. 1992; Morrow and Morrow 1999). Within the Eastern Woodlands, these inventories have led to the identification of several regions of concentrated Paleoindian activity. Among these regions, the Middle Tennessee River Valley stands out as one of the richest.

One of the primary archaeological research issues in the Middle Tennessee River Valley today is the context of Paleoindian sites. As a result of the fluted point survey, archaeologists consider the Middle Tennessee River a migration route and staging area for the colonization of eastern North America (Anderson 1996; Mason 1962; Futato 1982). This hypothesis is based primarily on the concentration of diagnostic Paleoindian projectile points recovered in two counties bordering the Middle Tennessee River, Lauderdale and Colbert Counties, Alabama (Anderson and Sassaman 1996; Waselkov and Hite 1987). Even with this significant situation and the fact that the region is one of the most intensively researched portions of the state, the context of the majority of these artifacts and the depositional history of this section of the valley remain unknown (see Chapter 3).

Some of the fluted points are found in the karstic uplands bordering the valley (Ensor 1992; Goldman-Finn 1995). Most of the identified Paleoindian and Early Archaic sites are adjacent to large subsidence sinkholes or dolines

(Goldman-Finn et al. 1996; Futato 1996; Waselkov and Hite 1987). Deflation and erosion due to historic land use have reduced these sites to lag deposits of lithics (Ensor 1992; Goldman-Finn 1995; Waselkov and Hite 1987). This artifact concentration extends into the valley floor, where numerous surface finds are reported by collectors and recovered during archaeological surveys.

Among the early efforts of the Alabama Archaeological Society was the 1950's discovery of the well known Quad Locale in the eastern Middle Valley, located on the north side of the Wheeler Reservoir, across from Decatur, Alabama (Cambron 1956; Soday 1954) (Figure 4.1). The Quad Locale consists of a prodigious series of diagnostic Paleoindian and Early Archaic artifact scatters, extending for 5 km on a intermittently inundated second and third levee where Beaver Creek enters the Tennessee River (Futato 1996; Hubbert 1989; Soday 1954). Paleoindian artifacts are made of various resource materials, including several exotics, but blue/gray Fort Payne chert predominates, and tool forms comprise blade-based scrapers and gravers and fluted points. All the early chert artifacts are patinated, distinguishing them directly from the Early Archaic pieces (Cambron 1955; Soday 1954). These materials have been reduced to lag deposits as the rising and lowering water levels eroded the sites, and as a result there is little information about context reported in any of the publications that cover this locale. The reports all note that the Paleoindian artifacts are derived from an eroding yellow clay beneath alluvial silts (Cambron 1955, 1956; Cambron and Hulse 1960a; Soday 1954)

Reservoir inundations make it difficult to search for and identify buried deposits in the Valley. Those that are known, like the Quad locale, have all been destroyed by the current lake levels and wave action. The problem is that compared to the extremely high number of diagnostic artifacts recovered in the Middle Tennessee River Valley, only a handful of dated Paleoindian stratigraphic contexts exist in the region (Futato 1996).

Currently the Paleoindian Stage in Middle Tennessee River Valley is divided into Early, Middle, and Late Periods. These three periods are generally accepted throughout the southeastern US, with slight regional variants in the Middle and Late Periods (Anderson et al. 1996). Diagnostic projectile point types distinguish these stages.

Early Paleoindian

The Early Paleoindian (12,000 to 11,000 B.P.) is characterized by Clovis fluted points and a blade based tool kit. There are few confirmed intact Early Paleoindian deposits known in the Southeast. A noted exception is the Carson-Conn-Short site, in the Western Middle Tennessee River Valley, that has produced thousands of lithic artifacts associated with Clovis point and blade tool manufacture (Broster and Norton 1993, 2001; Broster et al. 1994). In addition, a Clovis component is reported at the Johnson site in the Nashville

Basin which dates to over 11,500 B.P. (Broster and Barker 1992; Broster et al. 1991; Barker and Broster 1996).

Currently our interpretation of Clovis peoples as nomadic hunters following large herds of megafauna comes primarily from sites in the western US (Anderson et al. 1996; Morse et al. 1996). Associations between megafauna and Eastern Clovis hunters are, however, documented in the Southeast including Mastodon in Eastern and Central Tennessee (Broster personal communication 2001; Norton et al. 1998).

Middle Paleoindian

The Middle Paleoindian period (11,000 - 10,500 B.P.) is represented by Cumberland, Simpson, and Suwanee point types. No intact sites have yet been excavated to date securely this period in the Southeast, although survey results in the Nashville Basin look promising (Broster and Norton 1992). The points themselves, as noted above, are found in surface contexts throughout the region. Again, most of our interpretations and temporal assumptions come from dated sites in the West and the Northeast that contain morphologically similar point forms (Anderson et al. 1996, Morse et al. 1996).

Late Paleoindian

The Late Paleoindian (10,500 -10,000 B.P.) is identified by Dalton variants, Beaver Lake and Quad projectile points, but the latter two forms are also considered transitional Middle to late Paleoindian forms (Anderson et al.

1996). There are several dated contexts where these point types have been recovered in the Middle Tennessee River Valley. These contexts (some considered suspect due to complex stratigraphy) are all related to rock shelters or cave entrances and include: Stanfield-Worley Bluff Shelter in Colbert County (DeJarnette et al. 1962); Walls I rock shelter on Sand Mountain in Marshall Country (Clayton 1965); Russell Cave in Madison County (Griffin 1974); Dust Cave in Lauderdale County (Driskell 1996); and Flint Creek Rockshelter in Morgan County just south of the Tennessee River Valley (Cambron and Waters 1959, 1961).

Stanfield-Worley Bluff Shelter (1Ct125) is a large upland sandstone shelter near Cane Creek, approximately 7 miles south of the Tennessee River in the Hartselle Sandstone Formation (Figure 4.1). The multi-component site was excavated in 1961 and 1962, establishing Dalton at roughly 9,000 B.P. (DeJarnette et al. 1962). Excavations revealed important subsistence from four distinct strata with Mississippian, Woodland, and Middle Archaic components separated from a distinct basal (then considered) Early Archaic zone (Zone D) (DeJarnette et al. 1962).

The temporal placement of Dalton in the southeastern cultural chronology has been a topic of interest over the last 20 years (Anderson and Sassaman 1996; Goodyear 1982; Morse et al. 1996; Walthall 1998). Both Dalton and Early Side Notched (Early Archaic) point types were present in Zone D at

Stanfield-Worley, suggesting that there may have been two stratigraphic units in Zone D, or at least two mixed assemblages (Goldman-Finn 1998 personal communication). The original radiocarbon date and three subsequent dates (Josselyn 1966), however, may have been associated with the Early Side Notched component and not the Dalton (Goldman-Finn et al. 1996). The stratigraphic placement of Dalton in Dust Cave (although poorly represented compared to Quad/Beaver Lake) clearly places the tool type in the Late Paleoindian (Goldman-Finn and Driskell 1994). At this point it is well established in the Southeast that Dalton is a Late Paleoindian manifestation, continuing into the first part of the Early Archaic, appearing after the extinction of Pleistocene megafauna and before the firmly dated Early Archaic Side Notched point forms (Morse 1996; Walthall 1998).

At Dust Cave, Quad, Hardaway, Beaver Lake and Dalton point types are found in the basal zones, with unprecedented preservation of anthropogenic sediments, bone, and carbonized plant remains. We have gained rare insights into regional Late Paleoindian lifeways, in particular subsistence practices, based on this assemblage (e.g., Walker et al. 2001).

The general consensus in the Middle Tennessee River Valley, and possibly elsewhere (see Goodyear et al. 1990), is that these early populations practiced a general hunting and foraging economy while maintaining a highly curated tool kit that focused on quality Fort Payne Chert (Futato 1983; Hubbert

1989; Meeks 1994). This portion of the valley, based on the concentration of fluted points, probably served as a habitual use area or staging area (Anderson 1996). Most of the Early and Middle Paleoindian finds are restricted to upland karstic sinks and ancient levees or terraces along the Tennessee River (Futato 1980, 1982; Goldman-Finn et al. 1996; Meeks 1997a; Walker et al. 2001). By the Late Paleoindian the site distribution presumably expands to resemble an Archaic Period distribution, which extends beyond these two environments to include small transient settlements in rock shelters and caves (Driskell 1994; Walthall 1998). Some believe that the timing of these deposits in rockshelters and caves represents a shift in settlement patterns, which discounts potentially significant geomorphic factors that may have directly affected the presence or absence of such deposits (e.g., Walthall 1998; Wood and McMillan 1976)

Archaic

The transition from the Paleoindian to the Archaic is traditionally considered a progression from highly mobile foraging to more regional adaptations. This general hunting and foraging economy was in place by the Late Paleoindian Period, towards the end of the Pleistocene/Holocene transition (Anderson and Gillam 2000; Bousman and Goldberg in press; Meltzer and Smith 1986; Walker et al. 2001). The Archaic is associated with climatic stabilization at the beginning of the Holocene and with regional adaptations. This regionalization is reflected in local projectile point variability throughout the Southeast and is used to divide the Archaic into three main periods - Early, Middle, and Late. Additional tools, mortuary practices, and general subsistence patterns contribute to further subdivisions traditionally referred to as horizons and phases (Walthall 1980).

Early Archaic

The Early Archaic (10,000 - 8,000 B.P.) in the Middle Valley is marked by Kirk Corner Notched, and a Bifurcate cluster. Compared to the Late Paleoindian site distribution, diagnostic artifacts are both more frequent and more diverse across the landscape. Early Archaic components appear in more variable upland and tributary areas throughout the Southeast, indicating population growth and geographic expansion (Clayton 1965, Futato 1992; Moebes 1974). Buried Early Archaic contexts in open air sites are being discovered since Chapman's (1977) Little Tennessee River work made it clear that early sites can be preserved under deep alluvial deposits (e.g., the Refuge Site, see Chapter 3).

Early Archaic deposits appear at or towards the base of complex cave sequences such as Dust Cave, Stanfield-Worley, and Russell Cave. Russell Cave (1Ja940) is a significant cave site containing deeply stratified early deposits located in the easternmost part of the Guntersville Basin (Broyles 1958; Griffin 1974; Miller 1956, 1958). The Russell Cave sequence begins in the Early Archaic (ca. 8500 B.P.) and continues up to the Woodland and Mississippian periods.

The excavation contains stratigraphic data and, although not studied directly, the microstratigraphy appears to be similar to Dust Cave suggesting a similar microenvironment and human activities.

Early Side Notched Projectile Points are well represented at Dust Cave, and nearly 40 percent of the abundant blue/gray Ft Payne debitage recovered from the cave is associated with this component (Johnson and Meeks 1994). Subsistence data from the Test Trench indicate a continued heavy reliance on aquatic species with birds and fish each representing >30 percent of the total identifiable faunal assemblage (Walker 1998:136). The Early Side Notched component also sustains the Late Paleoindian selection of open habitat mammals (Walker 1998), suggesting similar environmental conditions continuing into the Early Archaic.

Kirk Corner-Notched projectile points are found in a horizon that appears throughout the forested eastern woodlands dating to 9,400 – 8,500 B.P. (Chapman 1976; Walthall 1980). Kirk Corner-Notched components have been discovered at several sites, located stratigraphically above Big Sandy and other Early Side notched forms and below Kirk Stemmed and Bifurcate components (Cambron and Hulse 1975; see Driskell 1994 for further discussion of these types). The Kirk Corner-Notched component at Russell Cave is associated with an impressive range of bone and antler tools and cane-matting impressions indicating the use of weaving technology (Ingmanson and Griffin 1974). The

Kirk Corner Notched component representing this time period is conspicuously absent at Dust Cave. Only two Kirk Corner Notched points have been found so far in the Dust Cave excavation, a small number relative to the other components and projectile point forms. The relative absence of this component is an important issue in understanding the cultural chronology of the cave. Perhaps the cave was inhospitable and was therefore abandoned during this time. This question is addressed directly using microstratigraphic data in Chapter 10.

Middle Archaic

The Middle Archaic (8,000 - 5,000 B.P.) coincides with environmental changes characterized by slight warming and drying, referred to as the Hypsithermal (Delcourt and Delcourt 1981; Chaptman et al. 1982). The Middle Archaic is distinguished by stemmed projectile point types including Kirk Stemmed/Serrated, Eva/Morrow Mountain, Sykes/White Springs, Benton, and a florescence of bifacial technology, groundstone and bone tools. An increase in the frequencies of bone tools, including fishhooks, atlatl components, bone points and needles, have been used to suggest new technologies (Goldman-Finn and Walker 1994; Griffin 1974; Webb and DeJarnette 1942). At Dust Cave, however, there is evidence for bone technology in the Early Archaic in the form of fishhooks and needles. Perhaps the cultural historical association of these technological development with the Middle Archaic is a result of preservation rather than technology.

Population, and presumably social organization, were increasing during this time (Sassaman and Anderson 1995). Territoriality related to resource procurement was becoming more prevalent as well, as evidenced by increased violence and stylistic diversity (Sassaman and Anderson 1995; Steponaitis 1986). This period has been called "a turning point in Archaic economy and adaptation" (Walthall 1980:58).

The Shell Mound Archaic is ascribed to the Middle Archaic, but these shell mound sites exclude earlier Kirk components and appear to begin with the Morrow Mountain "Phase" and persist well into the Late Archaic (Meeks 1997a; Walthall 1980). Shell Mound Archaic sites are well represented in the Valley and throughout the major river systems of the Southeast, especially the Midsouth. Similar sites termed "non-shell" middens are observed along the Tombigbee River (Bense 1987; Jenkins and Krause 1986). These sites are currently considered to be one aspect of a seasonal round that focused on riverine resources but included smaller upland sites (Futato, et al. 1992; Hensley 1994; Waselkov 1987; Stein 1982). These shell accumulations were almost always located on the riverbank adjacent to shallow mussel bearing shoals (Webb and DeJarnette 1942). Shell mounds are conspicuous on the landscape and known for preserving bone and rich mortuary assemblages, and therefore are well documented through numerous early excavations in the region (e.g. Webb 1939; Webb and Wilder 1951; Webb and DeJarnette 1942). This early documentation, however, has been criticized for lumping assemblages together and overlooking potential variability (Walthall 1980).

There are several variant "phases"[1] in the Tennessee River Valley but those most frequently represented in the western sections of the Middle Valley include the Eva/Morrow Mountain, and Seven Mile Island. Eva projectile point types tend to represent a Tennessee River aspect of the Morrow Mountain type (which is found all over the eastern woodlands), and have been recovered both stratigraphically below Morrow Mountain as well as in association with them (Driskell 1994; Lewis and Lewis 1961; Walthall 1980). Eva/Morrow Mountain points are considered mid-Middle Archaic and are often combined into one component if recovered together. The Seven Mile Island Phase is considered late Middle Archaic and is locally characterized by Benton, Buzzard Roost Creek, Crawford Creek, and Sykes (Driskell 1994). This phase is viewed with keen interest in the region given the increase in regional interaction exhibited in the "Benton Interaction Sphere", so called for the far-reaching exchange of local Ft. Payne Chert (Johnson and Brooks 1989; Meeks 1998).

Dust Cave contains an Eva/Morrow Mountain Component overlying a Kirk Stemmed Component, followed by a Seven Mile Island Component. The Middle Archaic zones in Dust Cave contain more concentrated anthropogenic activity relative to the previous periods in the form of frequencies of pits, burials, artifacts, and anthropogenic sediments (Goldman-Finn and Driskell 1994). Subsistence during this time includes a nearly equal use of aquatic and terrestrial resources with an emphasis on ecotonal habitats (Walker 1998). By the end of the Middle Archaic (ca. 5,200 B.P.), Dust Cave is no longer used by prehistoric populations.

Late Archaic

The Late Archaic Period in the region (5,000 - 3,000 B.P.) is identified by a wide array of large to medium stemmed projectile point forms including Pickwick/Ledbetter, Little Bear Creek, Wade, Kays, and McIntyre. Most of the general economic practices of the Middle Archaic continue into the Late Archaic. Evidence for population expansion continues but increases markedly over that of the Middle Archaic (Dye 1977, 1980; Futato 1980, 1982). Broad regional exploitation of cultigens becomes well-represented in the archaeological record (Chapman and Shea 1981) but is not found thus far in the Middle Tennessee River Valley. Storage technology, probably related to the increased dependence on plants, begins to appear during this time in the Tennessee River Valley in the form of upland subterranean pits and stone containers (Futato 1983). Jenkins (1974) formulated a hypothetical model for the Middle Tennessee River Valley suggesting seasonal settlement and subsistence based on shellfish, fishing, hunting and plant foods (see the summary in Walthall 1980).

The transition from the Archaic to the Woodland is generally marked in the Southeast with the introduction of ceramics. In the Middle Tennessee River Valley this period is referred to as the Gulf Formational Stage (3,200 - 2,200 B.P.), with the earliest introduction of ceramic technology primarily associated with fiber tempering (Walthall and Jenkins 1976). Gulf Formational components are found on top of many of the shell mound sites excavated in the region.

Conclusion

After the New Deal Archaeology and its emphasis on the conspicuous late prehistoric sites, the region's professional and amateur archaeologists worked to fill the early gaps related to unexplored time in the region's prehistory. After an early disregard for rockshelters and cave sites, subsequent excavations in these sites played a key role in deciphering early adaptations and cultural chronology. Now that the region's cultural chronology is generally in place, the depth and complexity of the prehistory in the Valley is evident. Current research questions address more complex issues such as environmental change and adaptive strategies, specific technological developments in lithic and bone tool manufacture, the development of cooking technology, and early band level social organization. Scientific techniques are being developed to understand better the nature of the archaeological record and unravel the complex depositional histories of archaeological materials. The early prehistoric sequence at Dust Cave and the phenomenal preservation offer an excellent opportunity to address these complicated research questions in a new arena.

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[1] I use the term "Phase" to discuss chronological, regional variation based on specific tool types. This use does not necessarily follow traditional culture historical use of the word.

CHAPTER 5

MACRO- AND MICROSTRATIGRAPHIC ANALYSIS

Introduction

Stratigraphy both structures and shapes our observations and understanding of the archaeological record. How we record archaeological stratigraphy sets the framework for the interpretation of an archaeological site. At Dust Cave there are basically two scales of observation that are applied in order to construct a comprehensive stratigraphic database and ultimately an interpretation of the site's geological history. Each scale incorporates a similar interpretive framework within the "human scale" (*sensu* Stein 1993), and focuses on a different interpretive spatial resolution.

Site-scale observations, incorporating macroscopic and microscopic scales, were made of the Dust Cave lithostratigraphic units and their attributes. A lithostratigraphic unit is a concept borrowed from the geosciences and refers to a sedimentary unit that is distinguished and delimited on the basis of lithologic characteristics (Stein 1987:342). The macroscopic observations were made in the field with designations and descriptions of these units and their three-dimensional shape. The microscopic observations were made by analyzing sediments in thin-section. I rely on each scale of observation to produce a comprehensive stratigraphic interpretation.

Site-scale research includes observation and recovery of lithostratigraphic units, and the recovery of related artifacts, within a high spatial resolution paradigm. This paradigm focuses on the spatial context of site structure and the organization of activity within the limits of a site. The relationships between microartifacts and macroartifacts at this scale are critical to the inferences drawn from the artifacts and their patterning. At Dust Cave, microartifact (≤6 mm) observations were made in thin-section but were not collected in relation to the macroartifacts (see Sherwood 2001, Stein and Teltser 1986).

This chapter explains the methodology used to record and describe the lithostratigraphic units at Dust Cave both macroscopically and microscopically. The nomenclature employed is clearly defined and consists of standardized terminology.

Macrostratigraphy

Observation and description are the simplest but most important tools for understanding the context of cave sites (Collcutt 1979). The initial recording and subsequent reporting of thorough field descriptions based on standardized criteria and terminology are requisite tools of archaeological investigation. Lithostratigraphic designations should not imply interpretation (e.g., house floor layer, glacial outwash zone) but should consist of descriptive terms that can be reproduced by others, incorporated into sampling routines and easily transferred to maps and other images.

<u>The Zone</u>

The stratigraphic recording system used at Dust Cave is based on lithostratigraphic units termed "Zones". Zones are three-dimensional lithologic units that can be distinguished in the field (*sensu* Stein 1987). Each zone was described using terminology based on standardized nomenclature of soils and sediments (see below) (Birkeland 1998; Folk 1980; Soil Survey Staff 1975).

Zones were designated and described as the excavation progressed. The zone was distinguished primarily on the basis of color and texture. The initial excavation of the test trench (see Chapter 1) provided full vertical exposures that were divided in 1992 by Driskell and Goldberg into major stratigraphic zones based on general lithostratigraphic similarity, major stratigraphic breaks (unconformable boundaries), and the chronosequence suggested by the artifacts and the preliminary radiocarbon dates. They devised a tripartite system that assigned upper case characters (e.g., A, B, C) to the major stratigraphic zones they observed in descending order from the top of the sequence down to bedrock, arbitrarily designated Zone Z (Driskell 1994:19). The letter "F" was reserved for designating features (see below), and "O" and "I" were not used to avoid possible numeric confusion.

The second part of the tripartite zone designation is the subzone designated by a number, and indicates the consecutive Zones observed within the basic group (e.g., A2, B4). The third part of the designation is an alphabetic lower-case character that was implemented to distinguish tertiary subzones. These subzones represent the smallest variability within a zone that could still be delineated and separated from the surrounding sediment for excavation (e.g., A2b, B4c). These tertiary zones usually include stringers or lenses of ash, charcoal concentrations, and isolated clay layers.

Two problematic issues regarding the implementation of this system should be noted. Occasionally tertiary zone designations were misapplied to more extensive zones or combinations of lenses. This typically occurred where only the margins of such a zone were encountered and appeared to be tertiary in nature. As the excavation progressed into adjacent areas and more of the zone was revealed, it commonly proved to be a subzone. In these cases the tertiary zone was either renamed and correlated (see below), or the designation (though incorrect) was maintained for purposes of consistency in the records.

The second issue regards the assignment of subzones and tertiary zones in different portions of the entrance chamber. As the excavation proceeded, it became evident that these zones were not consistently consecutive. Ideally the subzone numbers indicate stratigraphic position, with larger numbers located beneath smaller numbers. With the variability observed across zone groups and the excavation of different parts of the cave at different times, the second designation could not be applied consecutively.

Chronostratigraphic Units

Chronostratigraphic units are groups of zones (or strata) that accumulated during a specific time interval (Stein 1987, 1990). The chronostratigraphic relationships of the zones are defined in the field based on basic sedimentological principles such as the law of superposition and later organized by radiocarbon ages and diagnostic artifacts. A total of 48 radiocarbon dates exist so far for Dust Cave. These are presented in Table 1.1 as conventional radiocarbon ages (B.P.). The discussion of time at Dust Cave and its relationship to the general chronology in the Southeast is presented using these uncalibrated dates. Calibrated dates are only recently finding their way into discussions of southeastern culture history. In order to coordinate with traditional sequences in other caves in the region and with the Dust Cave materials published so far, I discuss temporal dimensions among the zones as uncalibrated radiocarbon ages. In Appendix B, the Dust Cave dates are presented in their calibrated form.

Zone Description

Zones were described in the field using physical characteristics. The physical attributes consist of color, shape, consistency, fine texture, internal organization (fabric), and post-depositional features. These attributes are described in detail in Appendix A. Attributes describing the texture of the coarse-grained fraction ≥ silt-size (including identification of the composition, their spatial organization, and estimated field percentage) have been recorded but are not, as of yet, organized in the database.

Features

Dust Cave has numerous "features" consisting of hearths, small charcoal and ash pits, and burial pits. Features are consecutively numbered as they were encountered in the excavation (e.g., F.23, F.24, F.25). The term feature is in and of itself an artifact, produced from conceptualizing the archaeological record as a series of artifacts and significant human intrusions (e.g., hearths, storage pits, structures) into a sediment or soil that generally represented only the medium holding the artifacts in place (Stein 2000). As archaeology has become more concerned with the formation of the archaeological record and in environmental reconstruction we realize that the "matrix", and not just the artifacts, is a significant data source (Macphail and Goldberg 1995). At Dust Cave we now observe, describe, and record the matrix at a finer scale. Even with these changes in the way the archaeologists conceptualize the archaeological record, the team continues to distinguish between stratigraphy and features. Stein (1987) has pointed out that features are fundamentally deposits. This is not to say that these anthropogenic deposits require different excavation protocols than do the surrounding strata. Features are still deposits and should be recorded using the same nomenclature and consideration in the stratigraphic sequence as the other depositional units. Thus, in the Dust Cave stratigraphy, features are considered as zones. This having been said, our field protocol is only recently catching up to our theoretical framework. As a result, features excavated during the testing phase at Dust Cave were recorded only in relation to gross zone relationships. Incorporating these relationships into the zone database is currently underway and beyond the scope of this work. Since 1998, all features encountered are incorporated directly into the zone database, and the process of incorporating features encountered since the beginning of the excavation is now underway. However, discussion of specific aspects of features, such as their function and detailed distribution in the site, are not addressed as part of this project. Detailed microstratigraphic study of these deposits with regard to construction, function, and repeated usage of hearths and ash and charcoal pits promises to be a productive means through which to understand the formation and diagenesis of these complex deposits. As their incorporation into the database is ongoing, features are excluded from the 1999 version of the Zone Database in Appendix A.

Zone Database

The zone descriptions are recorded in a complex relational database that was originally designed in dBase II and has since been restructured in Microsoft Access. The structure of this database is a collaborative effort between numerous individuals over a number of years (Sherwood and Riley 1998). The Dust Cave database has a unique structural foundation based on stratigraphic context. The stratigraphic context consists of zone field descriptions, with more detailed tiers of description and interpretation generated from micromorphological observation. This recording system allows for the correlation of complex stratigraphy at a variety of scales where stratigraphic units vary in size and extent and do not consistently appear in vertical profile.

The structure of the relational database will ultimately permit all the artifact and environmental data to be easily and efficiently related to depositional context and chronology. The database consists of a normalized set of tables that rely on the zone designations to organize data into a comprehensive record. The database emphasizes the importance of zones via the zone table, an entity that describes detailed geoarchaeological data at a range of scales anchoring different data tables within the depositional history of the cave.

The excavation, processing, and analyses at Dust Cave are carried out within the context of the lithostratigraphic arrangement. As each new zone or zone derivative is encountered in the field it is described and recorded directly into the relational database. The attributes recorded are described in Appendix A. The zone's spatial properties are recorded with all zones immediately above, below, adjacent to a specific zone. One of the most useful and time saving aspects of the zone database is a correlation function. As we have excavated different portions of the cave at different times, it is not possible to correlate among different areas unless those areas are directly joined in the excavation. The correlation function allows us to give the zones different designations until we are sure they are the same. When the correlation is made, the database automatically searches or considers the correlated zones bypassing the tedious task of going back through paperwork, artifact bags, and separate databases, changing designations in order to equate the zones.

Microstratigraphy

The microscale observation and analyses were carried out using sediment thin-sections. The thin-sections were analyzed using the technique of micromorphology. Micromorphology is the study of undisturbed soils, sediments and other archaeological materials (e.g., ceramics, bricks, mortars) in thin-section at a microscopic scale. The technique employs undisturbed, oriented samples in which the original components and their geometric relationships are conserved (Courty et al. 1989). Micromorphological analysis allows the observation of composition (mineral and organic), texture (size, sorting), and fabric (the geometric relationships among the constituents). Within an individual thin-section it is possible to observe micro-stratigraphic sequences that reflect temporal changes in depositional and post-depositional processes.

Sampling Protocol

The field protocol used to collect intact block samples for micromorphological analysis is quite simple, although it can vary depending on the cohesion of the sediment and the ability to remove intact blocks. Depending on the thin-section size, blocks vary from 15 x 8 x 8 cm blocks for "mammoth" size thin-sections, to 10 x 7 x 7 cm for large format thin-sections. The facilities to produce large format (7.5 x 5 cm) thin-sections are readily available in the US and were used in this study. Use of the "mammoth" size sections (14.5 x 6.5 cm), while highly desirable in the study of archaeological stratigraphy due to the larger area, is mostly practiced in Europe, where facilities are available to produce them. Regardless of the block size the protocol must include the vertical orientation of a sample, its exact location (three-dimensional coordinates) within the site, and observations as to the lithostratigraphic unit(s) which the sample represents.

Micromorphological sampling at Dust Cave began in 1990 during the testing phase when P. Goldberg collected samples from the test unit profiles. Sampling continued throughout the excavation seasons (see Chapter 1), and consisted of the removal of 10 x 7 x 7 cm blocks cut from the excavation exposures. Blocks were collected at boundaries between zones, from within zones and from specific structures within zones. Each sample was wrapped in tissue, secured with packaging tape and labeled. Many of the later season samples were collected using 6 x 8 cm rectangular vinyl downspout cut into 5+ cm sections. Each section was randomly drilled with a ~1 mm dremel bit (prior to sampling) to facilitate air exposure during the drying process, air removal and resin access during impregnation.

The drain-pipe sections were then either carefully pushed or cut into sediment exposures, vertical and horizontal, representing specific zones or the zone contacts. Each end of the section where sediment was exposed was padded with tissue and then the entire sample was wrapped with packaging tape to secure the contents. Labels were applied to the drain-pipe sections prior to sampling and afterwards to the taped sample. Sample locations were recorded on appropriate stratigraphic profiles or plan maps on level forms. Three-dimensional provenience was recorded within the site grid (north, west, and cm below datum), in addition to lithologic descriptions and observations including the zone and specific notes relating to the archaeological context. This information is presented in Appendix C.

Samples were taken to the laboratory following field collection. From 1990 to 1992 samples were processed in the Department of Geosciences at the University of Texas, Austin. From 1993 until 1999 samples were processed at the University of Tennessee, Knoxville, Laboratory of Analytical Archaeology. In the lab, portions of the packaging tape and tissue were removed to allow the sediment to air dry without jeopardizing the integrity of the sample. Thorough drying was completed in a convection oven at 60° to 80° C for a several days. Samples were impregnated under a low vacuum (typically in cardboard or plastic juice or milk cartons) using a ratio of 8:2 unpromoted polyester resin to monostyrene with methylethyl keytone peroxide (MEKP) as a catalyst. The hardening process took anywhere from a few hours to approximately 10 days depending on the brand of resin, the proportions mixed and the ambient conditions in the lab.

When samples were completely hardened, they were trimmed with an oil- or water-cooled geologic trim saw to a 7.5 x 5 cm, with variable thicknesses of 2 to 4 cm. These blocks were then ground and polished into large format 2 x 3 in (5 x 7.5 cm) thin-sections. Some of the samples from 1990 to 1993 were processed by Greg Thompson at the University of Texas, Department of Geological Science Petrography Laboratory. The remaining samples were cut in the Department of Geological Science at the University of Tennessee, Knoxville and ground and polished into thin-sections by Spectrum Petrographics, Inc, Winston, Oregon.

Thin-section Analysis

Thin-sections were systematically described using a combination of terminologies. Descriptive criteria were based primarily on Bullock et al. (1985), a comprehensive morphological descriptive system that focuses on soils, and Courty et al. (1989), which targets archaeological sediments. There is no universal descriptive system or format for soil thin-sections, especially archaeological sediments. Bullock et al. (1985) have suggested a worksheet format. Most descriptive formats are geared towards the specific soil type and address specific research questions. Some of those traditionally used in archaeological micromorphology have tended toward interpretive descriptive terms. Every effort was made to construct a descriptive format that avoided interpretive terminology. For universal communication and critical assessment it is important to use standardized terminologies. However, caves and archaeological sediments in caves offer some unique circumstances that required a variation on some of the existing terminology. A combination of terms, defined below, was employed in order to systematically describe each thin section.

Each thin section was first examined by hand and with the aid of a standard microfiche viewer. These initial steps allowed comparison with field notes and zone descriptions with observations of the macroscopic structural features. Thin sections then underwent detailed examination using a Nikon E600 petrographic microscope equipped with transmitted polarized light and epiflourescent capabilities. Magnification ranged from 20 x to 400 x. Most observations were made at a magnification of 20 to 40 x.

The detailed thin section descriptions and associated images are presented in Appendix D, provided on CD Rom. Any web browser such as

Netscape (versions 4.0 or higher) can be used to view the Appendix D thin section database and accompanying images. The images were created by scanning the thin section using a transparency adapter on a Microtek ScanMaker5 flatbed scanner. This image serves as a record of the thin section and provides a basic image for mapping and labeling the zones represented in each thin section. A microstratigraphic description accompanies each thin section image. This description is derived from a relational database created for the Dust Cave thin sections, and its design is described below.

Each thin section was organized into zones. The zones (as noted above) are lithostratigraphic units observed in the field, while the microzones are microstratigraphic divisions too small to isolate in the field and were observed and described using micromorphology. The structure of each lithostratigraphic unit visible in each thin section was described first by microstructure, followed by more detailed observations on the fine fraction, coarse fraction (silt, sand and gravel), aggregates, voids, and finally post-depositional features.

In Chapters 7, 8, and 9 digital photomicrographs are used to illustrate aspects of the narrative descriptions. The images are accessible in Appendix E on CD Rom in jpg format and captions are listed in Appendix E. These digital images were recorded with a Polaroid Digital Microscope Camera using Polaroid DMC V2.0 software. Each image includes a view with plane polarized light (PPL) and cross polarized light (XPL) representing standard features as well as unique features or attributes within specific zones.

Thin section Database

A relational database specifically for thin section description was designed and constructed using Microsoft Access. When analyzing a large number of thin sections a systematic recording system is necessary. Given the large amount of data produced by the descriptions, a relational database is ideal for purposes of organizing, summarizing and querying the database. With the larger Dust Cave Relational Database well underway it was also important to design a micromorphology database that would articulate with the larger site relational database. This was accomplished in the overall design. Ultimately, joining all the databases (zooarchaeological, archaeobotanical, lithic, etc.) in such a relational format will facilitate queries addressing new archaeological and site formation problems.

The micromorphology database is set up with a series of data tables for each of the attributes listed above. The primary keys are the zone (e.g., "B2"), sample (e.g., "98034"), and the thin section that refers to the number of thin sections (e.g., "a", "b" etc.), made from a single field sample. These primary keys link all the data tables; their relationships are illustrated in Figure 5.1. A graphic user interface designed with drop-down menus was used to maintain systematic descriptions during data entry in Access. The presentation of the

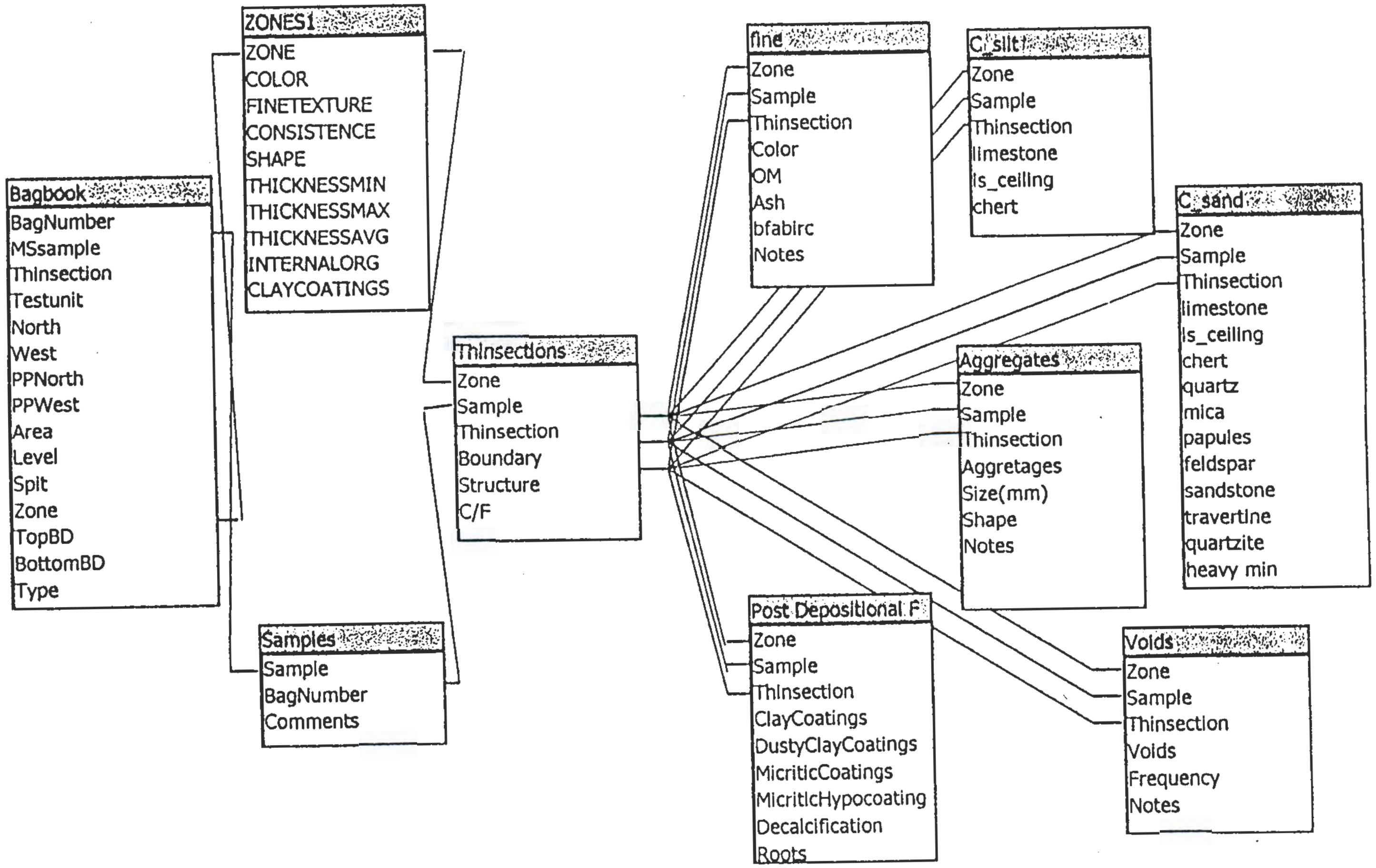

Figure 5.1. Relationships for the Dust Cave Thin Section Database. Note Some of the Tables Display only a Representation of the Contents. The Bagbook and Samples Tables Link to the Dust Cave Site Relational Database.

data, recorded for each thin section, was produced by querying the micromorphology database. The results for each zone entry are organized by thin section and presented in html format in Appendix D (CD Rom).

Thin section Description

Presented below are the definitions of the attributes and their descriptors (e.g., size, shape) in the order in which they appear in the database and in Appendix D. The majority of the parameters I observed are standardized micromorphological features and can be found in either Bullock et al. (1985) or Courty et al. (1989). In some instances, in the interest of defining consistent features that appeared in the thin sections and that are unique to Dust Cave, I used non-traditional terminology. These non-traditional terms were chosen for expediency and uniformity, and are described in detail below. Also in this section I define terms that require clarification because of their inconsistent usage in the literature. Micromorphological observations are made qualitatively (presence or absence) and semi-quantitatively. The majority of the semi-quantitative estimates are made using charts of visual field percentages within various particles sizes available in Bullock et al. (1985) and FitzPatrick (1980). Point-counting in soil/sediment thin sections can be an onerous task, and often produces quantitative data that are not necessary to address micromorphological questions. The use of percentage charts is a widely accepted, expedient, reproducible and reliable technique to estimate abundance in thin section (Courty et al. 1989; FitzPatrick 1980, 1984).

<u>Microstructure</u>

The initial entries for each zone, in each thin section in the database, are based on microstructure. The arrangement of the solid components, their size and shape, and the voids between them generally define microstructure or the geometry of the material. There are several ways to describe microstructure. Due to the variability within the Dust Cave sequence, the terminology applied here distinguishes the microstructure from several different viewpoints including boundary, structure, related distribution, and sorting.

Boundary

The contact between microstratigraphic zones is an important observation but one that is not assigned specific nomenclature in the literature. This attribute is typically relegated to the microstratigraphic scale of observation in soils and sediments. The nature of a transition between two units can inform as to the presence or absence of a conformable or unconformable boundary signifying the nature of the processes that created that boundary. In Dust Cave, for example, unconformable boundaries were critical in the distinction of prepared surfaces (see Chapter 6).

In an effort to describe the microstratigraphic boundaries, criteria were borrowed from soil science to define the distinctness of a boundary, here characterized by the thickness of the transition, although in soils the boundary limits are clearly thicker. The boundary was only described if the upper contact was visible in the thin section. If a boundary was not present in thin section then "n/a" was recorded. If a boundary was present than it was described as *sharp* (<0.5 mm), *clear* (0.5 mm – 3.0 mm), or *diffuse* (>3.0 mm).

Related Distribution

The spatial arrangement of the course and fine fraction is referred to as the related distribution (Bullock et al. 1985). The limit between the coarse and fine fraction is designated here as 2 μm (the division between silt and clay). The related distribution is described based on five established types of geometric patterns that relate the coarse and fine constituents (Bullock et al. 1985; Courty et al. 1989:73-4; Stoops and Jongerius 1975). The standard terms used to describe the distributions are monic, gefuric, chitonic, enaulic, close porphyric and loose porphyric (Courty et al. 1989:73-74). The majority of the zones in Dust Cave are described as either close or loose porphyric where the coarse particles are embedded in a matrix of finer material (typically silty clay), either concentrated (close) or scattered far apart (loose). Occasionally a combination of two patterns is present and both are listed.

Sorting

Sorting is expressed at two levels, either in the overall degree of sorting within the coarse fraction (generally considered a consequence of the source and transport medium) or as an estimate of the degree of sorting by type of material (e.g., quartz, papules, charcoal). This attribute can be determined in part by the frequency estimates for sizes, but this type of observation provides a straightforward way to compare among zones and between particle types within the database. Sorting has been successfully estimated from thin sections using a chart proposed by Courty et al. (1989:68). This chart distinguishes eight degrees of sorting, including perfectly sorted coarse sand, well-sorted silt, bimodal well-sorted sand, well-sorted variable sand (of different compositions), moderately sorted sand, poorly sorted silt, bimodal poorly sorted sand in well-sorted silt, and unsorted. The majority of the zones in Dust Cave were described as either bimodal poorly sorted sand in well-sorted silt or unsorted.

Fine fraction

The fine fraction is the clay size portion of the matrix (< 2μm). This material is difficult to define clearly in thin section using petrographic microscopy. Due to these limitations, description was restricted to the general descriptions of color (in PPL), b-fabric (see below), presence or absence of organic matter and ash, and general comments. The color designations traditionally suggest specific conditions. For example, the color red-brown generally indicated oxidized clay (typically burned) or residual clay. Black indicated charcoal and/or organic matter. Since Munsell colors are already recorded in the field, I distinguished color in thin section intuitively since I was the only observer and as the thickness of the thin section can influence color the designation has limited meaning.

The b-fabric (or birefringence fabric) is an expression of the internal geometry of the fine materials represented in interference colors and birefringence observed under XPL (Bullock et al. 1985:66; Courty et al. 1989:74, also see Fitzpatrick 1989 for a discussion of the term birefringence). This attribute reflects the nature of the mineral material in the fine fraction and possible post-depositional processes affecting the geometry. Four types of b-fabric are used to describe the fine fraction at Dust Cave: undifferentiated, crystallitic, speckled and striated. In the absence of interference colors suggesting either the presence of isotropic or opaque minerals or the masking by humus or sesquioxides, the fine fraction is identified as undifferentiated (Courty et al. 1989:74). Crystallitic b-fabric refers to the presence of fine birefringent materials (typically ash or secondary carbonate at Dust Cave) resulting in an overall birefringent appearance. Speckled b-fabric refers to the random appearance of birefringent materials (typically associated with fine quartz and carbonate sand at Dust Cave). A striated b-fabric was designated when elongated zones of birefringence were clearly present. The striated fabrics at Dust Cave were rare but, when present, suggest wetting and drying conditions resulting in pressure, sometimes visible around coarse grains (FitzPatrick 1993).

Ash and organic matter were noted as present or absent. Ash is generally silt size when the crystals are articulated, but the crystals may be dispersed, resulting in gray colored clay or fine silt size material. Ash is commonly subject to post-depositional dissolution or cementation by calcite, making it difficult to recognize individual ash grains. Both of these materials, when present among the coarse materials, were recorded in that portion of the database. Organic matter here refers to the presence of organic matter in the clay size fraction. In this fraction organic matter is typically present as dark coloration. There is little else that can be observed at this scale. The fine fraction observations were completed with general comments that typically noted the general character of the matrix.

Voids

Another important part of the microstructure are the voids, here defined as spaces within aggregated and non-aggregated materials. These features are described in the database in their own table, so they are presented apart from the microstructure section above. Different types of voids describe the morphology and imply the origin of the cavities. The void types are packing, channel, vesicular, vugh, chamber, plane, and sponge, following the usage of Bullock et al. (1985) and Courty et al. (1989). I added the type "combo" when all void types were represented and the matrix was too chaotic to attempt to estimate their frequencies. The void frequency is determined as a visual frequency estimate using the charts for percentages in visual fields with various particle sizes (Bullock et al. 1985:24-25). These estimates were made based on the representation of each void type combined to equal 100 percent. In retrospect, this aspect of the database should have an additional field that identifies the overall abundance of the voids within the matrix. There was a field for notation on each void type present so that, where possible, this information was noted in this section, along with other pertinent observations such as the size of chambers, type of packing voids, and other features directly related to the voids.

Aggregates

Different kinds of aggregates are identified in pedology and include peds, generally described as structure, and less permanent fragments of material generated by cultivation or frost action (Bullock et al. 1985). Here "aggregate" is used to refer to rounded compound grains made up of a combination of reworked soil, mineral and/or non-mineral grains. These aggregates consistently appear in the Dust Cave thin sections as six different types. These six types of aggregates are described in Table 5.1. Figure 5.2 provides photomicrographs illustrating each aggregate type.

Aggregates at Dust Cave must be distinguished from the coarse and fine fractions, as they can contain combinations of one or both size fractions but represent different origins and processes. There are four types representing

Table 5.1. Aggregate Types Defined in the Dust Cave Thin sections.

Red-Brown (Figure 5.2. a)
Descriptive Attributes • Generally 2-5 mm, or 0.5-1 mm, reddish color • Subangular to subrounded • Contain silt size quartz, papules, weathered chert, limestone, (sometimes adhering to larger sand size weathered chert and limestone), and as a result often have a high relief. In some contexts contain ≥10% ceiling rain (sand size microcrystalline secondary carbonate aggregates - see Table 5.2) • When observed in a "burned" context appear more broken or angular Probable Origin Autochthonous (derived from the cave's interior or associated with the drip line)
Light-Brown (Figure 5.2. b)
Descriptive Attributes • Generally 0.5-2 mm, light brown color • Subrounded to rounded but can be variable shapes, especially if in ash rich zones • Largely composed of well-sorted fine quartz silt groundmass (loess?) • May contain ~2% coarse silt (typically rounded) papules, concretions, amorphous OM, various heavy minerals • No voids, dense groundmass Probable Origin Allochthonous (colluvial material originating from loessial soils from the top and base of the bluff)
Yellow-Brown (Figure 5.2. c)
Descriptive Attributes • Generally 0.5-2 mm, yellowish brown color • Subrounded to rounded but can be variable shapes, especially if in very ashy zone • Composed of predominantly well-sorted fine quartz silt with lesser amounts of mica in a silty clay matrix. Do not contain silt size carbonate fragments or ash • Some may contain ~2 - 20% coarse silt (typically rounded) quartz but also present are minor amounts of feldspar, mica. birefringence clay fragments, concretions, and heavy minerals • Micro-striated b-fabric present - suggest pressure • Rarely voids, dense groundmass • Easily identified under XPL because the area is noticeably fine grained and well sorted Probable Origin Allochthonous (colluvial material originating in the Bt horizons from the top of the bluff)

Table 5.1 (continued)

Dark Brown (Figure 5.2. d)
<u>Descriptive Attributes</u> • Generally 0.5-1 mm, dark brown color • Coarse to fine silt size quartz • Sand to silt size organic matter (often with visible structures) • Minor amounts of fine silt-size mica can be present • Typically identified in a groundmass that included charcoal but the aggregate itself rarely contains charcoal <u>Probable Origin</u> Allochthonous (biological activity in the A horizon from sediments in the talus)
Articulated Ash (Figure 5.2. e)
Descriptive Attributes • Articulated carbonate ash crystals • Color will vary in PPL from gray to yellow to brown depending on the degree of combustion and secondary mineral composition such as phosphates (highly birefringent under XPL). • Shapes include rhombic, lozenge, oxalate spherulite crystals. • Sizes vary • These aggregates, in some cases, can indicate the original structure of burned plant material. <u>Probable Origin</u> Primarily autochthonous (suggest generated from *in situ* burning activity in the cave)
Rip-up Clast (*Figure 5.2. f*)
Descriptive Attributes • clasts laminated or bedded with variable sorted fine textures • often include zones of well-sorted quartz fine silt and papules or fragments of red dusty clay <u>Probable Origin</u> Autochthonous (i.e. slope wash or localized fluvial deposition, typically fragile so rarely transported far from the source area. Material may have originally been derived from outside the cave but the aggregate itself probably formed inside the cave)

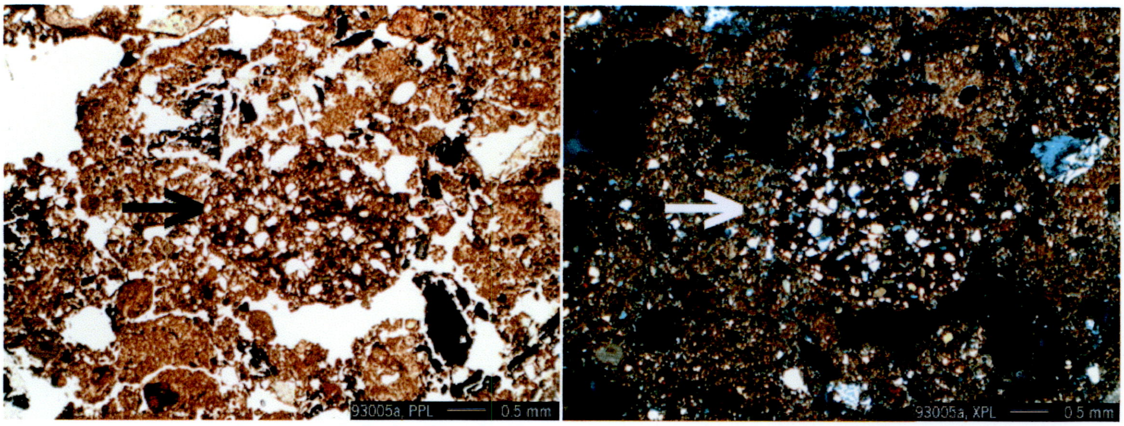

Figure 5.2.d. Dark-Brown Aggregate, Zone T2

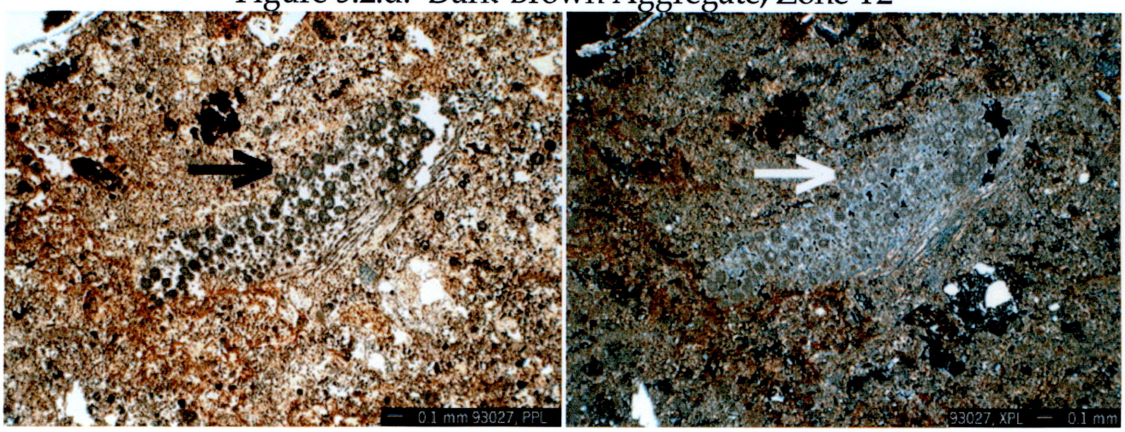

Figure 5.2.e. Articulated Ash Aggregate, Zone K2

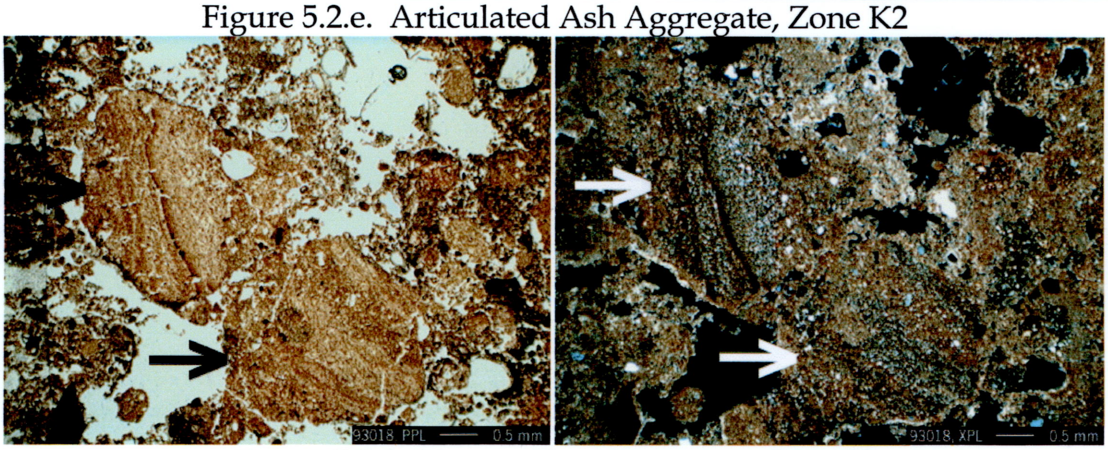

Figure 5.2.f. Rip-up Clast Aggregate, Zone J3

Figure 5.2. Aggregate Types.

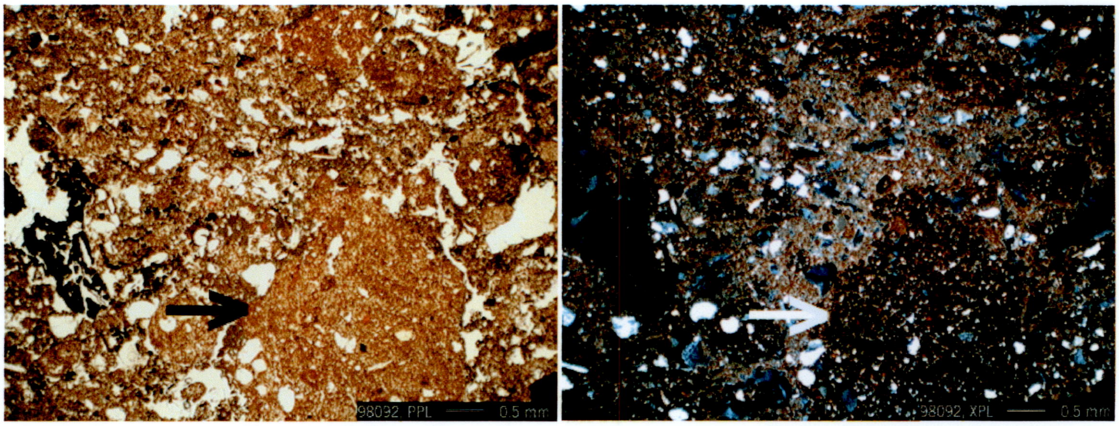

Figure 5.2.a. Red-Brown Aggregate, Zone T2

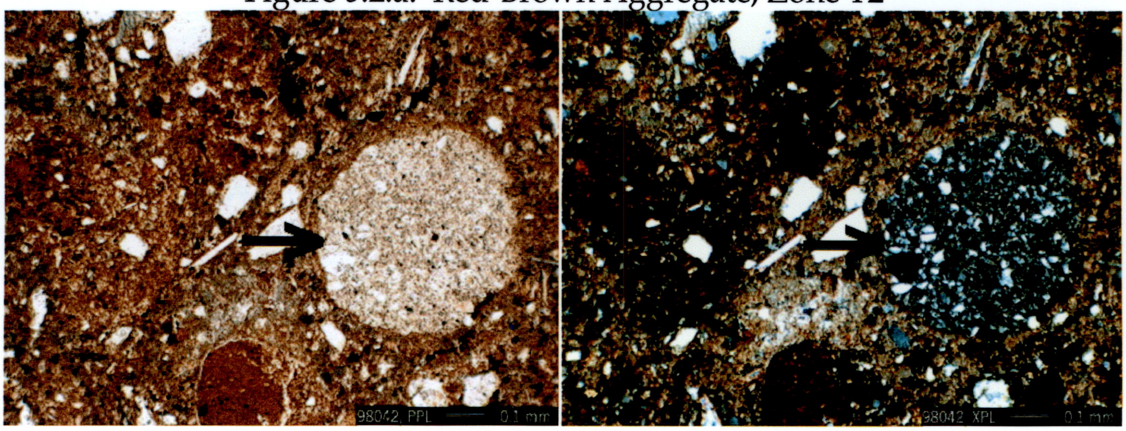

Figure 5.2.b. Light-Brown Aggregate, Zone P29

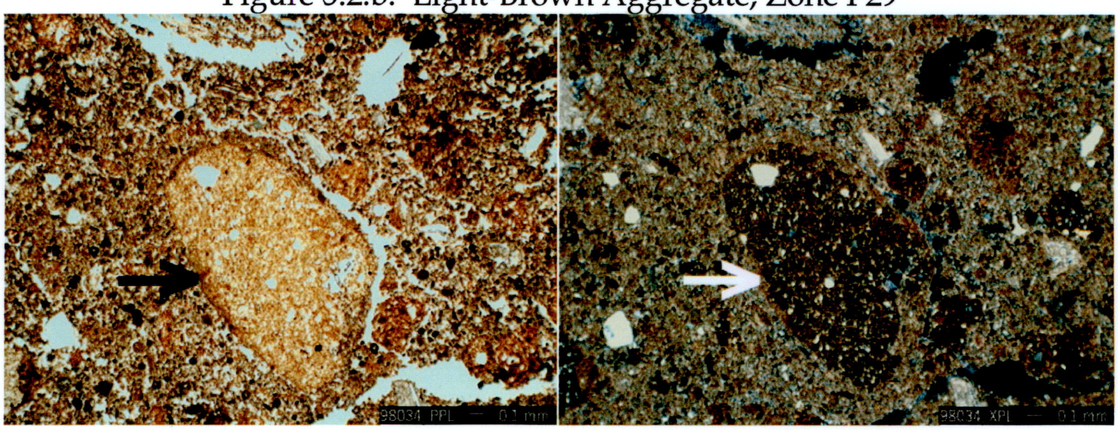

Figure 5.2.c. Yellow-Brown Aggregate, Zone P3n

Figure 5.2. Aggregate Types (Continued).

specific combinations of fine and coarse materials, designated by colors that are probably mostly biological in origin. Two other aggregate types are not biological and do not include soil material. These aggregates are designated by their contents and/or morphology: articulated ash and rip-up clasts. Table 5.1 also includes a suggestion for the probable origin of each type.

<u>Coarse Fraction</u>

The coarse fraction described in the Dust Cave thin sections consists of silt (50μm - 2 μm), sand (2mm - 50 μm), and gravel (>2mm) size materials. These materials include rocks, minerals, organic matter and artifacts. The frequency of each size range is estimated using the same visual percentage charts used for voids (Bullock et al. 1985:24-25). Gravel is recorded with percentage and the type is noted. Gravel in Dust Cave is typically composed of éboulis, chert (Tuscumbia Formation, see below), or charcoal. Gravel size clasts are usually avoided in block sampling techniques in order to remove an intact sample, so if they are present in thin section they are typically well represented in the zone.

Distribution, overall frequency and composition are recorded for both the silt and sand fractions. Distribution describes the relationship of the sand or silt particles with respect to the other grains within that textural category (also referred to as basic distribution pattern; Bullock et al. 1985:34). At Dust Cave only four distributions were identified based on Bullock et al. (1985:35). These types are: *random* - individuals are distributed randomly throughout; *clustered* - individuals are concentrated in clusters; *linear* - individuals have a linear arrangement; and *banded* - individuals are concentrated in bands, with the distance between the individuals smaller than the distance between the bands, which can be discontinuous. More than one type of distribution could be present.

Within each database table several possible particle types were listed. These particles are listed and defined in Table 5.2. Characterizations are included since some of these types are specific to the Dust Cave environment. Recorded in the database are particle types present in the silt and sand fractions. General notes on the predominant grain types and other observations, such as shape (referring to the basic sphericity) are listed in the note section for each fraction.

Post-Depositional Features

Post-Depositional Features include several pedofeatures and processes that occur in the sediment following deposition. In thin section, the presence of these features and their juxtaposition can indicate the order in which these processes occurred. The features selected for the micromorphology database were based on preliminary observations and the type of features observed in the field. In order to describe the intensity of the process in the database the distribution of each feature is listed as *none, homogeneous* (the feature appears

Table 5.2. Sand and Silt Particle Types and Descriptions Identified in Thin section at Dust Cave. Listed Alphabetically.

Ash	
	Ash crystals appear as single white, yellow and predominantly gray highly birefringent calcium carbonate crystals in various shapes (lozenge, rhomboid, spherulitic). Due to the single crystal size ash is recorded in the silt size fraction only. Among the sand-sized particles the crystals are aggregated and are recorded among the aggregates (see Table 5.1).
Bone	
	Bone (calcium phosphate) fragments and whole fish and microfauna elements appear both burned and unburned. Bone is identified by its unique shape, low birefringence and "ropy" pattern, going from yellow to brown in color (PPL) (Courty et al. 1989:109)
Ceiling rain	
	Ceiling rain refers to rounded micritic nodules, (calcareous precipitate speleothems) that vary in size from 0.031 mm (coarse silt) to 0.125-2.0 mm (variable sand). Ceiling rain is clearly distinguished from limestone or ash using UV epifluorescent light. Under this different wavelength the particles strongly fluoresce relative to other materials. The Polaroid DMC is not equipped for epifluorescent so no photomicrographs recording this view are included. Ceiling rain is produced by chemical weathering associated with the cave ceiling and typically only accumulates on surfaces exposed over a relatively long period of time, perhaps in wet conditions. Similar nodules have also been referred to as moonmilk. Various forms of moonmilk are described in the cave literature and typically appear as microcrystalline aggregates that are soft and crumbly with a high water content (Hill and Forti 1997). There are various theories on the origin of this material, but most point towards the disintegration of bedrock or groundwater precipitation. I avoid the use of this term "moonmilk", due to the variable forms and often subaqueous association. The term ceiling rain, though both interpretive and vernacular, is accepted in the literature.
Charcoal	
	Charcoal fragments are black or opaque, typically angular in shape with distinct internal structures (including both wood and nut). The degree of combustion and size varies. Deciduous trees (e.g., Oak, hickory), Conifer trees (e.g., Pine) and other types of plants such as River Cane were occasionally positively identified and noted. Whenever possible the presence of clear plant structure is noted in the hopes that the data set can be easily searched in the future for thin sections appropriate for botanical study.
Chert	
	In this context chert specifically refers to the relatively coarse microcrystalline fossiliferous chert derived from the Tuscumbia Formation. It is clearly distinguished in thin section, based on its coarse texture and high degree of weathering compared to the finer grained Fort Payne and other chert types used in lithic manufacture. When "weathered chert" is noted it pertains to the presence of neoformed clay adhering to irregular surfaces and voids inside the chert

Table 5.2. (Continued)

Concretion	
	Concretions are opaque nodules of iron or manganese that appear in various forms and sizes. The typical concretions are rounded fine sand size clasts that sometimes incorporate grains of quartz sand. The concretions are probably derived from soils outside the cave. Noted alternatives include various forms of manganese dioxide segregations that are typically related to wet conditions. Several of the concretions observed have distinct morphologies.
Coprolite	
	Coprolite fragments are rare in Dust Cave and are typically very small and composed of fine pale-yellow groundmass with possible bone fragments and sediment. Under UV light the material is highly fluorescent.
Feldspar	
	Though in far lower frequencies, like quartz, various feldspar minerals are ubiquitous throughout the cave sediments and appear to be at their highest frequency (as much as 5%) in Tennessee River alluvium.
Gypsum	
	Gypsum is very rare in Dust Cave sediments and then only present as single lozenge-shaped crystals
Heavy Mineral	
	Heavy minerals accounts for all the other (not mentioned in this list) minerals that are present. Typically these include pyroxene, garnet, rutile and others, but rarely account for more than 1% of the coarse fraction.
Limestone	
	Limestone is the general category relating to all the highly birefringent primary fossiliferous carbonate rock related to the Tuscumbia Formation.
Mica	
	Mica includes both muscovite and biotite mica as rod-shaped, pleochroic, highly birefringent laminar grains with high interference colors, some more weathered than others. >5% sand-sized mica is typically associated with Tennessee River alluvium (see Chapter 6).
Microdebitage	
	In accordance with the macro-lithic distribution in the cave the majority of the material appears to be Fort Payne Chert. Microdebitage is identified by its fine microcrystalline texture, angularity, and absence of weathering (compared to the more coarse-grained Tuscumbia chert weathering from bedrock).
Papule	
	Papules are defined as deep red, noncalcareous, often layered, dense high-relief clay appearing as round aggregates or angular fragments. The clay is derived from insoluble clay residues within the karstic system and can be fluvially transported or introduced directly through gravity from the weathering of the cave ceiling (Courty et al. 1989:89). The absence of silt or sand distinguished papules from "aggregates".
Quartz	
	This common anisotropic mineral is observed based on its optical properties. It is common in Dust Cave and is typically poorly sorted in the sand fraction with variable shapes and sizes.

Table 5.2. (Continued)

Quartzite	
	Quartzite is identified based on the compressed shapes of the metamorphosed quartz grains.
Sandstone	
	Sandstone is identified as cemented quartz grains. Only a few fragments of sandstone were identified in thin section and are most likely related to use of a wet stone or other sandstone artifacts imported into the cave.
Shell	
	Shell fragments are composed of fibrous calcium carbonate crystals in elongated thin shapes. This material can typically be distinguished as mussel, fresh water gastropod or terrestrial snail as well as burned (darker, duller aspect) and unburned.
Travertine	
	Travertine appears as fragments (typically angular) of laminated calcium carbonate. Sometimes fragments of limestone adhere to the laminations.

throughout the matrix), or *localized* (the feature or effects of the process are isolated or only visible in specific locations within the thin section). How the post-depositional processes manifest themselves and the features they create in the Dust Cave thin sections are described in Table 5.3. Further details about the post-depositional alteration of the zone are noted for each zone in each sample. Micritic coating and hypocoating features are discussed in relation to calcrete formation in Chapter 6.

In considering soil animals, the assumption in pedology is that these features occur post-depositionally; however at Dust Cave, humans transported soils and sediments, both accidentally (e.g., trampling, adhering to plant materials) and purposefully (prepared surfaces). Several microfabrics are the result of post-depositional bioturbation by soil animals at the source. These microfabrics, typically excreta of earthworms, maintain their granular structure, complete with packing voids, and are transported intact as "aggregates". So if bioturbation is identified under "Post-Depositional Features" then it should be understood that it was evident, based on other aspects, that the material was turbated *in situ*.

Summary and Conclusions

The methods described in this chapter combine microstratigraphic observations with those of field observations made at the macro-scale. The

Table 5.3. Post-depositional Features Identified in the Dust Cave Thin sections. Listed Alphabetically.

Bioturbation	
	Bioturbation is a term borrowed from the earth sciences referring to the reworking of sediments through the various burrowing and sediment-ingesting activities of organisms (Boggs 1987:268). We identify bioturbation in thin section by the presence of excrement (uniform rounded shape) and the presence of channel and chamber voids often containing excrement. Plant roots can also produce channels. Roots are defined under a separate category and refer directly to the observation of root material. Disturbance due to roots is often closely associated with soil animal activity. Excrements typically consist of two kinds based on size and general shape. The first are related to earthworms and typically measure 0.5 to 1.0 mm, and are spherical to ellipsoid in shape. Earthworms can thrive in variable conditions and can feed on both organic and mineral materials. The second kind of excrement probably relates to Enchytraeid worms that produce excrement measuring approximately 0.10 mm and are typically spherical. These small excrements are most likely related to the presence of organic matter at or near the surface and/or intensive earthworm activity facilitating the Enchytraeid activity (FitzPatrick 1993).
Cappings	
	Cappings are accumulations of sediments, occasionally micro-layered, on the top of larger grains. These features are rare at Dust Cave suggesting limited downward movement of fine sediments.
Clay Coatings	
	Clay coatings are identified based on the presence of clay coating the surfaces of voids, grains or aggregates (Bullock et al. 1987:99). Fragments of coatings are also observed embedded in the matrix. These distinct features are related to the downward movement or translocation of clay in solution, settling out as laminations resulting typically bright orange, birefringent domains. ***Dusty Clay Coating*** Dusty clay coatings are considered a subtype of clay coatings. They are distinguished from clay coatings based on the presence of more coarse-grained material (typically fine silt) giving the clay an impure, muddied appearance. Like the clay coatings, these micro-deposits will coat the surfaces of voids, grains and/or aggregates. Fragments of coatings are also observed embedded in the matrix. These distinct features are related to either the disturbance of the zone and/or the downward movement of clay and more coarse material in solution. These fine grains settle out as laminations, resulting in typically less bright orange, nonbirefringent domains.
Decalcification	
	Decalcification is the loss of calcium carbonate by the action of weak acids. The process can only be identified in progress. It is distinguished in thin section by the etching of limestone and other calcium carbonate sediments. It can also sometimes be inferred from the presence of charcoal or phosphates where there must have been carbonates. Once the material has been completely removed we can only note the absence of carbonate materials such as ash, limestone, etc. The process of decalcification is typically associated with wetter conditions (Courty *et al.* 1989).

Table 5.3. (Continued)

Micritic Coatings	
	Micrite is microcrystalline calcite that typically appears as highly birefringent clusters of indistinguishable crystal forms in thin section. The micrite forms thin layers coating the surfaces of voids, grains and/or aggregates. In the Dust Cave sediments there is also limited amounts of acicular calcite and sparite. These features are typically associated with secondary calcite deposition related to root activity - specifically when micrite coats void surfaces in channel voids. The micrite can also indicate calcium carbonate enriched waters moving through and precipitating in the profile. (See "Calcrete" discussion in Chapter 6)
Micritic Hypocoatings	
	Micritic hypocoatings are micritic accumulations, immediately adjoining a void surface. These microfeatures appear as dully birefringent clusters embedding the matrix with indistinguishable crystals adjacent to voids. These features are fairly common in Dust Cave and probably form though the impregnation of the groundmass with calcium carbonate enriched water. (See "Calcrete" discussion in Chapter 6)
Roots	
	Although roots are most certainly the source of many of the channel voids in the Dust Cave sediments, roots are only noted under "Post-Depositional Features" if plant residues in the form of tissue are still visible either in a void or in the matrix.
Secondary Iron Staining	
	Secondary iron staining signifies the movement of iron and its subsequent oxidation resulting in diffuse impregnations of the groundmass that appear as red to brown bands or amorphous concentrations. This phenomenon can also occur in porous materials such as decalcifying limestone. This phenomenon is relatively limited in the Dust Cave thin sections appearing as brown stains in oblique incident light.

nomenclature is based on standardized terminology. The zone data at Dust Cave are organized in what will ultimately be part of a site-wide relational database that will encourage and enable any number of questions or combinations of data to be generated using simple query language. Appendix A presents the macrostratigraphic field observations by zone as entered in the zone section of the Dust Cave relational database. The organization of the intra-zonal stratigraphic relationships is still underway and therefore is not included in this version of the database.

Appendix C presents the field provenience and pertinent information for each described micromorphological thin section. The thin section database, presented in Appendix D, is populated with systematic, semi-quantitative and qualitative micromorphological observations and is organized by zone with accompanying digital images. There are additional field observations recorded in individual field notes, but these are beyond the systematic coded entries required in the database. Some of those observations may be referred to in the narrative descriptions in Chapters 7, 8 and 9. These chapters combine and summarize the information in these three databases to create a narrative that defines the provenience of each zone and offers a description of the zone through various scales of observation. An interpretation of the data, based on the processes revealed by the contents and features of each group of zones, follows in Chapter 6.

Actively producing the zones at the site are geogenic, biogenic, pedogenic and anthropogenic processes. These processes produce specific signatures and in some cases deposits or features unique to Dust Cave or the project area. Chapter 6 reviews these processes offering descriptions and discussion of specific types of deposits.

CHAPTER 6

SEDIMENT SIGNATURES AT DUST CAVE:

GEOGENIC, BIOGENIC, AND ANTHROPOGENIC

Introduction

In the previous chapter I outlined the methodological framework and described the techniques used to characterize and interpret the site stratigraphy, microscopically and macroscopically. This chapter is a description and discussion of sediment signatures unique either to Dust Cave or to the region. I use "sediment signatures" to refer to specific combinations or distributions of clasts derived from a particular source, transport mechanism, or depositional environment. The processes themselves are universal, but the resulting character of the sediment is unique. This approach was selected because many of the sedimentological constituents in Dust Cave are the same. To avoid repetitive descriptions, I assign descriptive terms to the signature features and constituents and define the unique attributes (or signatures) of these groups of sediments. I also discuss their significance in this context. I begin this discussion with purely geogenic and pedogenic deposits such as Tennessee River Alluvium and sediment aggregates, followed by a discussion of characteristic anthropogenic deposits, including prepared surfaces and ash accumulations.

Much of the Dust Cave sequence is derived from a complex series of geogenic, anthropogenic, and biogenic processes. Very few of the sediment signatures described are attributable to one specific process, with the possible exception of the basal, pre-cultural deposits that are primarily geogenic. There are unique deposits -- mostly related to burning -- that can be considered purely anthropogenic, but they incorporate non-anthropogenic materials and are subsequently affected by other processes. If these deposits can be recognized in thin-section and in the field, then the sum total of the processes that produced them should be recognizable.

The following discussion outlines depositional signatures that are produced by specific processes. The establishment of these signatures is based on existing literature (e.g., Courty et al. 1989), as well as on the study of thin sections from known local contexts and possible source areas. These include various positions on the floodplain, the soil on the bluff top, and actualistic studies performed by either P. Goldberg or myself with the Dust Cave Field School students, most of these involving experimental burning.

Geogenic and Pedogenic Sources

Tennessee River Alluvium

The lithology of the Tennessee River alluvium today and prehistorically - both in the cave and in the floodplain - is easily recognized on the basis of a distinctive combination of mineral components. Tennessee River alluvium is distinguished in the cave by its prolific amounts of muscovite and biotite mica (Collins et al. 1994) and minor amounts of pyroxene. These signature minerals are the result of the original igneous and metamorphic rocks originating from the Southern Appalachians (see Chapter 3) appearing within the catchment system of the Tennessee River Valley. This signature is visible throughout the Valley, and I have consistently identified it in thin section in caves and floodplains in the Upper and Middle Tennessee River Valley (Meeks et al. 1997a, 1997b; Simek et al. 1997; Sherwood n.d.).

Tennessee River alluvium is primarily composed of sand and coarse silt-sized sediments consisting of (in relative order of frequency) quartz (typically mixed subangular and subrounded), mica, feldspar, and minor amounts of other rock and mineral fragments. These other fragments compose < 2% of the matrix. Pyroxene/amphibole may compose as much as 3-4 % of the matrix but typically appears at ~ 2%. This mineral is diagnostic in the signature composition due to its consistency and notability, and because it appears in no other contributing source material in the cave.

Unknown Silt

A well-sorted quartz silt, possibly aeolian in origin, appears consistently among some of the zones, enough to warrant a signature designation. For lack of a better term I refer to it as Unknown Silt since I have not yet determined its exact origin. The attributes of size and sorting, along with some silt-sized mica, point toward an aeolian transport agent initially derived from the Tennessee River floodplain. The silt may have originally been deposited along the base of the bluff, adjacent to the ancient channel of Cypress Creek. It is similar granulometrically and mineralogically to the remnant "loess" deposits noted on the bluff. On the bluff top, however, these deposits appear most likely aeolian, based on both macroscopic and microscopic observations. They are slightly finer grained than the Unknown Silt deposits and include evidence of soil formation.

I distinguish the Unknown Silt sediments from those on the bluff because they lack any distinct soil features. Initially they may have been aeolian in origin but have been reworked by water and transported into the Dust Cave system. The absence of sand-sized material - specifically sand-sized mica - distinguishes them from Tennessee River alluvium signature sediments.

Calcrete

Calcrete is the cementation and displacive and replacive introduction of calcium carbonate in various forms into sediments and soil profiles via saturated vadose and phreatic waters (Wright and Tucker 1991:1). The following discussion briefly reviews the formation of calcretes in the context of a karstic cave environment, followed by the definitions of the terms used to describe related features within the Dust Cave stratigraphy.

The source of the dissolved carbonate in a karst cave environment is obvious, although the rate of dissolution is dependent on a complex series of circumstances (e.g., H^+ activity, diffusion rates, presence of impurities, levels of CO_2) (Dreydrodt and Eisenlohr 2000). Water moves through the limestone joints adjacent to the entrance chamber, becomes saturated in calcium carbonate and enters the cave either as phreatic springs periodically saturating the lower deposits or flowing across the surface. Modern day phreatic or groundwater levels depend on TVA reservoir levels and local precipitation, while prehistoric phreatic levels would have depended primarily on precipitation and the elevation of the river.

Vadose water is another source of dissolved carbonate entering the system through ceiling drip, or along the drip line at the entrance (White 1988). Two other probable sources for the carbonate include wood ash and limestone clasts. Calcareous silts composed of ash from burned plant material (mostly wood) are decalcified through water movement and enter the vadose zone as dissolved carbonate. Limestone clasts or éboulis can be chemically weathered, releasing bicarbonate into solution.

The mechanisms of carbonate precipitation are not as clear as the potential sources. In deep cave contexts the issue is chemical equilibrium of karst waters (Dreydrodt 2000; White 1988). Calcrete deposition at Dust Cave is most likely due to mechanisms of degassing of CO_2, evapotranspiration, evaporation, and microbial activity. The degassing of CO_2 in the "soil water" can be strongly influenced by climatic variables (Salomons and Mook 1986). However, reconstruction of paleoclimates using the precipitation of calcretes in cave environments has proved unreliable due to the problem of equifinality (Schnurrenberger 1991), whereby similar deposits can be generated under very different regional climatic conditions. Carbonate dissolution and precipitation can take place in both warm, moist conditions and cold, dry conditions. The buildup of organic matter can affect the diagenetic environment, increasing the acidity and porosity of sediments, and indirectly increasing the moisture levels (Foreman and Miller 1984, Schnurrenberger 1991). The microenvironment created by this buildup of organic matter will increase the degree of chemical alteration within the cave.

It is difficult to classify the various forms of calcrete in the context of Dust Cave based on standardized classification schemes, since these taxonomies typically deal with specific climatic regimes and environments commonly related to soil or ancient sediments. The processes that form calcretes are highly variable, making it difficult to clearly relate the microstructures and the material itself to specific processes. The micro-contexts of the cave interior and the talus at the entrance are non-traditional environments for the study of calcretes. The talus deposits are subjected primarily to vadose influences. These processes might include carbonate-charged drip water evaporating from the bluff face. This would result in the formation of localized cementation zones. On the other hand, the variable processes generating and affecting sediments in the cave's interior include both vadose and phreatic, and subterranean and subaerial depositional environments that change as the deposits are buried. The resulting calcretes are therefore not part of a continuum but a consequence of variable processes occurring at various times in the history of the deposit. An example might be the decalcification of crystalline features altering or masking the original form of calcite precipitation that may have suggested specific microenvironmental conditions. Therefore, it is difficult to clearly relate specific features to defined chronosequences (e.g., Knox 1991, Machette 1985).

There are numerous limitations that currently hamper our ability to characterize and understand calcrete formation at Dust Cave. In an effort to clearly describe and distinguish features relating to the chemical precipitation of calcium carbonate, I employ the "microstructure classification" (Wright 1990) often used in soil science, in combination with standardized micromorphological nomenclature (Bullock et al. 1985). This approach is the most straightforward means to characterize the variability of calcretes at Dust Cave. Wright (1990) has defined two end-member types: Alpha, consisting of dense continuous masses of carbonate, and Beta, typically consisting of precipitated features associated with soil micro-organisms.

Microbial activity may account for far more carbonate precipitation than previously thought, especially in Beta calcretes. Considering microbial mechanisms, Wright and Tucker (1991:7) state, "much more work is needed before the links between calcrete morphology/micromorphology and climate/biology are clear enough for their use in paleoenvironmental interpretation." Unfortunately, at this point it is difficult to distinguish between microbial carbonate precipitation, other biological forms, and calcareous rhizomorphic features or plant root carbonate precipitation. All form tubes of similar shape (e.g., channel void) and size (Robert et al. 1983). However, the distinction, at least at Dust Cave, is probably not crucial to the interpretation of the archaeology.

The primary forms observed in Dust Cave include micritic coatings (void coatings) and micritic hypocoatings (the micritic embedding of the groundmass adjacent to a void) (Bullock et al. 1985). The assumption, based on the presence of root petrification (when the root structure is clearly observable), is that most of these features are rhizolith features. Related Beta features include micritic or sparitic cement, needle fiber calcite, microcodium, root petrification and concentric micrite. The needle fiber structures are only clearly visible outside the cave in the talus deposits (see Chapter 9). The calcite crystals lining voids inside the cave appear to be eroded with their original structure no longer distinct. This occurrence may be a product either of on-going decalcification destroying the crystalline structure as acidic waters enter the cave, or of the thickness of the thin sections and the microscopic limitations this thickness imposes.

Travertine

Travertine is the accepted terminology used to identify calcite precipitated in cave environments, typically on carbonate rock surfaces. The term is used at Dust Cave to describe the laminated calcite clasts that are fragments of speleothems from the karstic system. Speleothems refer to a broader category encompassing all secondary chemical crystallizations that are traditionally referred to as cave formations (White 1988).

Ceiling Rain

The term Ceiling Rain refers to a type of travertine, rounded carbonate microcrystalline sand-size aggregate. These carbonate clasts originate from two processes that are difficult to differentiate at Dust Cave. The first is the mechanical weathering of the cave walls. As moisture condenses on the cave ceiling and walls, it enters microcracks in the limestone and instigates the dissolution and subsequent removal of sand size pieces, which fall to the floor. The second process is related to the speleothem moonmilk. Moonmilk refers to precipitated aggregates of microcrystalline carbonate that form on cave walls, and that are soft when wet and powdery when dry (Hill and Forti 1997). In limestone caves this microcrystalline formation is typically calcite. These small circular (can be subrounded) clasts fall to the cave floor and accumulate there as sand-sized rounded carbonate. Such accumulations within cave sediments could be used to identify stable surfaces, either buried or current (e.g., Simek et al. 1998, Sherwood and Goldberg 2001). In the Dust Cave sediments these clasts are almost always identified with a thin rind consisting of secondary iron staining. This micro-feature probably relates to the dry brittle aspect of the calcite aggregate surface and the accumulation of oxidized iron and/or the flocculation of clay. Ceiling Rain typically appears in rubified autochthonous silty clay, some of which was selected for prepared surfaces in the cave (see below).

Aggregates

Pedologists identify various aggregate types, generally describing them as structured and less permanent fragments of material generated by cultivation or frost action (Bullock et al. 1985). Aggregates are defined here as various combinations of compound grains that include reworked fragments of soil, rock and nodules (Courty et al. 1989).

These grains must be distinguished from the coarse and fine fractions, as they can contain combinations of one or both size fractions but represent different processes. Compound grains vary greatly in composition, size, and shape, and are usually site specific. Therefore, the existing nomenclatures are general, requiring site-specific distinctions. There are six types of aggregates identified in the Dust Cave sediments. These types represent consistent, unique combinations of materials forming separate clasts. These compound grains of sediment often originate from sources and transport agents that differ from the matrix that surrounds them. There are four types representing specific combinations of fine and coarse materials - red-brown, light-brown, yellow-brown, and dark-brown. The last two types are based on known features - articulated ash and rip-up clasts. These signature aggregates were described in detail and their probable origin noted in Table 5.1.

Anthropogenic Sources

Burning

The use of fire in prehistory is a long-standing interest in archaeology, first in its significance as a technological milestone relating to various adaptive strategies and technologies (e.g., lithic heat treatment, cooking), and second in our ability to identify it in the archaeological record (Bellomo 1990, 1993; Bennett 1999; Buikstra and Swegle 1989; Eiseley 1954; Lyman 1994; Pyne 1983). The latter avenue of study, the identification of prehistoric fire, is relevant for the classification of burning at Dust Cave.

Based on the volume and distribution of ash and charcoal in Dust Cave, the burning of wood and other plant material (nuts, leaves) was a major contribution to the sediment infilling of the cave. Intentional burning, in the form of localized controlled surface fires for purposes of warmth, cooking, light and ritual, are the most likely types of burning.

Actualistic studies and experiments in campfires have identified different characteristics of the burning process and their effects on the surface (Bellomo 1990, 1993). Temperature ranges for open-air fires rarely rise above 700 °C with a mean temperature of around 550°C (Bellomo 1990; Rice 1987). The macroscopic effects of fire on sediment are typically limited to descriptions of the sediment being "relatively durable, consolidated and crusty" (Bellomo 1990:87). Reddening typically occurs due to the oxidizing atmosphere immediately following combustion during cooling. In clay and other fine sediments, experimentation indicates that the highest temperatures are reached within 1 cm of the fire and typically affected the adjacent 5 cm (Bellomo 1990).

In order to distinguish and ultimately interpret burning activity at Dust Cave, I set up a basic typology of burning deposits (Table 6.1). First, the use of fire by the Dust Cave inhabitants is unequivocal, based on the ample amount of charcoal and ash alone. Beyond this initial observation the variability can be divided into three types of burned deposits with additional variability defined as subtypes. At Dust Cave these types are used to infer the nature of the spatial integrity of the artifacts associated with these deposits and provide insight into the nature of the burning activity in specific areas and during specific time

Table 6.1. Types of Burning Deposits Defined at Dust Cave

Burning Deposit Type	Constituents	Micromorphological Fabric
IN SITU FIREPLACES		
Prepared Surfaces	Red silty clay: predominantly subangular quartz silt- and sand-size quartz, ceiling rain and weathered limestone and chert, occasionally dispersed single ash crystals 2 aspects: hard and soft	• Measure 1.5 to 3 cm thick • Always unique lithology compared to adjacent zones • Often aggregated structure but limited void area. Packing, channel and planar voids present (planar as microcracks) • Boundaries are unconformable sharp contacts, often with charcoal and ash articulated to the upper surface
Unprepared Surfaces	Red, variable textures depending on substrate, typically include limestone *éboulis* among loamy sediments with charcoal, ash and various microartifacts. Typically has "hard" aspect	• Rubified sediment with embedded ash and charcoal • Upper boundary typically unconformable sharp contact
Rock Pits	Concentrated ash and charcoal in shallow intrusive basins with numerous burned rocks	• None sampled for this project, considered "features"
MIXED BURNING		
	Mixed calcareous ash (both single ash crystals and lesser amounts of articulated ash), and variable-sized charcoal, and clasts of burned red silty clay in variable silty matrix. Concentrated clasts (sand to gravel), angular to subangular burned sediment (from either prepared surface or burned substrate).	• Various fabrics, can be laminated due to fluvial activity or aggregated due to bioturbation • Large clasts of sediment sometimes angular • Distinguished from Fireplace Rake-out due to more intact micro and macrostructures and more coarse
FIREPLACE RAKE-OUT		
	Concentrated mixed ash and charcoal. Sometimes laminated by localized sorting. Can include hard red sediment clasts derived from a burned surface that is now conspicuously absent	• Can be aggregated due to bioturbation or chaotic • Mixed void types • Sometimes post-depositionally altered by fluvial microfeatures

periods. These different burned deposits are primarily identified on the basis of microscopic signatures defined in Table 6.1. Note that these types pertain directly to the variability observed at Dust Cave, differing from the diagnostic types of "burnt layers" defined by Courty et al. (1989).

The first type is an *in situ* fireplace where the burning event, or a portion of it, is preserved in the archaeological record, including the surface on which the first rests and at least a remnant of the combusted material. The *in situ* fireplace is divided into three subtypes - prepared surfaces, unprepared surfaces, and rock pits. All types are defined based on the structure and the composition of the deposit (Table 6.1). The third subtype pertains to shallow intrusive pits lined with rock (typically limestone). The shallow pits are investigated as "features" in the traditional archaeological sense and are considered in this study in their most general capacity, as cross-cutting, localized, anthropogenic deposits. The reason prepared surfaces are discussed at length here, is that at the beginning of this study, these red tertiary zones were not recognized as features of intentional human construction. Instead they were assumed to be either incidental burning areas (with no preparation), or post-depositional anomalies cemented by secondary calcite. Their discovery as discrete anthropogenic structures was a result of micromorphological analyses.

The second type of anthropogenic burning is identified as a mixed burned deposit. In the mixed burned deposit, the burned surface and the combusted material are mixed through post-depositional processes. The result is a fabric that varies from that of the original deposit, but one in which the original constituents are still distinguishable.

The third type (Table 6.1) is referred to as fireplace rake-out, where the original burning took place elsewhere and the combusted materials are discarded in a different location. The result is a mixed calcareous ash deposit lacking any evidence of being associated with a surface or pit.

In Situ Fireplaces

The prepared surfaces are typically 1.5 to 3.0 cm thick with clear sharp upper and lower boundaries, and normally cover a horizontal area <1 m. These red deposits are often closely associated vertically, as if the organization of space inside the cave directed their location in the same place over time. These prepared surfaces are interpreted as burned surfaces, based on their often hardened aspect and ash adhering to the upper surface. They have both consistent and variable attributes. The most consistent attributes are their unique lithology compared to the zones above and below and their red color (2.5YR, 5Y).

The unique lithology of these red zones is derived from relatively fine-grained, noncalcareous clayey or silty clay sediment. Most of these zones have a microstructure characterized by red-brown aggregates (see Chapter 5 and previous discussion on signature aggregates). The aggregates are normally composed of well-sorted quartz silt with minor amounts (<5%) of mica and chert. Poorly sorted, typically subangular quartz sand is also sparsely distributed throughout the matrix. Other, less well-represented sand includes weathered chert.

Variable attributes of the prepared surfaces can include a larger clast composition, ceiling rain, and the presence of highly dispersed single ash crystals. Sometimes larger clasts, including limestone, chert debitage, and on occasion single charcoal pieces, are part of the matrix. In a few instances elongated clasts are vertically oriented in the zone, suggesting a transport mechanism that removed the material from the source area and deposited it in one dumping event. The source area(s) appear to be derived primarily from autochthonous deposits similar to those that produced materials in the rear of the cave and in the upper zones today (see Chapters 7 and 8). This interior source is also suggested by the absence of organic matter. The ash component, when present, is sparse, with dispersed single crystals that do not appear to have been introduced intentionally but were probably windblown from a nearby source area. Another lithologic variable among some of these prepared surfaces is ceiling rain, as noted above. Approximately 5% of the matrix consists of these round calcareous microcrystalline nodules, again distinctive compared to the neighboring sediments. These deposits typically rest on a horizontal substrate, often of mixed ash.

Thin section observation suggests that heating is the mechanism causing the hard consistency of the prepared surfaces. There is no secondary calcite deposition acting to cement these sediments, and the upper surface often displays a very thin micro-zone of darker red to black color, suggesting differential oxidation (see below).

The typically bright red color of the zone as a whole is derived from a combination of processes. First, the source material is composed, at least in part, of the iron oxides contained in the residual clay, from the weathering of limestone typical of cave sediments. When hydrous iron oxide is heated, it changes to ferric oxide, iron called hematite (Fe_2O_3), resulting in a bright red color. Red color in soil and sediment in general is typically caused by the presence of ferric oxide (Bigham and Ciolkosz 1993; Schwertmann and Taylor 1989)

The physical processes that occur in the sediment (or on the burning surface) are comparable to what transpires during the firing of low temperature earthenware (from 500 - 700 °C). Terra cotta, for example, is fired at temperatures under 900 °C and result in a red, porous, relatively soft ware. The structure of the clay molecule changes as water is driven out after 200-300 °C, then with higher temperatures reaching greater than 500 °C, the clay minerals are altered irreversibly (will not regain plasticity) by the removal of the hydroxyl group (Gibson and Woods 1990; Sinopoli 1991). The low intensity and short duration of these combustion episodes typically result in limited substrate alteration expressed in specific attributes of color and structure. They also contain a mixture of ash and charcoal in deposits above the burning surface that includes partially combusted materials produced at low temperatures. Low temperature is further suggested in the stability observed in the calcium carbonate clasts.

Along their upper boundary, several of these surfaces have a darker zone approximately 2-4 mm thick. The assumption is that this represents the articulation of the fire and the clay surface. This dark surface is most easily identified macroscopically, where the color change is very subtle and there is no obvious structural change. In thin section, the bright red birefringent clay of the red zone appears less birefringent and darker in color in this upper dark area. Otherwise the microstructure and coarse fraction appear unchanged.

Some of the prepared surfaces do not have this hard aspect, and I refer to these as "soft" red zones or soft prepared surfaces. Again, there is little to no secondary carbonate cementation that created a hardened aspect. The absence of the hardening suggests that temperatures were never greater than the 500°C, which would have irreversibly affected the clay minerals, and allowed plasticity to be regained as water was reintroduced. The introduction of water in these relatively clayey deposits might ordinarily produce clay coatings in the pore spaces, but these features are generally absent or poorly developed. Clays will tend not to stay in suspension in carbonate rich microenvironments or to remain flocculated (Birkland 1984). The relative lack of clay coatings may be due to this phenomenon, or to the dense microstructure discouraging the movement of pore water.

Mixed Burning

Ash makes up the majority of the mixed burned deposits. Ash is primarily composed of calcium carbonate with minor additional mineral inclusions in distinct crystalline forms. Ash is the visible residue produced by the complete and partial combustion of organic substances. Often in the case of open-air fireplaces the organic matter is not fully combusted, resulting in remnant fragments of plant structures. The degree of combustion can be affected by various conditions, including the amount of available oxygen, fuel, moisture content, and the intensity of the heat source (Bellomo 1990; Pyne 1983). These conditions would be highly variable inside the cave.

Mixed burned deposits are composed of remnants (typically ash and charcoal) of the fuel and fragments of the burned surface (see above). The result is a distinctly chaotic matrix identified on the basis of both composition and structure. Often, ash crystals are articulated, suggesting they have undergone only limited disturbance. They are distinct from the zones above and below, but rarely with sharp clear boundaries. These deposits were probably mixed due to variable processes including bioturbation and trampling.

Fireplace Rake-out

Fireplace rake-out deposits are primarily composed of ash, charcoal and burned microartifacts, with no evidence of burned sediment clasts. There is also a complete disarticulation of ash crystals and a general mixing that suggests some transport, such as wind and water. Graded bedding (water) or sparse single ash crystals among other sediments (wind) (as in the autochthonous source material related to the prepared surfaces discussed above) discounts rake-out. In addition, fireplace rake-out is only considered in the absence of a direct relationship with a pit or hearth feature.

Summary

Much of the Dust Cave sequence is derived from a complex series of geogenic, anthropogenic, and biogenic processes. There are repeated patterns, however, in composition and structure that identify signatures relating to specific processes in the cave. The geogenic and biogenic signatures include Tennessee River alluvium and specific carbonate features including travertine, ceiling rain, and calcrete. Unknown Silt is designated as a signature due to its recurrence, but its exact origin is not known. Six types of distinct aggregates are defined that are derived from a combination of processes. The anthropogenic signatures in the cave, excluding the traditional archaeological features such as burial pits, small basin shaped pits, etc., refer specifically to burning. These anthropogenic signatures are divided into distinct types based on composition and structures that imply specific depositional histories and human activities. Prepared surfaces are described and discussed in some detail due to their potential significance representing specific activities.

This chapter has outlined the basis for the identification of these signatures focusing on their appearance in thin section. The processes that lead to their construction, use, and post-depositional alteration are discussed. The identification of the sediment signatures proposed in this chapter are central to the interpretations of specific zones in the next three chapters.

CHAPTER 7

BACK PASSAGE STRATIGRAPHY:

ZONE DESCRIPTION AND INTERPRETATION

Introduction

The stratigraphic framework at Dust Cave is made up of a complex series of lithostratigraphic zones. This chapter presents narrative descriptions and interpretations of the stratigraphy observed in the back passage or dark zone of Dust Cave. The dark zone constitutes the back portion of the cave, deep in the karst system beyond the entrance chamber. The terms dark zone or deep cave signify the absence of natural light. The strata representing the dark zone sequence were recorded in Test Units B and C (Figure 7.1). The discussion begins with the lowermost zone in that sequence, closest to bedrock, and works upward by primary zone group, to the surface. The descriptions are organized by primary zones from Test Units B and C and condense the data presented in Appendices A, C, and D (see Chapter 5). The zone interpretations are based on field and microstratigraphic observation, in conjunction with radiocarbon dates. This chapter concludes with a synopsis of the zone interpretations and a brief discussion of the depositional history inferred from the back passage cave stratigraphic contents and structure.

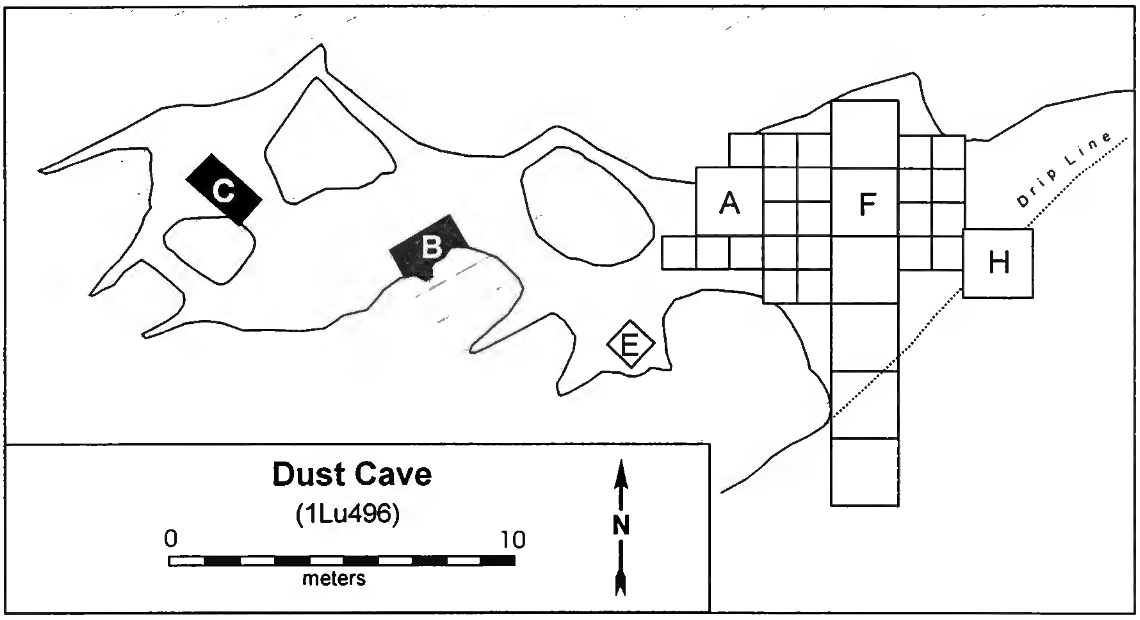

Figure 7.1. Dust Cave Plan Map Emphasizing Back Passage Test Units B and C.

The chronostratigraphic relationships among the primary zones are presented and are based on superposition, crosscutting relationships, and association defined in the field and organized by radiocarbon ages. Recall that Table 1.1 presents a summary of the radiocarbon ages for Dust Cave. There is currently only one radiocarbon date for the dark zone but several zones in Test Unit B are correlated with well-dated zones from the entrance chamber.

The Back Passage Stratigraphy

The back passage is the portion of the cave beyond natural light where nearly 30 m of short, interconnecting passages follow the joint pattern of the bedrock to the north and west of the entrance chamber (Figure 7.1). The provenience system has not been extended to the rear of the cave so the spatial relationships are recorded as distances from the entrance chamber or from the entrance of the cave. This discussion is limited to Test Units B and C (Figure 7.1). Test Unit E is also located in the dark zone but is excluded from this analysis due to its initial exploratory nature and the limited stratigraphic information available for the unit.

Test Unit C measures roughly 1 x 2 m and is located at the deepest accessible point in the Dust Cave system, in a small chamber marked by a solution dome in the ceiling, approximately 25 meters from the cave entrance (Figure 7.2, 7.3). To access this chamber today with the current surface elevation in the cave, one must "belly crawl" through a low arch. When this

Map and Profile Key

Symbol	Description
	clear boundary
	unclear boundary
A2	zone designation
F. 62	feature designation ("Fea" denotes a feature location, number not included)
92001	micromorphology sample location and designation
	limestone (scaled to size)
	gastropod concentration
	charcoal
	concentrated charcoal
	dispersed charcoal concentration
	soft red silty clay to clay lithology
	hard red silty clay to clay lithology
	hard surface (unprepared)
	concentrated ash
	bedrock - Tuscumbia Formation

Figure 7.2. Key for Symbols used in Plan Maps and Profiles in Chapters 7, 8 and 9.

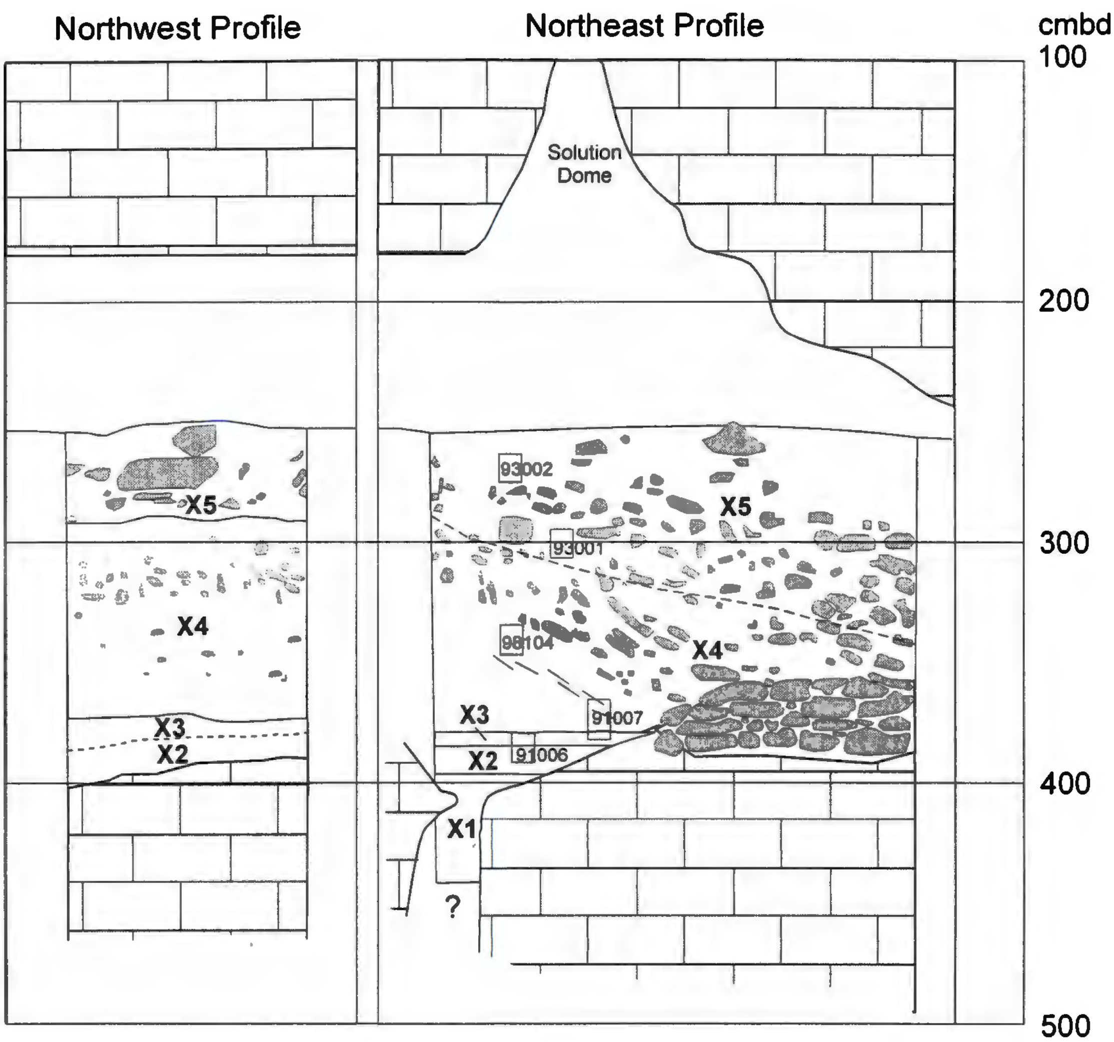

Figure 7.3. Test Unit C Profiles.

portion of the cave was undergoing active deposition the floor was lower and this area was more open. It probably adjoined other narrow passageways that are currently blocked with sediment. The unit was excavated to a depth of 190 cm (440 cmbd) until the floor sediments, due to dense weathered bedrock, became too restricted to excavate.

Test Unit B is located approximately 8 m from the western limits (W69) of the entrance chamber (Figure 7.1). From the entrance chamber the passage follows the joint pattern making a 90-degree turn to the north before turning west again. The unit was excavated against the bedrock wall giving it irregular dimensions but generally covering an area measuring 2 x 1 m.

The zones identified in Test Units B and C are grouped together under one primary zone designation of "X" followed by secondary numeric designations that indicate clearly separate units. Some of the zones in Test Unit B are correlated with primary zones from the entrance trench, but these correlations are based on similar lithologies, not on direct physical associations observed in the field. Thus, the dark zone strata are assigned a separate primary designation to avoid any confusion or misassociation that might occur if the profiles are ever extended to the entrance chamber.

Excavation Strategy

The excavation strategy needs to be described because it varies from the approach employed in the entrance chamber. As their designation implies, the units were part of the 1989-90 testing program attempting to identify the nature and extent of the deposits in the cave. Two restrictive factors in the excavation methods were the confined space (< 1.0 m of vertical crawl space) and the necessity of artificial light affecting visibility. Excavation was carried out in 20 cm arbitrary levels, all sediment was dragged out of the cave in buckets and water screened using ¼ inch (~6 mm) mesh. The profiles were recorded and representative micromorphology samples were collected from the profiles during the 1991 and 1993 seasons. Test Unit C was reexamined in 1998. No artifacts were recovered from Test Unit C, while artifacts were recovered from the upper zones in Test Unit B.

Test Unit C: Zones X1 - X5

Description

Distribution

There are 5 zones (X1 through X5) identified in Test Unit C (Figure 7.3). Zones X1 through X3 extend horizontally across the unit floor and Zones X4 and X5 dip to the southeast towards the opening that enters the main cave passage.

Lithology and Structure

The deepest zone, X1 approximately 400 cmbd, consisted of rubified clay with weak redox features (e.g., chroma 2 mottles). As noted above, exposure was limited at the base of the unit and this zone was not sampled. Zone X2, X3, X4 and X5 all contained signature Tennessee River alluvium with slightly varying grain sizes, structures and degrees of rubification.

The boundary between Zones X2, X3 and X4 appear conformable, marked by a change in grain size from well-sorted noncalcareous silty clay and fine sand (Zone X2) into a lens of laminated fine silt (Zone X3). Other attributes in X3 include small-scale deformation features including convoluted bedding, and vertical and horizontal cracks with translocated clay coatings. The upper boundary of X3 consists of a sharp transition to X4, a more coarse silty clay containing subrounded to subangular sand (predominantly quartz, chert and mica). The sand fraction composing X4 includes approximately 1-2% bone fragments including fish bone (partially fossilized) (Plate 7.1).

From the base of X4 grading into X5, a general fining upward grain size distribution takes place. The most striking feature of X4 is the platy structure consisting of elongated aggregates with rounded edges (Plate 7.2). Many of the voids defining these aggregates are coated in translocated clay, while other clay coatings are embedded in the matrix attesting to some reworking of the sediment mixing these relic coatings into the matrix. Well-developed clay coatings are also visible on some of the coarse particles (Plate 7.1).

Éboulis occur for the first time in the profile in X4 and X5. The ca. 20°-30° eastward dip of these zones is revealed both in the contact between the zones and in the orientation of the éboulis throughout X4 (less marked in X5). Clay intercalations also follow the same dip at the base of X4 (Figure 7.3).

In Zone X5 the signature Tennessee River alluvium still predominates, however the platy structure from below is more weakly developed, with extremely localized and thin clay coatings. Biological features appear to postdate the platy structure and include more rounded aggregates, channels and partially infilled chambers (Plate 7.3). Similar biological features are present in X4 as channels and partially infilled chambers but are not as numerous or well developed (Plate 7.4).

Interpretation

The composition of the sediments identified in Test Unit C suggests the Tennessee River as being the primary source. Based chiefly on this composition these deposits are attributed to alluvium that entered the cave through the entrance and accumulated in the cave interior. The corresponding alluvial events were massive in order to force coarse-grained alluvium deep into the passages of the cave. The fine texture and thinly bedded structure of X3 indicates changing energies and the possibility of slack-water conditions in the cave prior to the deposition of X4. The strong structure and the rubification of Zones X1, X2, and X4 indicate that the deposits probably date to the Pleistocene, perhaps around 30,000 years ago when other studies (e.g., Brakenridge 1982, 1984; Delcourt 1980; see Chapter 3) identify higher valley floors and peak sediment accumulations. This interpretation is based primarily on the signature Tennessee River alluvium and the unique platy structure, which has been directly related to freezing and thawing and the resulting cryoturbation. VanVleet, et al. (1984) and Texier, et al. (1998) have referred to these structures as ice lensing. Freezing in the typically stable microclimate of a cave system, could conceivably occur only in conditions of sustained extreme cold, which may have been the case during the Late Wisconsinan.

The deep red, well-developed clay, coating coarse aggregates and embedded in the matrix signifies repeated processes. The 20°-30° angle of the boundary between Zones X4 and X5 suggests an erosional surface formed as Pleistocene alluvial sediments were flushed from the cave (see chapter 3). One other possibility is the presence of a now extinct localized subsidence feature that may have been present to the west of Test Unit C or in the floor of the unit. Such a feature could resemble the weathered joint evident in the northeast profile and may have opened after or during the deposition of X4 causing the sediments to slump. Excavation could test this hypothesis if a unit was located between Test Units C and B.

Zone X5, though primarily derived from the same source as X4, is far less weathered suggesting that these sediments were deposited during a later influx of Tennessee River sediments. The extensive translocated clay and overall rubification of X4 are absent, indicating that X5 is younger and did not undergo the same post-depositional processes as X4. A weaker version of the platy structure is present in X5. Following the development of the platy structure, probably later in the Pleistocene or in the early Holocene when the rear of the cave may have been dryer and biological activity restructured smaller portions of the deposit. The frequency of biological features increases significantly upwards in the overall profile until Zone X5, when approximately 40% of the matrix is organized into granular structure.

The absence of extensive translocated clay in this upper deposit suggests that those prevalent in Zones X2, X3, and X4 developed prior to the deposition of X5. There are no apparent correlations between the Test Unit C and B profiles, further suggesting that the majority of the zones in Test Unit C were deposited during ancient Pleistocene alluviation in the cave. Dating of these deposits should provide a sounder chronostratigraphic basis for this interpretation.

The presence of Mn dioxide micro-features throughout the Test Unit C zones attest to redox processes, suggesting the deposits were periodically saturated (Plate 7.5). This wetting and drying could have occurred anytime in the history of the deposits and probably relates to changes in the water table, possibly seasonal, linked to flood events and even regional changes at the end of the Pleistocene.

Test Unit B: X6 - X10

<u>Description</u>

Distribution

The six zones identified in Test Unit B slope gently to the east with the lowest zones sloping up slightly against the cave wall (Figure 7.4). The zones are tabular and vary in thickness, but average approximately 35 cm. Whereas there is no correlation evident with Zones X1 through X5, Zones X7, X9 and X10 in Test Unit B are lithologically correlated with zones from the entrance chamber.

Lithology and Structure

At the base of Test Unit B, Zone X6, at approximately 450 cmbd, is one of the deepest zones in the cave (Figure 7.4). Zone X6 overlies weathered bedrock and is composed of dark reddish brown clay with Mn dioxide features, clay coatings and weathered bedrock fragments. Zone X7 marks an influx of Tennessee River alluvium and is tentatively correlated with Zone Y2 from the entrance chamber. Zone X7 contains Tennessee River alluvium in a well-sorted, dense matrix of laminar silts and fine sands (Plate 7.6). The boundaries between the varying textures are sharp. Void space is minimal at <5%

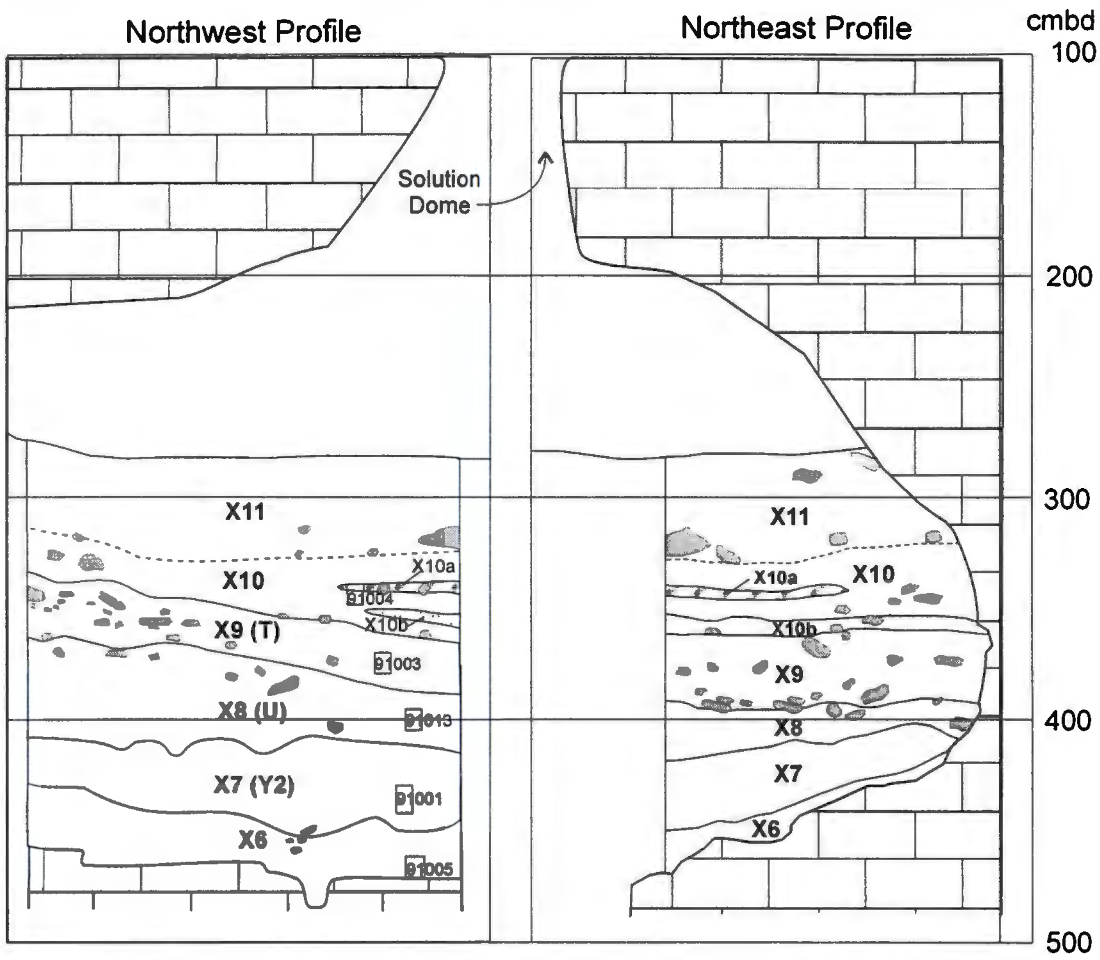

Figure 7.4. Test Unit B Profiles.

consisting of channel and planar voids. Most of these voids are coated in translocated clay. In the well-sorted silt microlenses the mica is horizontally oriented.

Deformation, though difficult to define microscopically, is evident macroscopically in the presence of large sediment clasts with sharp boundaries composed of varying textures.

Zone X8 is distinctly different from X7 both macroscopically and microscopically. Color changes from brown (X7) to red (X8), and texture and structures become finer and more dense. The clear Tennessee River Alluvium signature is replaced by one relating to the Unknown Silt signature. Zone X8 is composed of dense well-sorted noncalcareous clayey silt (predominantly composed of quartz and mica coarse to medium silt) with approximately 10% poorly sorted sand (Plate 7.7). There are possible microartifacts among the sand fraction including charcoal and bone (a few up to gravel-sized). The groundmass is less dense than Zone X7 above; however, the void area remains fairly low at ca. 5–10%. Most of the void morphologies are classified as channels and vughs, and most contain dense fragmented translocated clay either coating the voids or embedded in the adjacent matrix (Plate 7.8). Based on similarities in the microfabrics Zone X8 is tentatively correlated with Zone U3 (in the entrance chamber).

Zone X9 is described as a dark brown silty clay with éboulis. Tennessee River alluvium dominates with the first significant influx of possible microartifacts (charcoal and a relatively high concentration of bone) in the dark zone of the cave (Plate 7.9). Zone X9 is tentatively correlated with Zone T from the entrance chamber. No ash was identified in thin section relating to X9, and the carbonate sand observed is consistently etched suggesting extensive decalcification. The microstructure is chaotic, and though there are fragments of clay coatings and papules in the matrix, there is no clay coating the voids.

Zone X10 is described as dark reddish brown silty clay with a relatively dense artifact concentration including concentrated lenses identified as tertiary zones X10a and X10b. The zone slopes down to the east following the slope of the zone below with sharp upper and lower unconformable boundaries. Both of the thin tertiary lenses pinch out in the northwest profile (Figure 7.4). Zone X10b was examined only macroscopically and is described as interspersed stringers of black and grey silty clay with sand-sized charcoal. This zone rests unconformably on X9 in the northeast profile and then pinches out in the northwest profile in X10. Zone X10a is composed of dark red silty clay with additional stringers (noted but not isolated for excavation) of black, grey and red silty clay. Sparse relic root features were also noted in the profile description. In thin section, X10a is composed of laminated graded bedding of varying silt-sized grains of quartz, chert, ash, and various microartifacts (Plate

7.10). Among the finest laminated deposits, sparse vesicular voids are identifiable. Coarse sand-sized compound slaking crusts are mixed into the laminar structure (Plate 7.11). These laminar structures have undergone minor disturbance from localized soft sediment deformation and intrusive biological channel and chamber voids.

The uppermost zone (X11) in Test Unit B is described as dark reddish brown silty clay with éboulis. There are no micromorphology samples of this zone, and there is little else of note concerning the zone.

Interpretation

Despite their proximity, there are no direct lithologic correlations between the ostensibly ancient sediments in Test Unit C and the evidently more recent sequence in Test Unit B. The lithologies and microstructures examined in Test Unit B indicate an overall transition from Tennessee River alluvium to finer sediment (Unknown Silt signature - possibly an aeolian-based sediment) back to fluvial deposition containing anthropogenic materials. Zones X7, X8, X9, and X10 all appear to correlate with entrance chamber Zones Y2, U, T and K respectively. This will be further discussed in Chapter 8 in reference to the entrance chamber correlates.

There are no micromorphology samples for Zone X6, but the absence of mica in the field observation and the presence of decalcifying limestone (bedrock) suggests a non-alluvial source. Black stringers are described but their origin was not verified. Based on the field description and the basal deposits observed elsewhere in the cave, these features might be concentrated manganese coatings or redox features resulting from saturated conditions. The unconformable boundary between X6 and X7 suggests an erosional event followed by alluvial deposition.

The Tennessee River alluvium lithology and laminated microstructure of Zone X7 suggest variable energies relating to fluvial deposition and reworking of alluvium in the cave. Rounded silt- and sand-sized fragments of dusty clay identified in thin section may be direct evidence of the reworking of relic rubified alluvium (Plate 7.12). The curvilinear deformation structures, and the presence of vesicles and slaking crusts, suggest slack-water conditions and the influx of additional sediments while the substrate was still wet. Based on nearly identical lithologies, Zone X7 is correlated with Zone Y2. Zone Y1 in the entrance trench produced a date of 10,570 BP. The erosional surface on which X7 unconformably rests may be a remnant resulting from the dewatering of the uplands at the end of the Pleistocene and the flushing of the ancient alluvium preserved in the Test Unit C profile. The lithology, structures, and features in X7 suggest the zone represents a combination of processes, including reworking of ancient Tennessee River alluvium within the cave and possible influxes of new alluvium entering the cave.

The irregular, but unconformable boundary between Zone X7 and the overlying X8 suggest that X7 remained wet or plastic until X8 was deposited, deforming post-depositionally with the influx of X8. Zone X8 is decidedly different, both in lithology and structure, from X7. The primary source appears ultimately to be aeolian, most likely related to the Unknown Silt signature material. The absence of fluvial microstructures, however, further complicates our understanding of the Unknown Silt signature. To get from outside the cave entrance deep into the cave the sediment would have had to undergo extensive transport. The matrix is fairly consistent throughout the zone suggesting either extensive bioturbation resulting in the homogeneous material or a massive event. Although there is a well-developed solution dome over the unit, papules and neoformed clay aggregates, typically related to such autochthonous sources, are not present. Clay coatings are, however, relatively well developed throughout X7, both as reworked fragments embedded in the matrix and as void coatings, suggesting that the solution dome may have at least introduced phreatic water carrying suspended clay into the zone. The embedded translocated clay fragments may also relate to biological disturbance. I cautiously propose that a combination of compaction due to decalcification (suggested in the absence of any carbonates) and bioturbation removed any remaining fluvial features. It must have been a relatively wet period, if not in the region then in the immediate vicinity of the cave, based on the extensive clay coatings and the overall oxidation of the iron that most likely is responsible for the bright red color of the zone.

Based on lithology, Zone X8 appears to correlate with Zone U3 in the entrance chamber. Zone U3 is interpreted as a combination of two sources, Tennessee River alluvium and Unknown Silt. This zone is temporally assigned to ca. 10,200 to 10,500 years ago based on radiocarbon dates.

Zone X9, generally correlated with Zone T, and marks a shift back to the Tennessee River alluvium signature with possible microartifacts in the matrix (including charcoal and bone) (Plate 7.13). Some of the bone fragments, such as the one in Plate 7.13 are thinly coated with fine sediment suggesting transport of the material from the entrance chamber via a fluvial event. Zone T2 (see Chapter 8) might also suggest such an event. The initial deposition of Zone T is dated in the entrance chamber to before 10,000 B.P, perhaps as early as 10,300 B.P.

The X10 zones are rich in artifacts, ash and charcoal (concentrating in X10a and X10b). It is doubtful, however, that these deposits are the product of human activity. The boundary between X9 and X10 is erosional suggesting possible fluvial scouring processes. In addition, the Test Unit is beyond the reach of natural light. Caching or storage could have occurred in this portion of the cave, but there is no evidence for pit excavation, rock concentrations, or artifact distributions that might signify primary deposition. The micromorphological analysis of X10a revealed graded bedding and vesicular voids indicating variable-energy fluvial events with lingering saturated conditions. The thin lensing of these tertiary zones suggests that the fluvial events were more akin to sheetwash where only a thin veneer of material was transported and deposited.

The one conventional radiocarbon date from Test Unit B was collected from Zone X10 and produced an age of 6,560 +/-140. The artifacts recovered were clearly mixed and included a bone needle, a Benton Point and Big Sandy Point base (Goldman-Finn and Driskell 1994). Thus, while the elevation of the deposits would lead me to suggest a correlation with Zone P, the radiocarbon date points to Zone K. The concentrated anthropogenic sediment, fluvial transport features, temporal placement, and mixed assemblage all suggest a reworked deposit that combines materials from various periods.

The conformable boundary between Zones X10 and X11 suggests that Zone X11 is the result of a slow shift to autochthonous sources as the cave fell into disuse. The alluvial environment in the valley was stable by this time, no longer characterized by massive flood events reaching the elevation of the cave. The slopewash events that remained active at the entrance lacked the energy necessary to reach the dark zone of the cave.

Summary

Zones X1 through X5, in Test Unit C, are composed of ancient Tennessee River alluvium that entered the cave, most likely relating to regional scale aggradation and episodic flooding. Relic cryoturbation features such as ice lensing suggest their presence no later than the Late Pleistocene. During the proposed Late Pleistocene/Early Holocene flushing of the cave, these sediments were extensively eroded, but in the dark zone relics of these deposits remain protected, generally unaffected by the subsequent Holocene deposition in the cave.

Following this major erosional event (or long term erosional process), deposits began to accumulate in the dark zone but closer to the entrance. These deposits related to the reworking of the ancient alluvium and periodic flooding events bringing new Tennessee River alluvium into the cave. Sediments in the dark zone appear to have been intermittently saturated during this time. This permeation of water could have come from several sources, including the intermittent spring that moved through the rear of the cave into the entrance chamber from the back passage. This entrenched feature (channel) is evident in the karstic joint in the bedrock floor of the entrance chamber and is suggested in the steep slope of the floor in the base of Test Unit B. Other possible sources include fluvial sediments making their way into the dark zone resulting in ponded water, and an overall wet microclimate inside the cave. This microclimatic, like the activity of the phreatic spring, was most likely brought on by increased regional precipitation.

Following this wet period of sedimentation, more Tennessee River overbank deposition occurs but with the dark portion of the cave becoming increasingly dry after ca 10,000 B.P. (reflected in decreasing phreatic clay and increasing biological activity). During this time, Tennessee River alluvium signature is the material identified in the back passage as a mixture of minor amounts of the Unknown Silt. Minor fluvial events occurred again after 8,000 BP, transporting artifacts and anthropogenic sediments, such as charcoal and ash, from the entrance chamber into the rear of the cave. After roughly 6,000 BP, the dark zone contained a deep series of deposits with less than a meter of open space between the sediment surface and the joint ceiling. Deposition slowed significantly with a limited influx of sediments from autochthonous sources and cave visitors such as Traglophiles and Tragloxens. Raccoons and mice frequent the rear of the cave today.

THE GEOARCHAEOLOGY OF DUST CAVE: A LATE PALEOINDIAN THROUGH MIDDLE ARCHAIC SITE IN THE WESTERN MIDDLE TENNESSEE RIVER VALLEY

A Dissertation
Presented for the
Doctor of Philosophy Degree
The University of Tennessee, Knoxville

Sarah Catherine Sherwood
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Volume Two

CHAPTER 8

ENTRANCE CHAMBER STRATIGRAPHY:

ZONE DESCRIPTION AND INTERPRETATION

Introduction

The entrance chamber is the focus of human activity in Dust Cave. This chapter presents the complex series of lithostratigraphic zones both east and west of the Test Trench within the cave entrance. Each primary zone group is discussed with narrative descriptions followed by interpretations. This discussion centers on the portions of the entrance chamber where the most recent excavations have allowed an indepth analysis of the zones both during excavation and with the exposure of new profiles.

The most complete sequence in the cave, and the most recently exacavated, is the western portion of the entrance chamber. The west section concentrates in the area between N56 - N64 and W64 - W68 and has undergone the most detailed stratigraphic study in the cave (Figure 8.1). This area, referred to as the western chamber, is a well documented sequence that begins at bedrock and continues upward to the surface (Figure 8.2). This portion of the chamber includes several north-south and east-west profiles (some including the entire vertical sequence) allowing positive zone correlations across this portion of the cave.

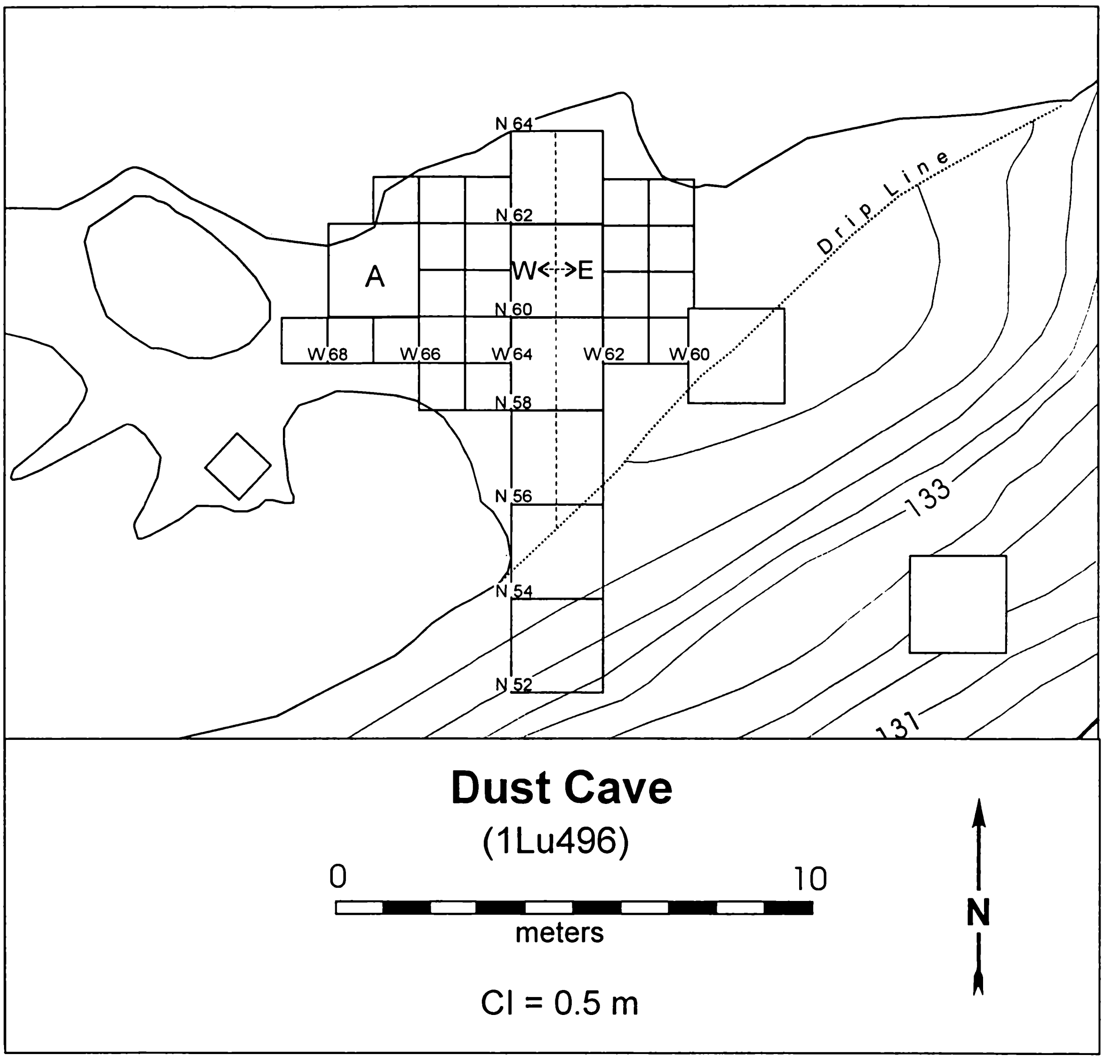


Figure 8.1. Dust Cave Plan Map Emphasizing the Provenience, and West and East Portions of the Entrance Chamber.

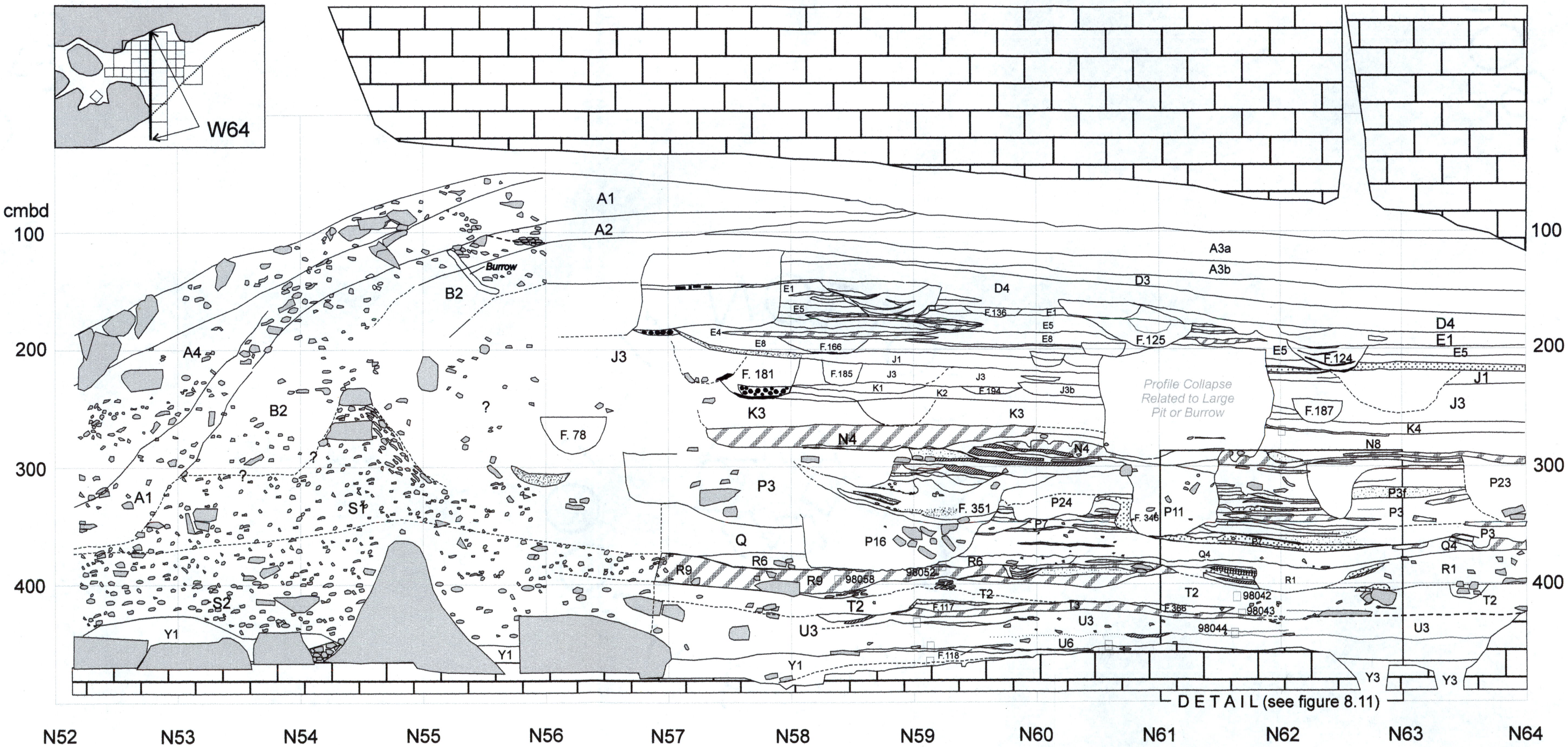


Figure 8.2. Profile W64, N52 to N64, Test Trench.

Test Unit A was one of the first test units excavated in the cave and predates the systematic stratigraphic descriptions from the later phases of the excavation. A partial collapse in this early phase of the excavation resulted in the loss of the upper walls of the test unit. As a result, several of the profiles representing the western side of the excavation are recorded in detail only from roughly Zone K downward.

The discussion of the zones in the eastern portion of the entrance chamber is more limited compared to those in the western portion. The eastern portion encompasses the eastern profile of the Test Trench along W62 (Figure 8.3), Test Unit H, and excavation units from W62 – W60 and N59 – N63 (Figure 8.1). This 8 meter square excavation was temporarily halted (as of 1999) at approximately 260 cmbd. Thus stratigraphic details (post-testing phase) with the definition of secondary and tertiary zones only exist for the zones above this point. Below 260 cmbd we are limited to observations and samples collected from the W62 profile (Figure 8.3).

Test Unit H (N60.20 W59.80), a 2 x 2 m test unit is referred to briefly here in the entrance chamber discussion, though it crosses the drip line into the talus (Figure 8.1). Like the other test units, the exploratory aspect of the unit limits our ability to correlate the stratigraphy beyond very general primary zones. Only the north and east profile walls in Test Unit H were recorded and subsequently sampled. This profile was drawn during the initial testing phase

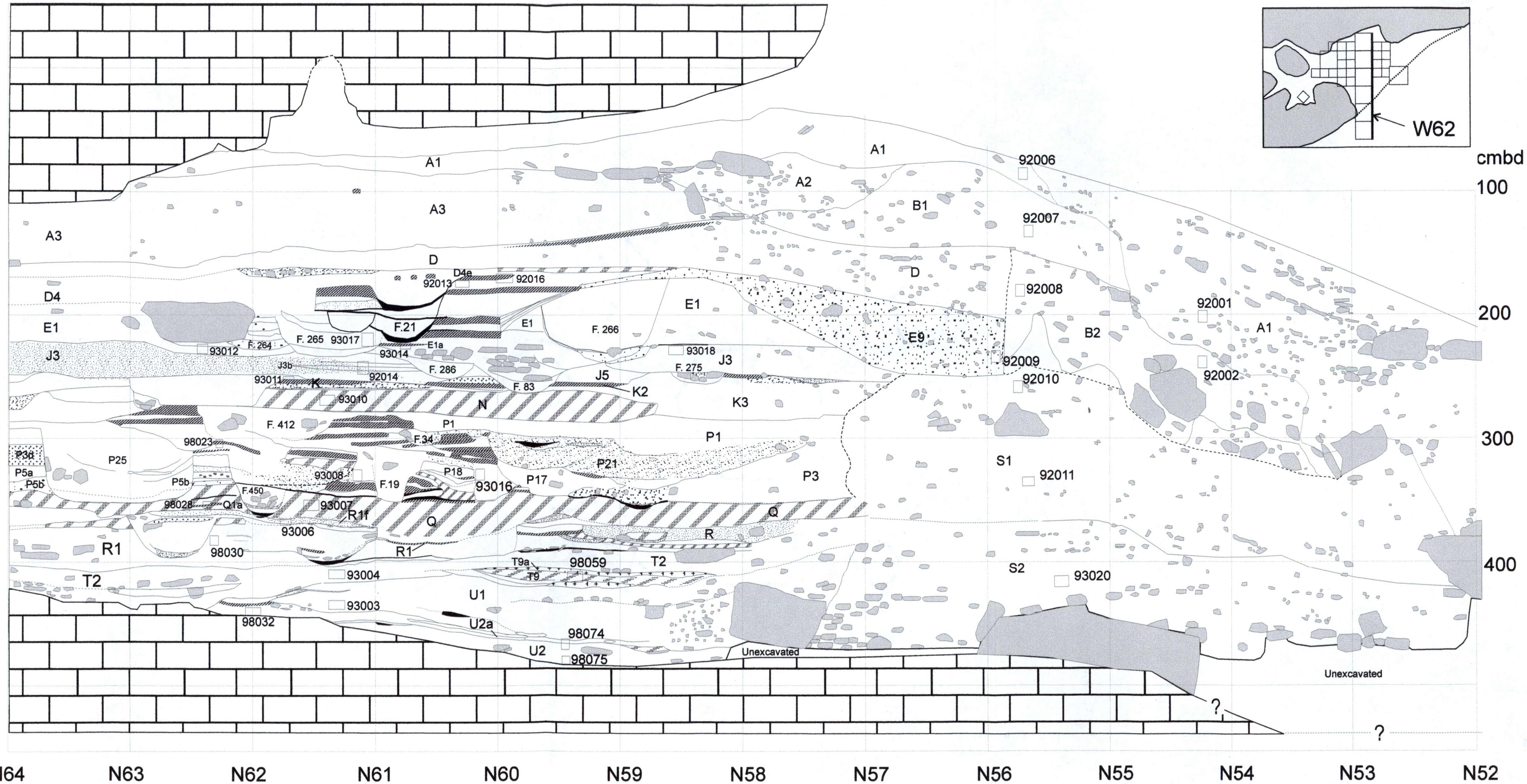


Figure 8.3. Profile W62, N52 to N64, Test Trench..

and has remained protected behind plywood shoring to ensure the safety of those excavating west of the test unit. I have not personally observed this profile and only large scale stratigraphic changes were recorded in the original drawings.

Correlating zones across the Test Trench, especially at the scale of secondary or tertiary zones, was problematic. Due to the exploratory nature of the testing phase and the progression of the excavation, profiles connecting the 2 m between the east and west walls of the Test Trench do not exist except for the north wall along N64 at the back of the entrance chamber. The resolution of this profile is limited. We have been unable to re-examine the profile, because after its original recording during the testing phase it was disturbed by vandals, rendering it unstable and the upper portion destroyed. Due to the risk of disturbing it further, it has remained under plywood shoring. In the event that there are specific correlation questions across the Test Trench it is possible to glean information from the level forms corresponding to the 2 m units composing the Test Trench. But due to changing excavation strategies, the absence of systematic stratigraphic descriptions at the time, and the varying qualifications of those doing the recording, the information is not always reliable for correlation. As a result, those zones deeper than 260 cmbd (below Zone J) are typically described and correlated only at the level of primary zone with some success for distinct secondary and tertiary zones.

The descriptions in this chapter are organized by primary zones and are summarized in narrative form from the data presented in detail in Appendices A, C, and D). Thin-sections, several of which are referenced in the text of the chapter, are described in systematic detail in Appendix D. The profiles offered in figures throughout Chapter 8 represent vertical sections recorded in the field with zone labels and sample locations and designations. As the stratigraphy in Dust Cave is exceedingly complex (in the interest of clear, legible presentations) only the zones discussed in the text are labeled.

Chronostratigraphic relationships among the primary zones are presented in the interpretations and are based on superposition, cross-cutting relationships, and associations defined in the field and organized by radiocarbon ages. Table 1.1 lists the radiocarbon ages for Dust Cave by zone. This radiocarbon distribution is organized by component and depth illustrating two significant gaps within the sequence (Figure 8.4). These gaps and other irregularities is this othewise linear distribution are addressed in the context of the depositional history of the entrance chamber.

The descriptions begin with the lower-most zones in the entrance chamber and work upward by primary zone group to the surface. Each description includes two sections, distribution, and lithology and structure. The distribution section outlines briefly the arrangement of the zone group and the subzones in the spatial confines of the cave. The lithology and structure

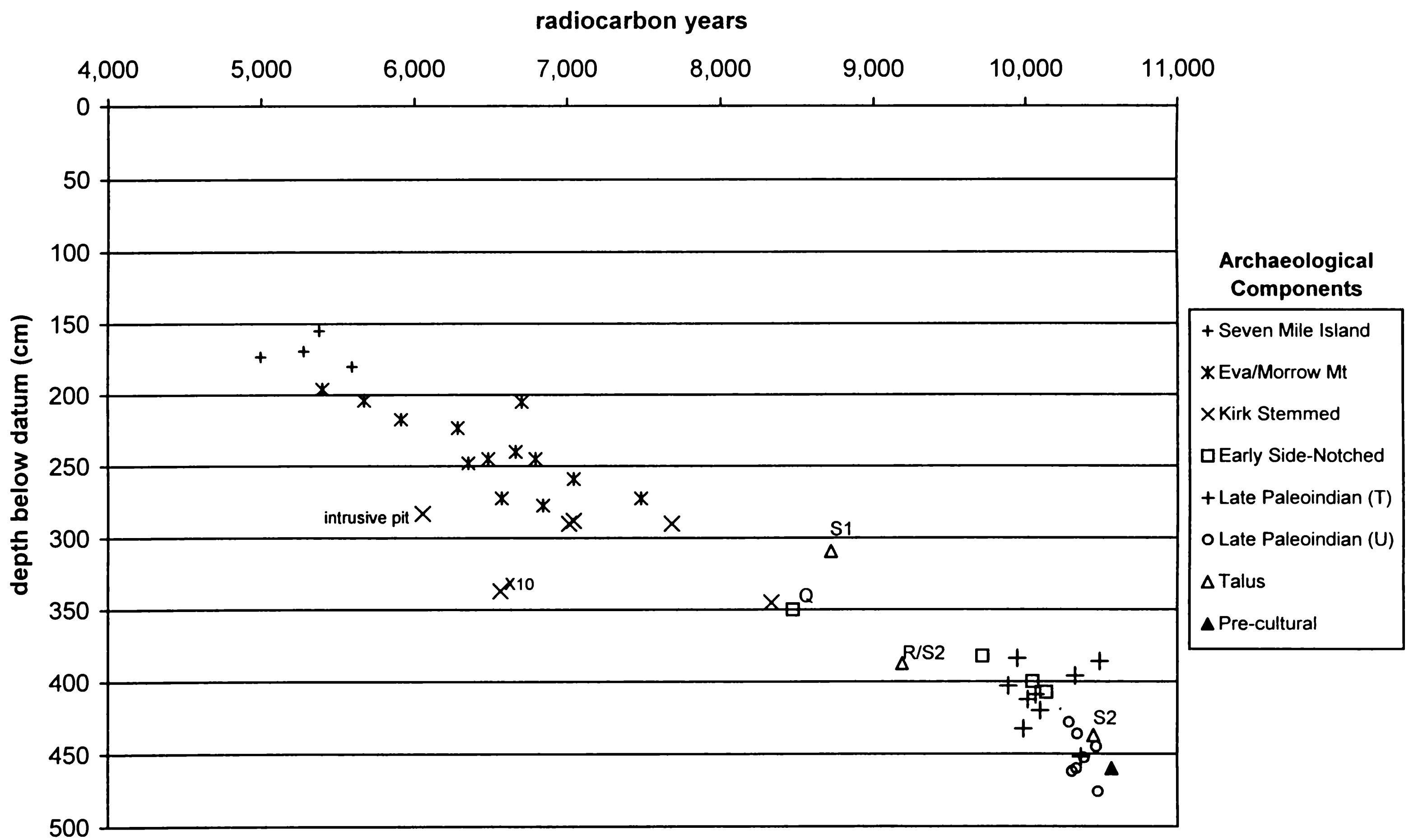


Figure 8.4. Dust Cave Uncalibrated 14C Dates by Component and Depth. Specific Povenience Noted for Talus Samples and Others Noted in the Text.

sections describe both microstratigraphic and macrostratigraphic observations. Each description is followed by a narrative interpretation. The zone interpretations are based on field and microstratigraphic observation in conjunction with radiocarbon results. Chapter 10 presents a synopsis of the zone interpretations from Chapters 7, 8, and 9, and a discussion of the depositional history inferred from the cave's stratigraphic contents and their structure.

Zone Y

Description

Distribution

The basal deposits in the entrance chamber, associated with the joint controlled drainage system in the bedrock floor, are designated as Zone Y (Figure 8.5). Y1 represents those portions excavated in the Test Trench during the testing phase along the western wall near the drip line (Figure 8.2). Y2 and Y3 were identified during the 1998 season, not in direct association with Y1, so they were given different designations although their similar placement in the floor crevasse features probably identified them as the same or similar zones (Figure 8.6, 8.7, 8.8). Following the 1999 field season the test trench and western area were connected, and additional areas of the bedrock were exposed, clarifying the correlation of Y1, with Y2 and Y3. Y1, at the entrance of the cave, was identified in association, not with the crevasse drainages in the floor but

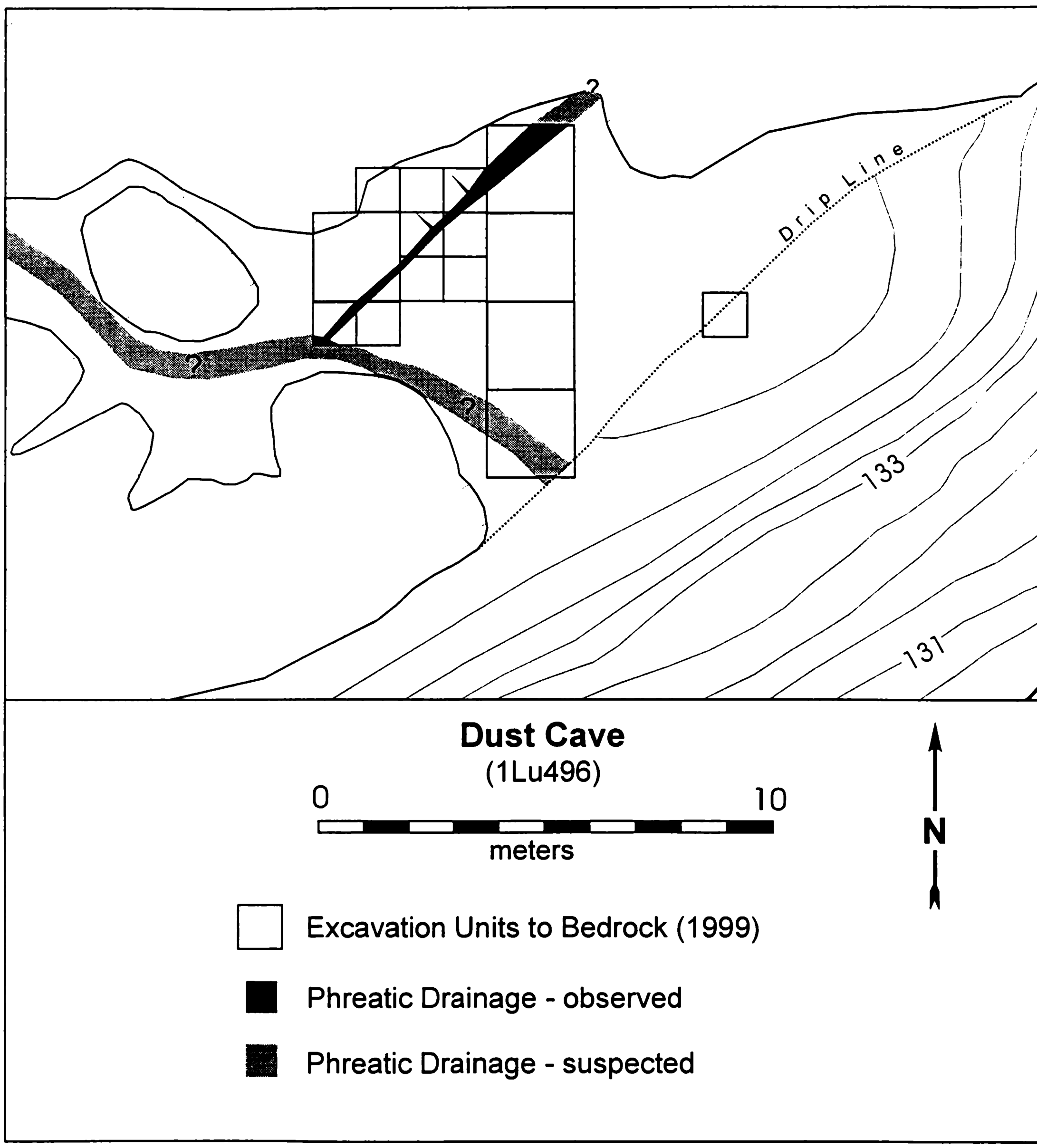


Figure 8.5. Dust Cave Plan Map Emphasizing Excavation Units Exposing Bedrock and Floor Joints Observed and Suspected.

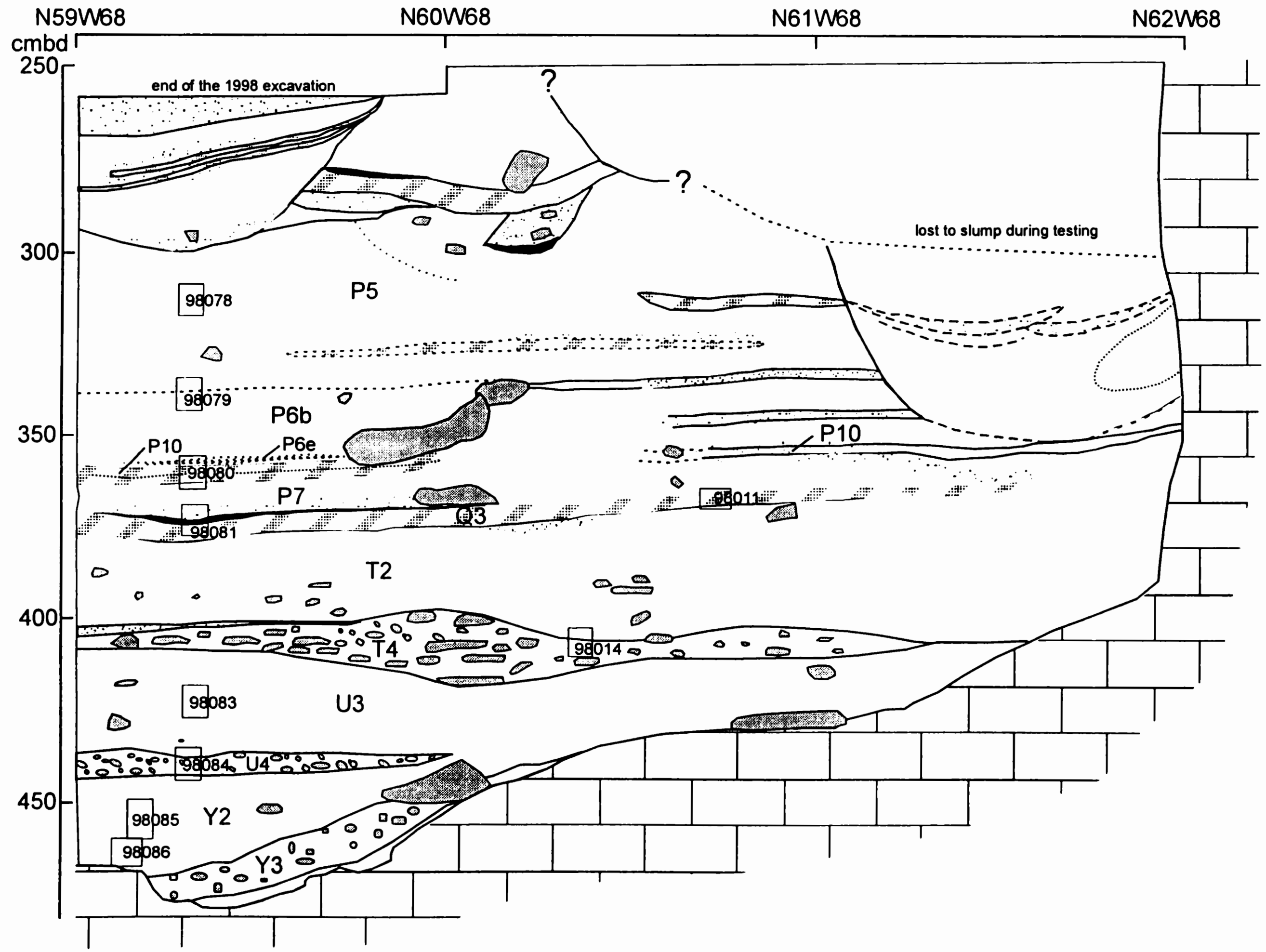


Figure 8.6. Profile W68, N59 to N62, 250 cmbd to Bedrock.

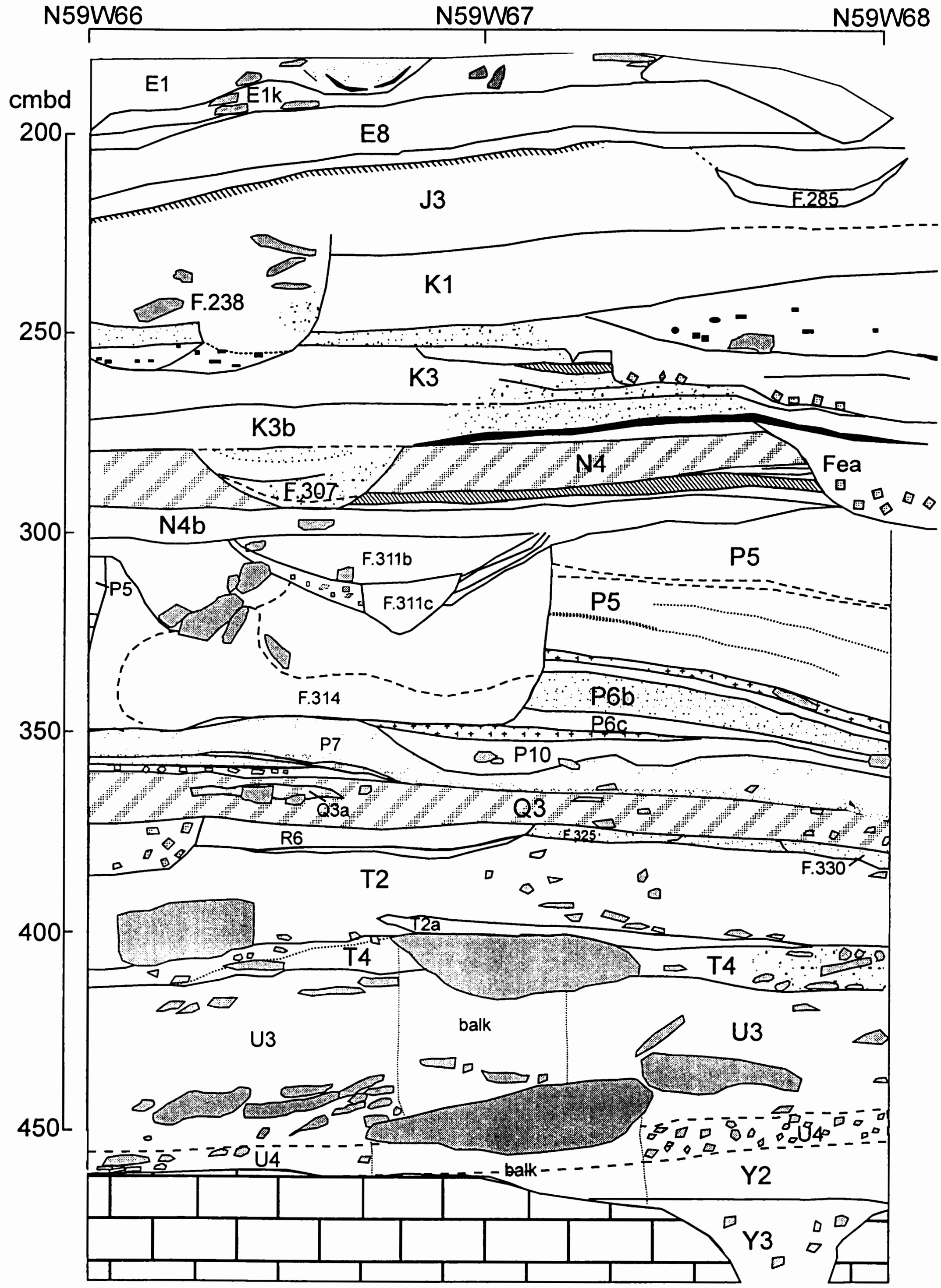


Figure 8.7. Profile N59, W66 to W68, 180 cmbd to Bedrock.

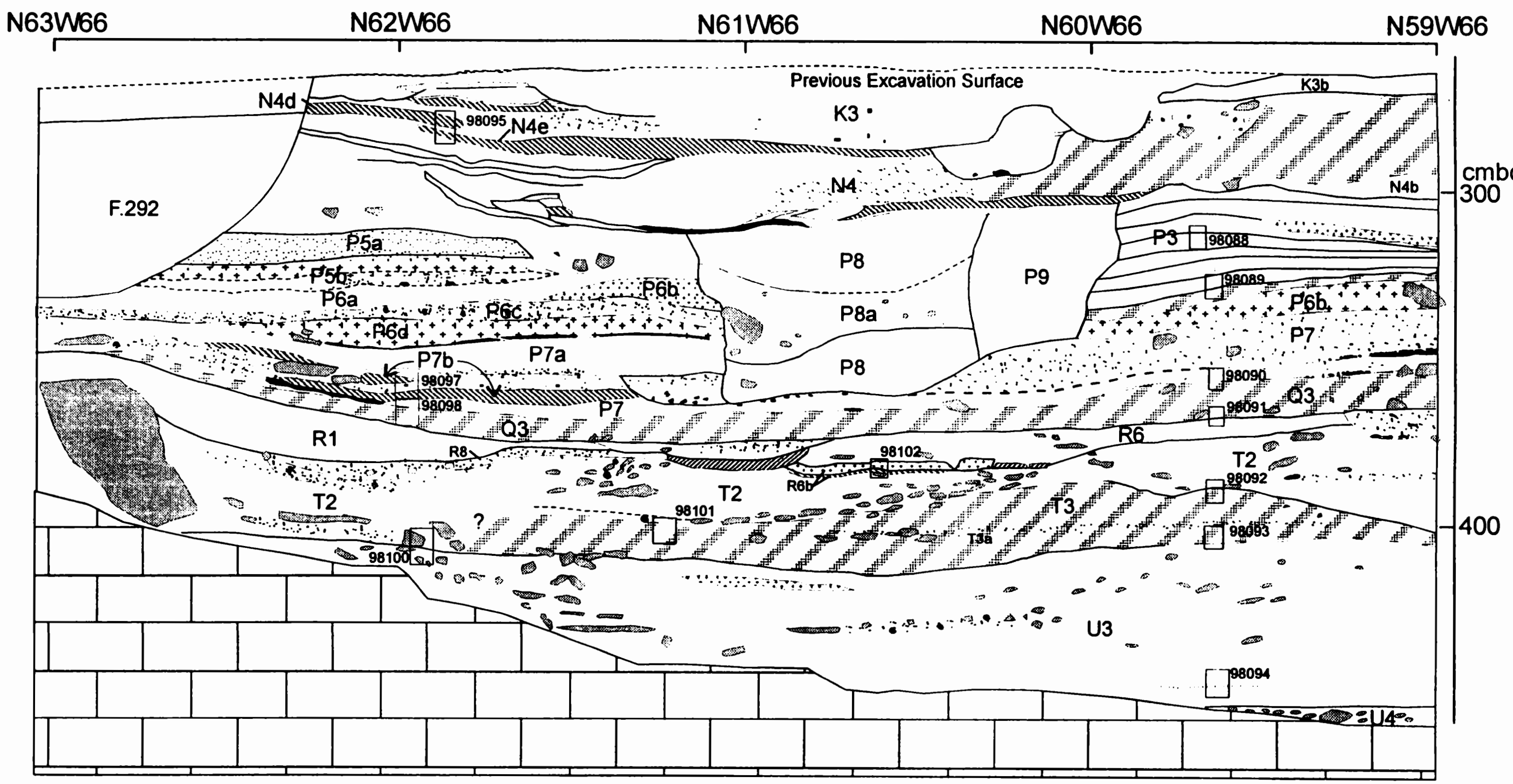


Figure 8.8. Profile W66, N59 to N63, 280 cmbd to Bedrock.

with areas between large limestone roof blocks lying on or near bedrock at an elevation of ca. 450 cmbd. Zone Y2 overlies Y3 at an elevation of 450 to 470 cmbd, depending on the slope of the floor.

Lithology and Structure

Zone Y3 represents deposits lying directly on the floor and lining the southwest-northeast trending joints in the cave floor below an elevation of ca. 450 cmbd. Y3 is described as red sandy clay with >40% gravel- to cobble-sized rounded éboulis. There were numerous fossilized or partially fossilized bones and teeth recovered in zones Y2 and Y3. Zone Y1 and Y2 are both described as a yellowish red silty clay with varying amounts (<10%) of sand with gravel- to cobble-sized subrounded éboulis. A few sand- to small gravel-sized charcoal fragments were recovered, but no cultural artifacts were identified.

One thin-section was examined representing Y1 and two from Y2 (Figures 8.3, 8.6). An intact sample of Y3 could not be extracted from the rocky, wet and loose matrix without rendering the profile unstable. Macroscopically the matrix of Y1 appeared to be very similar to Y2 but with an increase in coarse material in the form of sand and gravel, chert and highly weathered limestone. In addition, Y3 is redder and mottled with chroma 2 (grey) mottles.

Microscopic examination of Y2 reveals a changing grain-size from the bottom to the top, coarse to fine (sample 98085 specifically, see Appendix D). The lower quarter of the thin-section consists of a complex matrix including banded silt and sand composed primarily of quartz, mica, and chert (Plate 8.1). Representing less than 2% of the coarse fraction are weathered feldspar, pyroxene, and partially fossilized bone. The sand is poorly sorted and the clast shapes vary. A void structure of channels, chambers and vughs changes at the boundary to the upper three quarters, where there are planar and spongy voids and a platy structure. Rip-up clasts mark the boundary between the upper fine matrix and the sandier matrix at the base of the thin-section (Plate 8.2). These rip up clasts are composed of banded clayey silts with micro-lenses of clay and bands of manganese dioxide.

The upper three quarters of the Y2 thin-section consist of a bimodal distribution of noncalcareous well-sorted fine silty clay with approximately 2% sand and a platy to spongy structure (Plate 8.3). The sand is composed of mixed quartz, chert and mica. Also visible in thin-section are partially fossilized sand- to gravel-sized bone fragments. The sediment is dense for the site, with void space limited to 5 to 10% of the matrix. Partially infilled channels and chambers make up less than 5% of the area. Many of the infillings contain mixed sand, some in the form of aggregates. Thin birefringent and dusty clay intercalations line >50% of the voids (Plate 8.4). Other clay fragments are incorporated into the finer matrix. There is a complete deficiency of any carbonate as clasts or precipitated coatings.

Y1 is also composed of a mixture of grain sizes with well-sorted silt and relatively well-sorted sand. The silt is predominantly of angular quartz and mica. The sand fraction combines quartz, feldspar, chert, ceiling rain, papules (with banding evident), and mica. The microfabric is partially aggregated and partially massive. The massive areas consist of the well-sorted silt primarily composed of the Unknown Silt signature but with approximately 5% sand of papules, chert and ceiling rain and/or limestone (Plate 8.5). The carbonate clasts show evidence of decalcification (pellicular alteration), and the majority exhibit clay residuum associated with the weathering process. There are micro-clusters of sand-sized aggregates and clasts, predominantly carbonate, (not clear if these are ceiling rain or limestone), that also show signs of decalcification (Plate 8.6).

<u>Interpretation</u>

Zones Y1, Y2 and Y3 are all related to sporadic fluvial activity in the cave prior to human habitation. The sediment is probably a combination of reworked material from the Terminal Pleistocene flushing and sediments introduced immediately following the period of major wash out. The flushing ensued after the Late Pleistocene infilling by the aggradation of this section of the Middle Tennessee River Valley. These processes resulted in a mixing of extinct Pleistocene fauna and Early Holocene fauna in sediments that produced a conventional radiocarbon date just prior to 10,500 B.P. The bone sample is still relatively small from these deep zones, but Parmalee's (1999) identifications thus far include Giant Beaver (*Catoroides*), Dire Wolf (*Canis dirus*) as well as other fauna including White-tailed deer, raccoon, turtle, various birds and reptiles. At least partially fossilized bone fragments are also evident in thin-section. Zone Y2 is tentatively correlated with Zone X7 in the dark zone passage to the west (Test Unit B). The similarity in lithology and microstructure between these two suggests that reworking of fluvial deposits continued beyond the entrance chamber into the dark zone.

The well-sorted medium to fine silt in Y2 and Y1 is assigned to the Unknown Silt signature (see Chapter 6). The changing grain size and the fining upward sequence in Y2 suggest changing fluvial energy and slack water conditions. The structure and accompanying features (rip-up clasts) also imply periodic drying of saturated sediments.

Only the northwestern-most extent of Zone Y has been exposed, showing the majority of the localized deposits of Zones Y2 and Y3 lining what is interpreted as a paleo-channel within a narrow northwest southeast trending joint that is part of a terminated karstic aquifer (Figure 8.5). From this channel, Zone Y follows the cave floor sloping upward to the north. The aquifer is still active at some level today based on the wet condition of the sediment and the presence of chroma 2 mottles, which suggest near constant saturation. The deposits are probably eroded due to repeated fluvial events and then compaction following burial. Additional Y3 deposits have been identified along another narrow joint in the floor located perpendicular to the channel just described (evident at the base of profile N63 and in the rear of the Test Trench (Figure 8.5, 8.9). These joints are characteristic of the bedrock joint system reflected in the overall formation of Dust Cave and other caves in the area. This joint appears to be the lower counterpart of a large northeast-southwest trending joint clearly expressed in the ceiling.

Zone Y3 represents the remnants of the Late Pleistocene flushing of the cave as the karstic aquifer was reduced to a trickle with the lowering of the water table. The source of the Pleistocene faunal remains could be associated with the sinks on the Plateau above the cave. Catastrophic flushing of sinkhole contents into cave systems below is well documented in the recovery of similar fauna in the regions cave systems (see, for example, Parmalee 1992; Womochel and Barnett 1980). The fauna also could have wandered into the cave and died or been washed into the system with alluvial sediment sometime during the Late Pleistocene. Based on the good condition of the bone and the lack of other exogenous, possibly alluvially transported gravels in Y3, it is doubtful that this material washed in as part of the Late Pleistocene infilling of the cave. There is not yet a large enough assemblage of this early faunal material to further address the taphonomic issue.

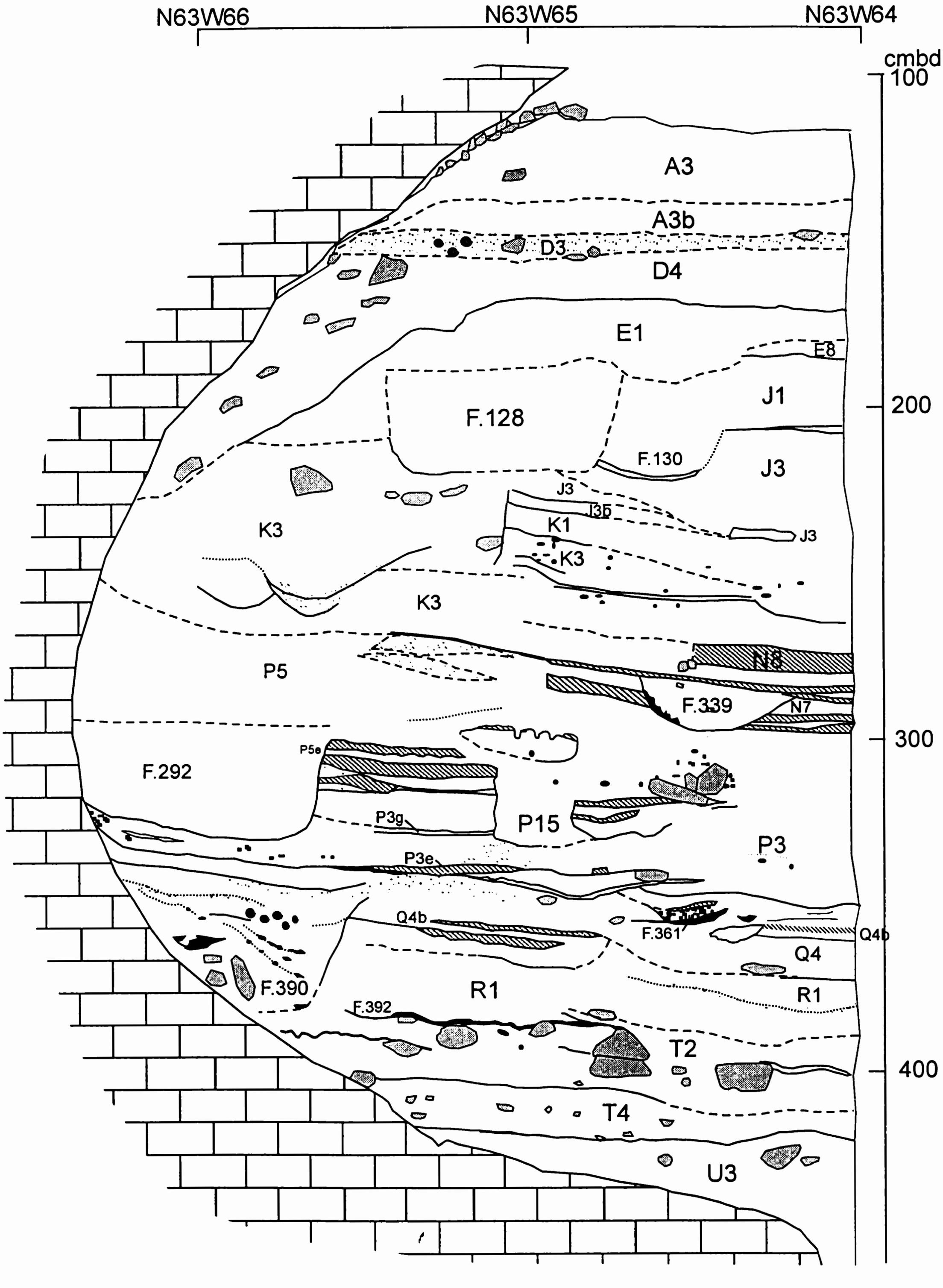


Figure 8.9. Profile N63, W67 to W64.

Following the initial flushing of the cave, water flowed into the cave with some pooling and intermittent wetting and drying. The presence of the well-sorted silt material and the microstructures (banding and rip up clasts) indicate that there was allochthonous alluvium entering the cave. Localized granular segregations and micro-banding of manganese dioxide suggest periodic waterlogging. Following the waterlogged conditions, repeated wetting and drying resulted in limited clay translocation. Clay coatings on planar, channel and chamber voids indicate the sediment was periodically dry enough to encourage limited biological activity. Biological activity continued as the surface stabilized. The majority of the activity - based on the mixing at the Y3/U4 boundary (discussion below) and the coarse material transported into the finer Y3 - occurred after the deposition of U4 and the burial of Y3. Zone Y1 no longer possesses the fine-grained platy structure found in Y2, although, the remnants of this structure are still evident. The bioturbation that is present in the upper reaches of Y2 is more extensive in Y1 and appears to have reworked most of these early fluvial structures.

Lithology and structure in Zone Y1 suggest stable periods during wet conditions in the cave's interior, as evidenced in the micro-concentrations of ceiling rain and rounded, partially decalcified limestone. Similar accumulations of ceiling rain have been identified on other cave surfaces, suggesting stability during a wet time in the cave's history (Sherwood and

Goldberg in press). Compared to later sediments in the cave, Zone Y exhibits relatively high frequencies of intercalations, clay coatings, decalcification features, and manganese dioxide banding throughout, all implying an often wet microenvironment in the cave that probably relates to its formation during the Pleistocene/Holocene transition and subsequent saturation following impoundment.

Zone U

Description

Distribution

Zone U is the micaceous silty clay to clayey sand deposits that blanket the floor of the cave and overlie Zone Y. These deposits are generally tabular and vary from 20 to 50 cm thick depending on the bedrock topography. West of W64, bedrock slopes down from the curved wall toward the northeast-southwest trending floor joint. In this portion of the entrance chamber, W64 to W68 between N58 – N60, Zone U is thickest as it maintains a general upper elevation of approximately 420 cmbd (Figures 8.2, 8.7, 8.8). Toward the back of the entrance chamber along the northern most part of the excavation, Zone U follows the floor upward and thins until it is no longer clearly represented north of N62-63. Note in Figure 8.3 that Zones U1 and U2 do not continue north of N62. The bedrock floor of the cave slopes upward in the rear of the cave but the upward slope of Zone U appears to be truncated by Zone T2, suggesting some sort of disconformity. At the drip line, Zone U grades laterally to the south into a homogeneous massive zone designated S2.

The secondary designations (subzones) represent slight changes in color and texture (varying amounts of sand and limestone gravel) and are typically distinguished by stringers of concentrated charcoal, a slight increase in clay, and concentrated microartifacts. These stringers typically were too small to excavate definitively and are described in profile or targeted in microstratigraphic observation. Some of these concentrations are more substantial and associated directly with macroartifacts, so were therefore excavated as "features" (e.g., Fea. 118 resting on Y1 in Figure 8.2). These features are typically stringers of concentrated rock and charcoal lacking any clear pit boundaries. One such deposit in the east profile of the Test Trench, W62, was more substantial and defined as U2a (Figure 8.3).

Lithology and Structure

Thirteen thin-sections were examined representing the variation in Zone U. The secondary zones share the same basic matrix components and microstructure but vary in the type and frequency of gravel-sized clasts, sand content, and the degree of decalcification. There are also visible differences from west to east when comparing the western Zone U to the east wall of the Test Trench. These differences include a slight variation in structure and lithology and more apparent structural differences.

Zone U4 is a relatively thin (ca. 10 cm) tabular deposit that is distinguished based on limestone gravel (including Pleistocene fauna fossil fragments) in a micaceous loam matrix (Figures 8.6, 8.7, 8.8). U4 rests on Y2 with a distinct boundary. Micromorphological observation reveals mixing along this boundary, but there is a clear distinction between the two lithologies and their structures (Plate 8.7). U4 pinches out from W68 to the east around W66 where the bedrock steps up (Figures 8.7, 8.8).

Zone U3, deepest on the eastern side of the chamber, directly overlies U4. In the field, we distinguish the eastern manifestation of U3 (on the east wall of the Test Trench) with designations U1 and U2 (Figure 8.3). With U1 representing the lower reaches of Zone U3 overlying bedrock, and U2 the upper half of Zone U3 overlying U2. For simplicity sake I will discuss all three zones as Zone U3, since it is one primary unit with lateral variation produced in the post-depositional environment and vertical variability primarily introduced by human activity.

Zone U3 has a complex structure and mixed lithology that appears to be derived from two distinct sources. The first is a bimodal distribution of poorly-sorted sand and well-sorted silt, characteristic of the Tennessee River alluvium signature (see Chapter 6). This material includes quartz, mica, feldspars and pyroxene. The clay matrix in this portion of the zone is composed of varying forms of clay, including residual clay weathered from decalcifying limestone and papules of phreatic dusty and birefringent clay (Plate 8.8). There are also localized clusters of sand (>50%). I observed similar micro-clusters of sand in Tennessee River alluvium on the present day floodplain (see Meeks et al. 1997a, 1997b).

The second source in Zone U3 is a dense, well-sorted medium (subangular) silt composed chiefly of quartz and mica. This material is attributed to the Unknown Silt signature (see Chapter 6), well represented in Zone Y. The structure of U3 varies from extensive packing and channel voids to a more dense structure, marked by fewer voids, mostly vughs, vesicular and planar forms. When the well-sorted silt is not completely incorporated into the more coarse Tennessee River alluvium it appears as large aggregates (Plate 8.9) or masses typically containing rip-up clasts (Plate 8.10). These features are often composed of graded bedding (fine silt and clay), with rip-up clasts occasionally containing vesicular voids (singular and interconnected). Similar features are observed in the dark zone in Test Unit B suggesting a correlation of Zone U in general with Zone X8.

Moving west to east, U3 becomes less heterogeneous, with the two lithologies and sedimentological structures becoming more distinctive. The incipient surfaces or stringers are also easier to distinguish and appear more frequently to the east. The stringers are characterized microstratigraphically by a slight decrease in the void frequency and size with concentrated charcoal, clay, and microartifacts (typically burned) (Plate 8.11). Ash, mostly disarticulated, can also be present but tends to be preserved only in the more calcareous microenvironments to the east.

There are several post-depositional features of note in Zone U3. The most clearly represented is a fabric of rounded aggregates of various sizes, still conspicuous both in the fabric and as concentrations (Plates 8.11, 8.12). Other less well-represented post-depositional features include weak clay coatings associated with the coarsest sand and coating voids, concentrating in the western thin-sections (Plate 8.13). To the west there is also etched limestone gravel (pellicular alteration) and a total absence of smaller carbonate clasts suggesting the removal of carbonates. To the east the precipitation of secondary calcite is well represented in micritic coatings and hypocoatings (Plate 8.14), with several coatings suggestive of rhizomorphic features (Plates 8.14, 8.15). In addition, calcareous materials such as ash are preserved (although these appear to have undergone some diagenesis) (Plate 8.16).

Interpretation

The lithology and structure of Zone U suggests three distinct source materials, Tennessee River alluvium, Unknown Silt, and anthropogenic sediments, with lateral change due primarily to variability in the depositional environment and post-depositional alteration. During the formation of these deposits the cave microenvironment was periodically or seasonally wet, especially in the vicinity of the drainage represented by Zone Y. The temporal proximity of ca. 200 radiocarbon years of charcoal samples for Zone Y and Zone U (Table 1.1, Figure 8.4) suggest the relatively rapid formation of these deposits, between ca. 10,500 and 10,300 B.P.

Zone U4 represents the transition from Zone Y with a resurgence of the drainage channel (then sediment filled), possibly eroding some of the surface of Y2. It is probable, based on the presence in the gravel of Pleistocene fossil fragments, that this material was reworked, derived from the ancient alluvial deposits in the back of the cave (see Chapter 7). The resurgence resulted in lag deposits of material overlying Y2. This surface became relatively dry and stable with mixing occurring along the boundary between the two zones. The nature of the fabric at the contact is tentatively related to cold-climate cryoturbation features.

The presence of Tennessee River alluvium in U3 suggests periodic flooding that probably entered the cave with a low velocity resulting in no discernable unconformities. The well-sorted silts that contain the rip-up clasts indicate periods of slackwater conditions associated with Unknown Silt material, probably affected by periodic activity (seasonal?) from the phreatic karstic aquifer and/or ceiling drip in the cave. Based on the fine-graded bedding and the presence of well-sorted papules, it appears that some of the Unknown Silt may be reworked by this phreatic activity with other material added from within the cave system. In addition, the silt and clay rip-up features are not cemented so they would be very fragile, suggesting they were not necessarily transported but reworked in place. This depositional sequence continues into the back passage based on the correlation with Zone X8. This further suggests that some of this material is derived from autochthonous phreatic activity.

Thus, a large flooding event appears unlikely since such energy would have created a major unconformity or result in the accumulation of more substantial Tennessee River alluvium. The incipient surfaces clearly visible in Zone U would also have been destroyed by such high-energy transport in the confines of the cave. Instead, the cave probably was subjected to periodic overbank deposition associated with Cypress Creek and the Tennessee River. In addition, the growing talus (see Figure 8.2), and vegetation at the cave entrance slowed fluvial transport into the cave, probably often deterring it altogether.

Human occupation - based on the subsistence data for the Late Paleoindian Period represented in Zones U and T (Detwiler 2000; Walker 1998; Walker et al. 1999) - occurred primarily in the fall, likely both the driest season in the cave and the time when the subsistence resources (e.g., woodland mammals, migrating waterfowl, and mast crops) were at their peak. As people generated sediments through brief seasonal occupations, incipient surfaces formed that incorporated anthropogenic material. During this time the cave was probably both dry enough for human occupation but may have also been subjected to extreme seasonal cold evidenced in the potential cryoturbation microfabric .

The perpendicular floor joints guided seasonal subsurface and surface water movement from the west and from the rear of the cave contributing to the eastern side of the chamber being slightly drier (Figure 8.5). This variation in the depositional environment explains the slight increase in translocated clay observed in the western portion of the cave as well as the decalcification. The eastern portion was closer to the center of the chamber and the entrance, a more desirable place in terms of light and a dry substrate. The western area, however, would typically be a wet and damp microenvironment near the cave wall, associated with the phreatic drainage. The distribution of secondary calcite is greater in the eastern samples and there is ash preserved here as well. The micritic coatings and hypocoatings may have been introduced in the system by drip, although likely root activity acted as a pathway for the influx of the secondary calcite. This interpretation is based on the localized "patches" of embedded matrix associated with rounded, uniform channels, often containing remnants of rhizoliths. The relationship of the sediments and the carbonate hydrological regime on either side of the drip line is complex. Still, these basic observations would suggest that during this time period the sediments in the eastern, or front part of the cave, probably periodically supported plant growth. As a result, the influx of carbonate associated with root activity (see Chapter 6) took place in a microenvironment that favored ash preservation.

Incipient surfaces were buried, thus insulating them from subsequent trampling and localized fluvial actions including activity from the back drainage and slope wash. Extreme cold (possibly seasonal) ensued, mixing these sediments within a restricted area away from the cave entrance. Cryoturbation may have removed traces of other anthropogenic surfaces so that the ones we observe today represent only the most intensive human activity. Another factor preserving anthropogenically derived lenses may be the precipitation of secondary calcite.

An interesting feature of an anthropogenic lens in Zone U3 is the nature of the micritic coatings and hypocoatings. Red-brown and dark-brown aggregates (see Chapter 5 for definitions), untouched by secondary calcite are surrounded by matrix embedded in micrite (Plate 8.17). I suggest that these aggregates are burned. The burning process reduces their porosity and drives off the water in their matrix, making it chemically difficult for the calcite to precipitate. Goldberg (personal communication) has observed soil aggregates in hearth deposits that he attributes to soil adhering to the plant roots burned in a hearth. A similar circumstance may exist in the anthropogenic lenses in Zone U3 (and numerous other anthropogenic deposits in the cave). Subsequent decalcification and biological mixing may have removed other clear signatures of a hearth.

These zones temporally correlate with the Younger Dryas chronozone (ca. 11,000 to 10,000 years ago), a cold and dry interval once thought only to have occurred in Europe and the northern most part of Canada is now well documented in the Midwest (Anderson 1997; Mayewski and Bender 1995; Wright 1987). Though this interval was not a major climatic setback to the south it may have initiated extreme winters. The implications of the post-depositional features reflecting extreme cold and the absence of supporting data among regional faunal studies will be discussed in Chapter 10.

Zone T

Description

Distribution

Zone T is the first zone to extend across the entrance chamber. My description and discussion will focus on the secondary zones T4, T3, and T2, west of W64 where Zone T is most clearly defined and correlated. The eastern and front portion of Zone T have not yet been explored beyond the initial Test Trench and are described only from samples from the W62 profile. Other than T9 and T9a, which are associated with similar anthropogenic deposition along the W64 profile overlying Zone T3, the identification of secondary T zones in the eastern wall are estimates. The deepest manifestation of Zone T in the cave system is identified in the back passage way in Test Unit B. Zone X9 is correlated with Zone T based on signature lithology. Between W68 and Test Unit B, approximately 8 m apart, Zone T inclines roughly 30 cm up to the northwest. The zone follows the upward slope of the ancient sediments that descend from the rear of the cave towards the entrance chamber (most likely due to an erosional disconformity).

Zone T4 is a variable 10 cm thick lens at ca. 400 cmbd, the clearest zone at the western extent of the entrance chamber (Figure 8.6). This zone directly overlies Zone U3 and is thickest along the W68 profile, thinning as it trends east, disappearing at W66 or grading into Zone T3 (Figure 8.7). The exact nature of this boundary is unclear.

Beyond the concentration of Zone T4, Zone T3 overlies U3 with its thickest portion (ca. 20 cm) originating in the vicinity of Test Unit A, visible along the W66 profile (Figure 8.8). The contact with U3 is clear and horizontal. This zone has a clear to sharp undulating upper boundary disappearing and reappearing in areas between W66 and W64 (Figure 8.10). Zone T3 has not been correlated across the Test Trench to the W62 profile.

T2 is the largest and most extensive zone within the T series. At the drip line, T2 correlates with the upper portion of S2. T2 is an expansive tabular zone that averages 20 to 30 cm thick, between 380 to 420 cmbd. The irregular boundary between T2 and T3 is interpreted as a disconformity. Numerous pit

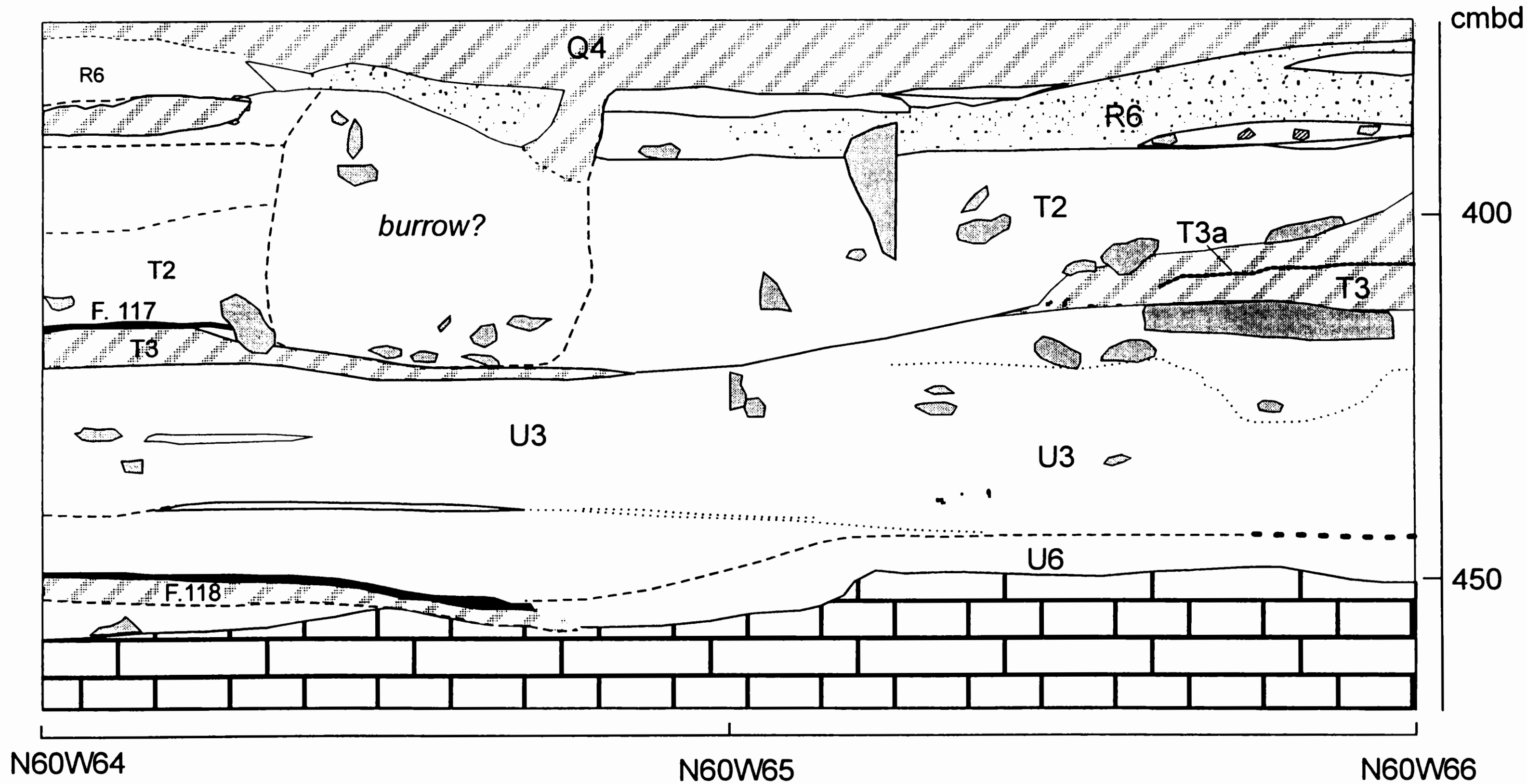


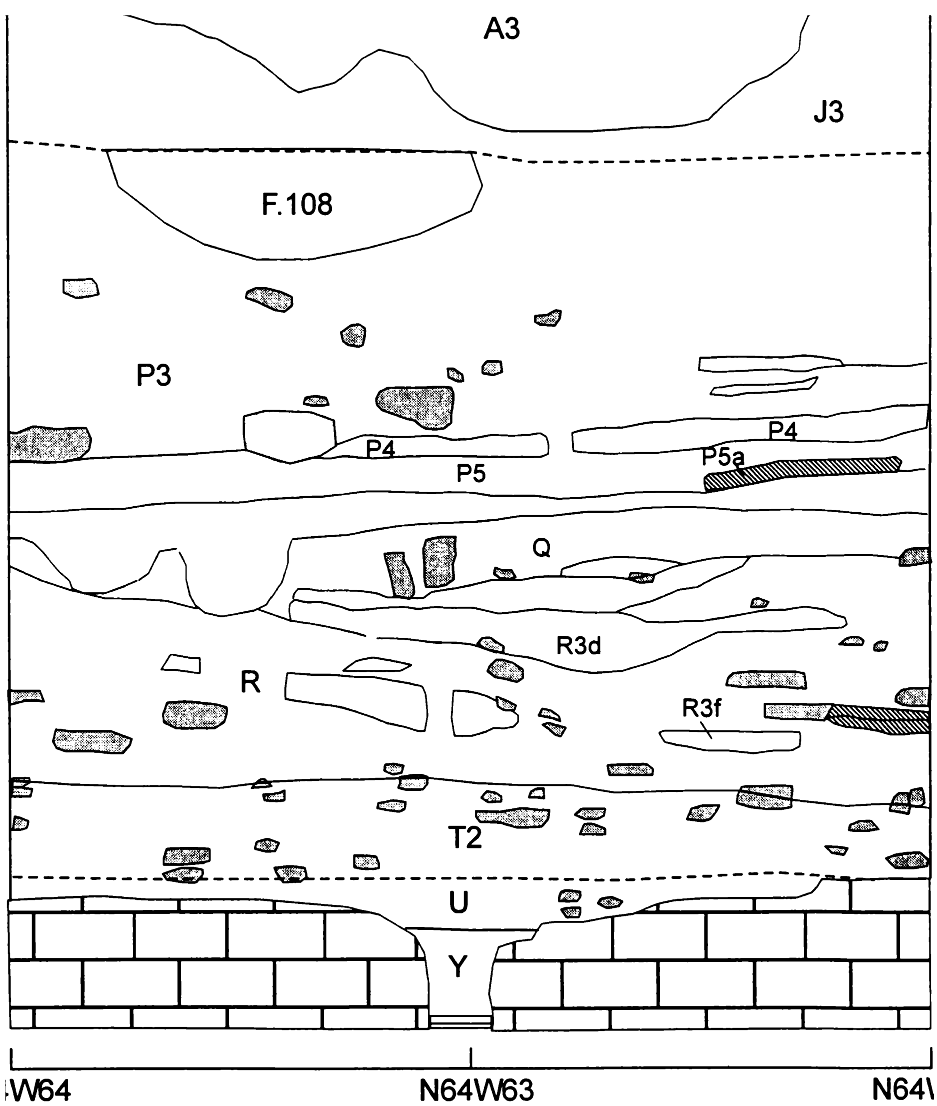
Figure 8.10. Profile N60, W64 to W66, 370 cmbd to Bedrock, Connecting Test Unit A and the Test Trench.

deposits and activity surfaces related to Zone R are visible, intruding into the top of T2. West of W66, T2 overlies T4 in the absence of T3 (Figure 8.7). In the northern portion of the entrance chamber as the bedrock floor steps up to meet the wall, T2 continues past the limits of U3 to the north wall of the current excavation in the absence of T4 (Figures 8.2, 8.9). Observations across the northern profile (N64) connecting the northernmost extent of the Test Trench are limited and speculative. Nevertheless, T2 is probably present (as is T4) in the northern most portion of profile W64 (Figure 8.3), but since it cannot be confirmed at this point this area is labeled as merely T on the W62 profile (Figures 8.2, 8.11).

Lithology and Structure

The secondary zones in Zone T appear to distinguish relatively major shifts in the depositional environment. These discrepancies are represented among the secondary zones and are clearly represented in the overall configuration of the units, their varying lithologies and microscale remnants of sedimentological structures.

Zone T4 is a transitional zone, consisting of a dark brown to reddish silty clay with concentrated tabular-shaped weathered limestone gravel- to cobble-sized clasts. The high density of gravel clasts made it difficult to collect an intact micromorphology sample, and consequently the thin-section examined intruded into the T4 matrix from above. The matrix is composed of non-



gure 8.11. Profile N64, W62 to W64, North Profile Connecting the orthernmost Extent of the Test Trench (Incomplete).

calcified Tennessee River alluvium and biological aggregates (Plate 8.18). Field examination of the large limestone clasts revealed extensively weathered surfaces where the silicified fossils are protruding from the soft weathered calcareous matrix.

Zone T3 is distinguished in the field on the basis of its red, soft, silty clay appearance. The zone is primarily composed of noncalcareous, well-sorted medium silt comprised of quartz, mica and papule fragments in a dusty clay matrix. Compared to T4 there are few limestone gravels or cobbles except for a few localized lenses (Figure 8.8). The structure is variable, with localized areas of uniformly round aggregates or clayey rip-up clasts incorporated into silt aggregates (Plate 8.19). Still other areas are completely mixed with variable void morphologies and grain compositions. The consistent composition of these structures, however, is the presence of well-sorted laminated silt and clay (Plate 8.20).

Channels and chambers crosscut many of the aggregates (Plate 8.21). Many of these voids are infilled with a far less dispersed dusty clay attributed to a secondary source (a "cleaner" unimodal quartz silt with papules) and rip-up clast features composed of fine laminae exhibiting fine scale graded bedding (Plate 8.22). Well-sorted ash and charcoal also appear in silty coatings and infillings (Plate 8.23).

A stringer identified as T3a is composed of anthropogenic sand- and silt-sized material trends horizontally through the center of T3, and is visible in profile W66 (Figure 8.8). This subzone disperses to the south past N60 but is included in sample 98093 by the presence of scattered ash, charcoal, and microartifacts, such as fish vertebrae (Plate 8.24). The relative intact nature of this subzone suggests that post-depositional disturbance may be limited and highly localized.

Two other related anthropogenic deposits, T9 and T9a were observed in thin-section, exposed in the east side of the Test Trench (Figure 8.3, Sample 98059). These deposits are similar in elevation to other anthropogenic deposits located in the west side of the Test Trench (Fea. 117, Fea. 366) (Figure 8.2), and are situated in the front central part of the entrance chamber. Zone T9 is composed of two basic materials, mixed residual clay with extensively weathered chert (Plate 8.25), and a well sorted unimodal silt composed of quartz, papules, and secondary concentrations of mica (similar to the Unknown Silt) (Plate 8.26). The two lithologies are clustered and patchy in the zone. At the upper contact of T9 is a 1 mm lens of well-sorted angular sand (Plate 8.27). Unconformably overlying T9 is Zone T9a, composed largely of ash. Just above the contact the ash is dense with planar voids and various aggregates that are composed of a different lithology from that of Zone T9. These aggregates consist of allochthonous light-brown and red-brown aggregates (Plate 8.28).

Moving upward in T9a the matrix becomes less dense and the aggregates decrease while the voids increase with a more spongy structure. The ash crystals in T9a have variable morphologies and form a matrix composed of both dispersed and articulated burned red-brown aggregates (Plate 8.29). Micritic coatings and hypocoatings are also present (Plate 8.28, 8.29). Charcoal is limited to approximately 2% sand-sized fragments and the microartifacts (shell, bone and microdebitage) are burned.

Overlying T3, along an irregular unconformable boundary, is Zone T2, a tabular extensive gray-brown clayey silt unit that contains well preserved bone (including fish and bird) (Plate 8.30). The matrix is predominantly calcareous due to the presence of ash (mostly dispersed) with a relatively high concentration of unsorted clasts including burned microartifacts of charcoal, bone, shell and microdebitage (Plate 8.31). Nearly 20% of the matrix consists of burned red-brown aggregates further indicating anthropogenic burning. The charcoal fragments are relatively small in thin-section (mostly sand-sized) but constitute as much as 10% of the matrix.

Among the sand-sized sediments in Zone T2 is signature Tennessee River alluvium, which is evenly mixed among the calcareous anthropogenic sediments. The structure is generally chaotic, with no discernable macro-organization, and very limited micro-bedding, and no consistent void morphology. There are few well-defined post-depositional features such as precipitation of secondary calcite or biologically aggregated structure. There are, however, a few instances where the deposition of well-sorted silt and/or clay is observed as rip-up clasts or dense partial channel infillings (Plate 8.32). Several of these localized rip-up clasts are composed of dusty clay fragments in a fine silt (Plate 8.33).

On the east side of the Test Trench (profile W62) the macro- and micro-lithology and structure of Zone T2 appear much the same as to the west. Clasts of well-sorted laminated medium silt and clay are slightly better represented to the east, but the overall calcareous lithology and general structure remain consistent. Bioturbation is extensive with partially infilled channels and chambers visible throughout the microstructure; there is a slight increase in the amount of secondary calcite. The calcite and void structure are typically directly related to the presence of root channels and ash (Plate 8.34).

Interpretation

Based on the radiocarbon dates, the deposition of Zone T commenced prior to 10,000 B.P, perhaps as early as 10,300 B.P (Table 1.1). The correlation of Zone T with Zone X9 is based only on lithology and general elevation. It is difficult to speculate on the nature of the extension of these deposits into the dark zone until these zones are physically connected by excavation.

Zone T4 suggests a transition between Zones U3 and the T complex and indicates changes in the depositional environment. The concentration of weathered éboulis in T4 suggests a resurgence of phreatic flow in the cave during this time. This is further supported by the similarity in the matrix of Zone U3 and T4 and the distribution of T4, extending from the western portion of the cave over the drainage channel associated with Zone Y. The flow energy may have been just sufficient to erode the local upper surface of U3, thus mixing the coarse material with later (T4) materials and resulting in deflated larger clasts (weathered gravel- and cobble-sized tabular limestone), and in some cases macroartifacts, from the two zones.

This erosion of the fine particles, occurring during the deposition of T4, would account for pre-10,000 B.P. dates associated with diagnostic Late Archaic Early Side Notched projectile points (Driskell 1994). The excavation areas where T4 has been exposed are juxtaposed over the joint controlled phreatic drainages associated with Zone Y and Zone U. Caution should be exercised in the temporal and spatial interpretation of archaeological remains recovered in these areas.

The boundary between Zone T4 and T3 is unclear, and may represent continued localized phreatic activity as Zone T3 deposition began. Sedimentary structures imply a localized slack-water microenvironment in areas along this contact. The lithology and structure of Zone T3 suggest a history beginning with the influx of fluvial sediments represented in the well-sorted clayey medium silt (primarily composed of quartz, mica and papules). Localized fluvial transport is interpreted from the fine-grained sediments and the absence of the sandier Tennessee River alluvium that produced the majority of Zone U below. The preservation of these fluvial structures is variable across Zone T3 due to the varying severity of subsequent bioturbation. The source material in general appears to be mixed aeolian (partial Unknown Silt) and alluvial deposits available as reworked material both inside and outside the cave. Small-scale fluvial processes reworked the finer fraction of these deposits creating fine-grained bedding, and subsequent slackwater produced clayey laminae. Following this initial deposition the zone was stable and dry long enough to undergo bioturbation and intermittent human occupation including trampling.

Relatively well preserved anthropogenic deposits, such as Zone T3a[1] (Figure 8.8), Feature 117 and 366 (Figure 8.2), and Zone T9 and T9a (Figure 8.3), are associated with or probably correlate to Zone T3[1]. These deposits are all located at elevations ca. 410 – 430 cmbd and represent some of the earliest and best preserved anthropogenic deposits in the cave, comprised of preserved ash, bone and numerous botanical and lithic materials and at least one possible prepared surface (Zone T9) discussed below.

Following initial stabilization and turbations, another transport event or series of slopewash episodes occurred, resulting in localized infilled voids with dusty clay and silt, probably due to the variability in micro-relief. It is difficult to determine the exact source of the second fluvial event of fine-grained sediments in T3. The sediment is devoid of limestone suggesting that it was not derived from within the cave system (phreatic aquifer). The deposits are very well-sorted, medium silt to clay, with graded micro-bedding.

This second source of T3 material may be drip activity in the cave, which is capable of locally removing most of the clay or lighter minerals. The absence of particles of ceiling rain, or some micro-form of travertine, does not support the drip interpretation, nor does the concentration of anthropogenic activity on the micro-relief highs. Damp conditions in the cave due to drip could affect sediments regardless of the floor elevation. Limestone, ceiling rain, and travertine could have been removed by decalcification, but the void structure does not suggest extensive decalcification nor does the localized presence of well-preserved bone and calcareous ash. This deposition occurred at a localized scale and probably consisted only of limited surfical slopewash. The process transported silt-sized materials such as ash, charcoal, quartz and mica into voids within the existing deposits. This slopewash probably resulted in localized waterlogged conditions that enabled suspended silt to infiltrate into the void system. The microfeatures produced by the later slopewash episodes are not represented in the abovementioned anthropogenic deposits located in the center of the entrance chamber. This further supports episodic saturation as a highly localized phenomenon that may have affected only the micro-relief lows while anthropogenic activity concentrated on the dryer micro-relief highs.

Zone T9 is interpreted as a prepared surface, based on the abrupt change in lithology and unconformable sharp boundary with ash below and above the zone. The sediments composing T9 are unique compared to the neighboring deposits and were transported as bulk sediment from an autochthonous source. The unimodal silt appears as large clasts with some graded bedding as if it too was transported in bulk (not grain by grain) suggesting human agency. The sand concentration marking the upper boundary of T9 suggests additional preparation. It is unclear if this was intentional or a product of the overall preparation process. Intensive burning of wood and other vegetal materials on the surface of T9 constitute Zone T9a. This tertiary zone, in association with T9 is interpreted as an *in situ* fireplace. The ash is partially articulated and the base is mixed with aggregates from the underlying. The limited charcoal and extensively burned microartifacts suggest thorough burning on the prepared surface.

I suspect that what remains of T3, and T9 along the east profile, may be only a vestige of the initial deposit. To the west, as evidenced in the east-west N60 profile connecting the Test Trench with W66 (Figure 8.10), Zone T3 slopes noticeably toward the east in an unconformable boundary, disappearing then reappearing along W64. This slope does not conform to the micro-topography.

I suggest a combination of processes resulted in this erosion including low energy scouring, burrowing and trampling.

Low energy scouring or erosion may have occurred as the original T2 material entered the cave. T2 is a complex combination of Tennessee River alluvium and anthropogenic sediments and may have initially represented a major flooding event that breached the large rocks and talus material at the entrance. As the then-reduced energy floodwaters entered the cave, they removed or reworked portions of the fine and presumably fragile silt deposits of Zone T3, especially those in the micro-relief low areas, and washed them into the dark zone. In the dark zone where T is tentatively correlated with Zone X9, the energy dissipated, and the deposit accumulated on an unconformable erosional surface of the relic Pleistocene deposits toward the rear of the cave.

A problematic issue for this higher energy flood hypothesis is that it might be unlikely that fragile anthropogenic deposits such as those noted above (specifically Zone T9 and T9a) would survive such an event. Perhaps the micro-topographic high spots on the surface of T3 were vegetated, protecting them from higher energy. Perhaps large rocks or rock concentrations, later removed or not recorded in the test excavations, diverted the floodwaters as they entered the cave. Localized cementation may also have protected these deposits from the erosional effects of the overbank alluvium. Subsequent excavations along the east side of the entrance chamber should carefully investigate this aspect of depositional history of the cave.

After the initial deposition of Tennessee River alluvium in Zone T2, the cave was the location for extensive, though probably sporadic, human activity. The number of artifacts, the density of ash and charcoal, and the degree of preservation and faunal element articulation (Detwiler 2000; Walker et al. 1997) present in T2 could not be the result of anthropogenic sediment washed in the cave as part of a flooding event(s). The near absence of fluvial (macro or micro) structures and the mixed, unsorted matrix also supported this. The few structures that do exist are probably from the event that brought the initial Zone T2 sediments into the back passage of the cave but were subsequently destroyed by processes such as human trampling, and animal burrowing. Large-scale burrowing is difficult to isolate but hard to deny due to the overall turbated matrix, visible in the field. The absence of a clearly defined biologically produced matrix (uniform aggregates) suggests that trampling and other processes contributed to this chaotic but uniform organization. This mixing phenomenon may also explain the general absence of clearly defined lithologic boundaries (subzones) attributed to human activity and the associated accumulation of artifacts in T2. Such artifact concentrations are well documented in T2, but relatively few "features" are recorded. Some of the well-sorted laminated silt and clay aggregated clasts may also be the result of burrowing intruding into T3, incorporating these clasts into the T2 matrix, and contributing to the disconformity between the two zones.

Following the deposition and most of the turbation of T2 the zone underwent further limited slopewash or slackwater resulting in the deposition of well sorted laminar silt and/or clay in selected voids. The curvilinear fine-grained rip-up clasts represent either the localized translocation of these sediments or slackwater deposition. They were draped over sand-sized grains resulting in their unique shape. This phreatic movement of sediment had to have been limited or brief, however, due to the absence of well developed clay coatings.

Zone T2 contains well-preserved bone and a high percentage of charred wood and nuts. As noted above, the charcoal fragments are relatively small in thin-section (mostly sand-sized) but compose approximately 10% of the matrix. In the field, charcoal concentrations are recorded as high and appear dispersed throughout the matrix. A consistent problem in the field is the seemingly poor representation of this material derived from the flotation process. The assumption has been that the techniques used and the often still-wet bulk samples are responsible for this limited recovery of charcoal from the zone. This poor representation of the charcoal is instead probably due to its fragmentary nature. In thin-section the charcoal is clearly composed of articulated fragments (Plate 8.35). The floatation process (Pearsall 1989; Watson

1976) disperses the material to a size range that either bypasses the flotation system or renders it unidentifiable. This taphonomic condition should be carefully considered in the quantification and identification of botanical remains in Zone T2.

Zone R

Description

Distribution

The Zone R group overlies T2 and is situated between ca. 400 and 370 cmbd (Figures 8.2, 8.3). Subzones of R are identified throughout the entrance chamber but pinch out west of W66 where they disappear and Q directly overlies T2 (Figures 8.7, 8.8). As above, this discussion focuses on the western portion of the entrance chamber, since the majority of the samples and the units excavated pertain to that side of the chamber. Correlation across the Test Trench within the R zones is difficult because of localized lateral variations and the clearly different subzones represented on both sides of the trench.

Zone R1 was used in the testing phase to identify the bulk of Zone R. Until additional excavation is carried out on the lower deposits on the eastern side of the Test Trench, most of the deposits associated with R are subsumed under the general designation of R1. Zone R1 is visibly thicker at the back of the entrance chamber along the back wall, measuring as much as 30 cm north of N62 and west of W62 (Figures 8.2, 8.3, 8.9, 8.11). The zone thickens even more near the wall (visible in profile N63), which is adjacent to an area of intensive pit excavation and feature deposition (e.g., Fea. 360) (Figures 8.9).

An exception to the eastern R1 generalization is Zone R1f, a 10 cm thick lens that overlies R1 north of N61 (Figures 8.3). There are numerous other distinct tertiary zones and features, probably anthropogenically derived, that are visible in the east profile. These zones were not sampled and will not be designated until excavation continues there. They are noted but not described in this discussion.

Beneath Zone R1, along the back wall of the entrance chamber and throughout the western back portion, concentrated anthropogenic deposits overlie and intrude Zone T2 (Figure 8.8). One of these anthropogenic tertiary zones, R6b, is briefly described and discussed.

Zone R9 is restricted to the west side of the entrance chamber and appears to correlate with the northern extension of lower S1. The correlation is clear both lithologically and spatially, visible in the W64 Test Trench profile (Figure 8.2). Zone R9 averages 10 to 20 cm thick and thins to the west; it is no longer visible past W65 (Figure 8.10). Like R1, tertiary zones and pit features intrude into Zone R9. These are visible in profile throughout the entrance chamber. I will discuss a series of these tertiary zones that intrude into R1 and R9 along the western profile of the Test Trench between N61 and N62 (Figures 8.2, 8.12). These thin deposits constitute zones R1e, R1b, R1a and R1c and

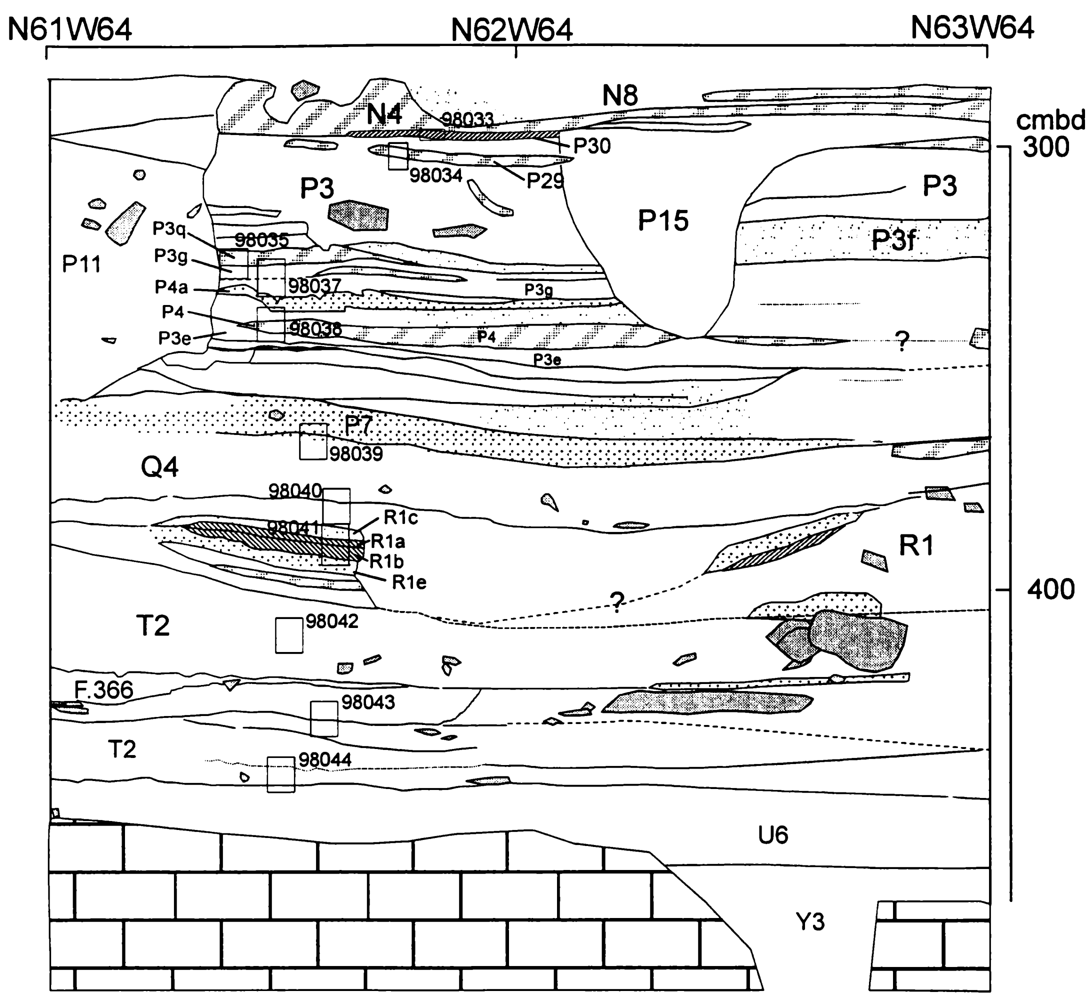


Figure 8.12. Profile W64 Detail, N61 to N63, 280 cmbd to Bedrock.

cover an area <50 cm^2, and each varies from 1 to 3 cm thick. The zones are truncated to the north, perhaps by a burrow or a poorly defined pit feature (Figure 8.12).

Zone R6 overlies R9 and T2 and underlies Q. The zone first appears at N57 along the west profile of the Test Trench and continues to the west where it thins (like R9) and is no longer visible past W67.5 (Figures 8.2, 8.7, 8.8). Zone P16 (actually an intrusive burial pit) crosscuts Zone R6 and intrudes into a portion of the surface of R9.

Lithology and Structure

Relatively intensive anthropogenic activity and disturbance mark the transition from Zone T2 to R1 and R9. This activity is suggested through numerous tertiary zones in the form of small pit deposits and burned surfaces that are intrusive into T2 and the adjacent deposits. Zone R6b is such a zone, visible at the boundary between R2 and overlying R6 (Figure 8.8). Some of these localized zones originate at the base of R and others crosscut R into T. Zone R6b is made up of essentially two lithologies. The altered upper boundary of T2 is overlain by a lens of mixed ash referred to as R6b (Plate 8.36). This section of the upper portion of Zone T2, an otherwise extensive gray brown clayey silt tabular unit, is unique in association with R6b in several ways. It was initially described in the field as a restricted area of noticeably aggregated and friable sediments, rubified, with a finer grained aspect as compared to the adjacent T2 sediments. The contact with the ash above was abrupt but not sharp as in several of the other red zones underlying ash zones (see below). In thin-section, the matrix is composed of unsorted calcareous silty clay with randomly dispersed sand-sized grains of limestone and ceiling rain, microartifacts, and sparse limestone gravels in a chaotic fabric. The finer grained aspect appears to be attributable to a number of variably-sized (1-3 mm) fragments of graded fine silt and clay (Plate 8.37). This material is very similar to that of Zone R9. Overlying this rubified surface of T2 is the remainder of Zone R6b, a grayish brown calcareous silt loam with intact ash aggregates (Plate 8.38), and mixed aggregates and sand-sized microartifacts. Aggregates of the rubified T2 material are mixed into the lower ca. 1 cm of these calcareous sediments (Plate 8.39).

Overlying this area of intensive anthropogenic activity and disturbance are R1, R9, and R6. These zones mark the transition from Zone T2 to Zone R. Due to crosscutting contacts and irregular transitions, it is difficult to determine which deposit originated first. In general, R1 and R9 appear to be contemporaneous, with R6 overlapping a portion of R9. I will first describe R9 followed by superimposed R6, and finally R1 adjacent to the north and east.

Zone R6 slopes down into the cave from the talus Zone S1 and is clearly expressed inside the drip line extending across a portion of the western entrance chamber. Composed of a soft, dark red, fine-grained matrix, R9 consists of well-sorted characteristically noncalcareous silty clay. The deposit was accretional as there is a clearly preserved burned surface visible in R9, in the N62 profile, partially truncated by the large intrusive pit P16 (Figure 8.2). In thin-section, R9 is composed of localized areas of graded bedding with variable distributions of clay, papules, clean quartz and mica (Plates 8.40, 8.41) – identified as well-sorted silt of an unknown source. These micro-features vary and appear as infillings, complex aggregates, and probable intact sections of graded bedding. Other portions of the matrix are extensively disturbed with aggregated structures, packing voids, vesicle, and vughy void structures (Plate 8.42). Randomly mixed in among this fine matrix are coarse sand- and small gravel-sized microartifacts including charcoal, bone, shell and few concentrations of red-brown and dark-brown aggregates. Single ash crystals are also sparsely and randomly dispersed through localized areas of the matrix along with variably-sized grains of ceiling rain. Micritic coatings and hypocoatings are observed in approximately 20% of the matrix and are associated with channel voids (Plate 8.43).

Zone R6 directly overlies R9, portions of T2, and the numerous anthropogenic tertiary zones intrusive into T2, including R6b. R6 is composed of well-sorted, generally noncalcareous silt mixed with unsorted sand, including quartz, weathered chert and rounded papules (Plate 8.44). The matrix is chaotic with no micro-bedding evident as in Zone R9.

The matrix of R6 is made up of calcareous silt loam with unsorted sand including quartz, mica, charcoal and other burned microartifacts, as well as numerous aggregates of various sizes (Plate 8.45). The fabric is chaotic with all void types represented. Rhizolith structures are evident in some of the channel voids. Localized areas (approximately 30% of the matrix) contain micritic hypocoatings and coatings associated with channel voids.

Zone R1, as a general subzone representing much of the back of the entrance chamber and the eastern exposure, is a stark contrast to Zone R9. The sediment is unsorted, a mixed calcareous silty clay texture with burned and unburned microartifacts and variable gravel-sized material including limestone, and macroartifacts (Plate 8.46). The fabric is generally chaotic with no consistent void structure or microstructures.

A series of lenses identified as tertiary zones R1a, R1b, R1c and R1e intrude into the R1 sediments. These zones, and similar deposits throughout the entrance chamber sequence, offer a rare opportunity to study intact anthropogenic sediments. From bottom to top, as identified in sample 98041 (Plate 8.47), the sequence begins with R1e. R1e is composed of dense calcareous ashy silt mixed with approximately 25% light-brown and yellow-brown aggregates (similar to the composition of R9) (Plate 8.48). There are numerous burned fish bone fragments visible in thin-section. Deposited abruptly above R1e is R1b, a 3.5 cm thick dark red, hard, aggregated noncalcareous silty clay containing weathered chert sand and papules (Plate 8.49). The structure is aggregated but compacted with minute planar voids throughout the matrix that appear as micro-cracks (Plate 8.50). Also present are localized (~5% of the matrix) micritic hypocoatings adjacent to small channels and some of the planar cracks. Bioturbation is limited to ~10% of the matrix and includes partially infilled channels.

Overlying R1b and extending into micro-cracks at the surface is a thin veneer of mixed ash measuring approximately 1.0 to 1.5 mm thick (Plate 8.51). The ash contains sand-size particles, partially combusted charcoal and rounded light brown aggregates 0.5 to 1.0 mm in diameter. These aggregates are distinctly different than the underlying surface of R1b, which has a coarser texture and a deep red color. Immediately overlying the ash veneer is Zone R1a, a 1.0 cm thick lens with sharply unconformable boundaries, varying from R1b in color, consistency and texture. The color is not dark red, the field consistency is soft and although the lithology is similar to that of R1b, the texture is composed of less clay and more silt and sand (Plate 8.52). The void structure between R1a and R1b is similar, but the micro cracking of R1a is not as well developed.

Zone R1c is superimposed over R1a and consists of mixed calcareous ashy silt mixed with approximately 30% red-brown aggregates, many clearly derived from the substrate of R1a (Plate 8.53). Sand-size particles (20%) include weathered chert, charcoal, quartz, burned bone and shell. The fabric is chaotic with a partially aggregated structure including poorly developed packing voids, channels, and chambers.

Zone R1f is visible in the eastern wall of the Test Trench as a 10 cm lens following the upper surface of R1, between N61 and N63 (Figure 8.3). This lens is micro-laminated exhibiting graded bedding/slaking crusts, silty clay with variable amounts of "clean" quartz, dusty clay and papules (Plate 8.54). Partially infilled chambers, channels and localized micritic coatings and hypocoatings are associated with some of the channels. There is little to no anthropogenic material in this thin-section.

Interpretation

Following the stabilization of T2, just after 10,000 B.P., occupation took place on the surface of T2, digging small pits and building fireplaces on unprepared surfaces such as on Zone R6b. While T2 was still exposed, the sediments of Zone R9 began to accumulate from episodic slopewash derived from the talus that continued to grow at the cave entrance. Zone R9 is clearly an extension of the steep S1 talus formed along the western edge of the drip line (Figure 8.2). The lithology is suggestive of allochthonous fine particles washed from the talus into the entrance chamber. Incorporated into these fine fluvial sediments are random coarse materials most of which relate to human activity. Throughout the formation of this deposit the zone was periodically stable and dry enough to function as a surface on which to construct fires, evidenced in the surface truncated by P16. Other localized areas were extensively bioturbated by various soil fauna (based on the variable channel and fecal pellet sizes) resulting in aggregated structures, dusty clay coatings and infilled chambers. Micritic hypocoatings suggest root activity and drip infiltration.

Zone R6b and the above-mentioned surface in R9 are examples of the burned surfaces active during this time. Both burning episodes involved unprepared surfaces resulting in an aggregated, rubified substrate and sparse, mixed ashy remnants of the process preserved above. These features, and others to the east and west (e.g., Zone R8, Fea. 325, 333), are evident at the same elevation (~380 cmbd).

To the north and east, R1 represents a different microenvironment than that of R9. Clearly there is far more resolution and variation in Zone R1 than I have described here. In general the zone appears to be the result of intensive human activity mixed with allochthonous materials entering the cave via slopewash and trampling. The mixed structure of the material and the lack of sorting are suggestive of extensive trampling and localized bioturbation. There is very limited post-depositional secondary carbonate, far less than compared to R9, which suggests that the rear of the cave was relatively dry, even during periods of intensive drip at the entrance. Specifically there are isolated anthropogenic deposits in portions of the back of the cave that prior to this time were intermittently associated with phreatic water movement. Therefore, it appears that during the formation of Zone R1, the joint-controlled drainage system was not active.

R6, adjacent to R1, differs in lithology as well-sorted, generally noncalcareous silt, suggesting R6 was influenced both by R9 and the entrance slopewash processes that appear to be the source of much of the fine material. In addition, the zone is also extensively trampled suggestive of increased activity at the rear of the cave.

Zones R1a, R1b, R1c and R1e appear to crosscut into Zone R1 and are interpreted as a series of *in situ* fireplaces composed of prepared surfaces and intact ash deposits. Their slight slope to the north is probably the result of subsidence when their northern extent was truncated and removed (through pit excavation or localized burrowing). Zone R1e signifies either a mixed burned deposit that was stirred or trampled, or a rake-out deposit that was subsequently bioturbated and trampled. Concentrated preserved burned fish bone suggests that fish processing played a significant roll in the function of this particular burning activity.

The reason for the compaction of the zone is not clear. It may relate to the preparation and application of Zone R1b above. Zone R1e served as the substrate for the construction of a prepared surface (Zone R1b) composed of mixed autochthonous sediments. These sediments include dense, bioturbated silty clay with various sand-sized materials that were probably incorporated biologically at the point of origin, prior to transport. There are limited and very localized areas of secondary cementation but not enough to account for the hardened aspect observed in the field. I suggest the sediment was heated at a high temperature (>500°C), as a result of a fire built on the prepared surface. Relatively dry sediment was collected somewhere in the entrance chamber (perhaps near the back wall), and spread out to a uniform thickness with a smooth surface. A fire was built on this surface, driving off any moisture, creating the micro-cracking observed in thin-section, and resulting in a hard surface. The ultimate purpose of that surface is not evident, but I believe this and the other prepared surfaces in the cave are associated with food preparation (see Chapter 10).

The thin veneer of ash resting on top of the sharp upper boundary of R1b suggests that this is all that remained of this original fire. Apparently a concerted effort was made to remove the ash prior to use and certainly prior to the application of R1a. Zone R1a is clearly another prepared surface constructed in a similar fashion, from similar material, on top of R1b. The zone, however, differs from R1b with a higher value color, near absence of micro-cracking and a soft aspect. These attributes suggest R1a was heated at a lower temperature or fewer times than the surface below. The overlying mixed ash layer implies an *in situ* burning event that subsequently underwent limited bioturbation, evidenced in the structure and the limited mixing along the contact between the clayey substrate of R1a and R1c.

The distinctions between Zone R1 and R9 suggest two separate microenvironments at the front of the cave and at the rear of the cave. The front must have been periodically wetter, affected by drip and localized slopewash off the talus while the rear of the cave was relatively dry, inviting concentrated human activity. Prior to this time most of the activity in the entrance chamber focused at the center of the chamber towards the entrance. Zone R designates the first intensive use of the rear of the cave, most likely due to the finally dry substrate.

Based on the radiocarbon distribution there is a significant gap of >1,000 years between the most recent date associated with the Early Side Notched componenet of Zone R and the overlying Zone Q (Figure 8.4). Zone R began to form after 10,000 B.P. (it is not yet clear how soon after) and the youngest date derived from Zone R is ca. 9,720 B.P. (Table 1.1). The only date for Zone Q is 8,470 B.P. over 1000 years later. The stratigraphy reveals no significant sediment accumulation overlying the anthropogenic subzones within R that might account for a long-term abandonment within the cave. In the western portion of the entrance chamber Zone R, made up of several secondary and tertiary anthropogenic deposits, appears to be truncated (Figure 8.7). I describe these deposits as truncted rather than thin since several of these deposits (e.g., Fea. 325, 330) are remnanst, or the base of what was probably a larger pit or anthropogenic deposit. Zone Q on the other hand is a comparatively massive deposit that is consistent through the entrance chamber. The contact between Zone R and the overlying Zone Q is abrupt and is interpreted as a chamber-wide erosional episode.

The idea of such a large-scale removal of sediment is further supported by the absence of one of the region's Early Archaic components. The various regional Early Archaic diagnostic projectile points are well represented throughout the zone sequence, save one: - a portion of the Early Archaic typically related to the Kirk Corner Notched point type, is not present in the cave. This diagnostic artifact is concentrated elsewhere in the project area, specifically on the floodplain, and typically dates from 9,000 to 8,500 B.P in the Pickwick Basin (Meeks 1997a, 1997b; Meyer 1995). The relative absence of this component in the cave would suggest that perhaps it was removed when the disconformity marking the top of Zone R was created.

The type of event that might be responsible for eroding the upper portion of Zone R has yet to be determined. We can assume based on the depositional environment that the only potentially active force strong enough to erode sediment throughout the chamber would be water. There is no direct evidence to suggest the direction of the energy, whether it came from the river or creek outside the cave or if it came from the interior of the cave, similar to the initial event that flushed the cave nearly 2,000 years earlier. Based on the absence of the signature Tennessee River Alluvium it appears doubtful that the erosion was caused by a large-scale alluvial event.

One final consideration is the potential that the >1,000 year gap represents not a major erosional unconformity but is instead a sampling bias. This is a distinct possibility with Zone Q represented with only one, possibly two, radiocarbon age estimates (Figure 8.4). If the gap is a sampling bias then the disconformity between Zones R and Q may be directly related to the deposition of Zone Q with very little of Zone R having been eroded. If this is true then other reasons for the absence of the Kirk Corner Notched component must be considered. Additional radiocarbon dates should illuminate this issue.

Zone Q

Description

Distribution

Zone Q is one of the only primary zones that is consistently identified and correlated throughout the entrance chamber. As the fieldwork progressed, subzone designations of Q2, Q3, Q4, and Q5 were assigned when correlation with the primary Zone Q was uncertain (Figures 8.2, 8.3, 8.6, 8.8). Subsequent analyses and observations indicate that the subzones do indeed correlate, and so this discussion will focus on the primary Zone Q.

Zone Q is tabular, and ranges in thickness from ca. 10 to 30 cm, and is located approximately 350 - 380 cmbd. The zone is thickest at the front of the cave, close to the cave entrance, and thins towards the rear of the entrance chamber in the vicinity of W68 (Zone Q3) where it is less than 10 cm thick (Figure 8.6).

Lithology and Structure

Zone Q is generally red silty clay with a variable coarse fraction. The lower boundary is clear and, based on the truncated zones beneath (Zone R), appears to be an erosional disconformity (Figure 8.7). The upper boundary is typically abrupt and is uniformly associated with a thin lens of charcoal that varies in grain size and density (Plate 8.55). The greatest variability is to the north along the rear of the chamber (>N62) where there are tertiary zones (Q3a, Q1a, Q4b) evident within the otherwise typically homogeneous zone (Figures 8.3, 8.7, 8.9).

Twelve thin-sections were examined from Zone Q (Appendix C). These thin-sections revealed a generally bimodal distribution of a well-sorted silty clay matrix, often calcareous, with 10% poorly sorted sand composed of quartz, limestone, ceiling rain, weathered chert, travertine, bone, shell (typically burned), microdebitage, mica and feldspar (in order of frequency from highest to lowest) (Plate 8.56). The frequency of ceiling rain, and the overall calcareous nature of the matrix is concentrated in the center of the chamber and towards the back wall (north) where the zone is thinnest (Plate 8.57). Disarticulated single ash crystals are scattered throughout the zone. The zone thins to the west beyond W 66 and becomes less calcareous but still contains macro- and microartifacts (Plate 8.58). The area's thin-sections are composed of >30% void space including a combination of packing and channel voids. Some of the packing voids are spongy depending on the intensity of decalcification and the size of the aggregates. Chamber voids are also relatively frequent and are typically infilled partially with fecal pellets (Plate 8.58).

Aggregates comprise ca. 20-50% of Zone Q and consist of both red-brown and light-brown types. These aggregates vary in size from 1.0 mm down to 0.05 mm and are mostly biologically produced based on their shape, size and uniformity. The red-brown aggregates in particular are scattered (not concentrated) throughout the matrix. Very localized areas of a relatively undisturbed microstructure composed of graded bedding (well-sorted quartz silt and clay) are present among the light-brown aggregates. These small areas (typically 2-4 mm) are probably rip-up clasts. Their boundaries are often obscured by bioturbation. Their fine texture, however, suggest that they were fragile and could not have been transported far. In some cases these rip-up clasts were very subtle and difficult to record digitally due to secondary calcite hypocoatings masking their details. Sediment is visible adhering to some of the aggregates, including a few instances of water-lain ash adhering to the surface of some red brown aggregates (Plate 8.59).

At the macro-scale, artifacts varying in size are numerous but dispersed throughout Zone Q. In addition, gravel- to cobble-sized éboulis is scattered throughout. Individual clasts were not quantified in the field but are consistently noted on the excavation forms and in the various field descriptions of the zone.

In thin-section, Zone Q exhibits micritic void coatings and hypocoatings (Plate 8.60). Iron/clay deposition was observed relating to some of the secondary calcite resulting in faint orange bands (Plate 8.61). It is not clear if these microfeatures are the result of clay deposition between phases of micrite formation or if this is clay absorbed into the calcite structure. Secondary calcite was also observed as cappings on limestone sand and gravel (Plate 8.62). Relatively infrequent eroded limestone clasts, shell and etching of micritic coatings suggest limited decalcification.

Among the few tertiary zones, the only one sampled for micromorphology was Zone Q1a (Figure 8.3). Q1a is consistently 2 cm thick and is composed of well-sorted silt suggestive of the Unknown Silt (see chapter 6) (Plate 8.63, 8.64). The material is very compact with only ca. 5% voids, where vughs and packing voids dominate. The upper boundary is abrupt and horizontal with perhaps two phases of ash represented (Plate 8.65). The lower phase adhering to the surface and extending down into micro-cracks at the surface is composed of single ash crystals mixed with other sediments (Plate 8.65). The dense upper phase is separated by a 0.025 mm thick coating of dusty clay overlying the lower phase. Individual ash crystals in the upper phase cannot be distinguished suggesting recrystallization within the matrix. Above the ash phases mixed calcareous sediments occur with microartifacts. Approximately 30% of the matrix is embedded with secondary calcite while millimeters away the dense matrix of Q1a contains none (Plate 8.66).

The final characteristic of Zone Q that should be described is the regular charcoal lens that is consistently noted in the field as marking Q's upper surface or boundary. The lens is composed of variably sized (silt, sand, and gravel) wood and nut charcoal mixed into the local matrix (Plate 8.67). Though this concentrated charcoal appeared to be part of Zone Q at the macroscopic scale, microscopic observation of the upper boundary suggests that the charcoal actually rests on top of Q, with bioturbation and possibly trampling obscuring the boundary (Plate 8.68). The stratum was too thin and ephemeral in some areas to excavate as a unique subzone. As a result the lens is not described as such and the interpretation is discussed in both the context of Zone Q and the overlying Zone P since it directly relates to the unconformable boundary between these two primary zones.

Interpretation

There are several intriguing issues surrounding the formation of Zone Q. First, the zone is unique in that it appears in profile as one relatively massive, distinctly red unit that is visible throughout the entrance chamber at approximately the same elevation. Artifacts were recovered throughout the zone. The second issue invovles the radiocarbon age related to Zone Q and the implications for the initial depositional enviornment of Zone Q and the ~1,000 year gap that follows this date within the radiocarbon age distribtion (Figure 8.4). As noted in the Zone R interpretation, a sampling bias could clearly be responsible for these temporal gaps. One, possibly two dates, make it difficult to declare these gaps significant erosional disconformities, especially when so few samples exist representing the depth range in the cave between 300 and 375 cmbd.

A charcoal sample from the top of Zone Q produced a radiocarbon age of 8,470 +/- 50 (Table 1.1), whereas the youngest date in the underlying Zone R is 9,720 +/- 70. These dates suggest one of two things. Either the relatively homogeneous Zone Q accounts for approximately 1000 years in the cave's depositional history or there is a major disconformity at the contact between Zones R and Q that represents the removal of ca. 1000 years of sediment accumulation. This can only be reliably addressed with additional sampling.

The lens of charcoal that marks the upper boundary of Zone Q is another intriguing characteristic of this zone. Within this charcoal concentration the density and size of the charcoal varies, but it is consistently observed along the boundary between Q and P. The charcoal lens is clearly represented in the profiles across the entrance chamber, even where Q thins to the west. The only place it is absent is where an intrusive pit has cross-cut the lens, removing it.

The overall red color of Zone Q appears to be the result of a combination of factors. The presence of clay, the oxidation of the iron, the general absence of organic matter and the high concentration of red-brown aggregates (which are scattered throughout the matrix) all contribute to the color.

Two scenarios addressing these characteristics are discussed. These scenarios seek to explain the issues of the limited amount of sediment accumulation, the potential for a missing/absent cultural component, the overall character of the sediments, and the unconformable boundaries. The initial idea was that Zone Q represented a substantial flood event that eroded significant amounts of sediment from inside and outside the cave, resulting in a disconformity and the deposition of one massive deposit. This early hypothesis was based on the unconformable contact between Zones R and Q, the absence of the Early Archaic component, and the upper charcoal lens possibly being a float deposit. Detailed stratigraphic study has allowed me to dismiss this initial notion based on several observations.

First, a massive overbank flood event would have resulted in significant deposition of Tennessee River alluvium. No such signature sediments are associated with Zone Q. In addition, the presence of preserved incipient surfaces in Zone Q, specifically Q1a and Q3a, and others towards the back wall, discount the possibility of only one large depositional event. Zone Q1a indicates there had to be at least a brief period(s) of stability during this time when people could inhabit the cave. Attributes that might point to a massive event resulting in the charcoal floating to the surface are also absent. Second, such an event would result in at least some degree of graded bedding throughout the deposit. Even with bioturbation some aspects of this bedding should have survived but none are evident. In addition, "heavy" material such as chert and limestone sand and granules are mixed in among the charcoal negating the notion that the deposit was composed of only material that would float. Massive saturation or the presence of slack water as the floodwater receeded should also result in well-developed dusty clay coatings on the sediments immediately underlying Zone Q. These too are absent.

The second scenario is based on the macro and microstratigraphic data that designate Zone Q, in the broadest sense, as a series of massive slopewash deposits altered by bioturbation and root activity. The majority of the sediment is derived from allochthonous sources (much of it burned). Some sort of localized fluvial event, either massive slopewash from the entrance or flow from within the karst system, mixed materials (derived from anthropogenic, geogenic and biogenic processes) and transported it, at least a limited distance. Enough energy had to be involved to erode the existing surface, incorporate gravel-sized materials and produce a fairly consistent tabular deposit(s) across the entrance chamber of the cave. Thinning of the zone to the western reaches (rear) of the entrance chamber, advocates a source area at the front of the cave. The lack of extensive Tennessee River Alluvium (as noted above) among the Zone Q sediments is problematic for an alluvial transport agent. This might then point to slopewash and colluvial materials (supported by the unsorted sediments and high concentration of red-brown aggregates), however, such mass wasting would be generated by increased precipitation which would conceivably rise the river levels as well resulting in overbank deposition.

The mixed and transported artifacts suggest that human activity played a secondary role in the source of Zone Q. Some of the artifacts could be derived from the eroded surface of Zone R, especially since Zone Q contains both Early Side-Notched and Kirk Stemmed projectile points. Ash crystals are dispersed throughout the zone, also attesting to the mixing and transport of the anthropogenic sediments. The few tertiary zones observed imply that human occupation was at a minimum during this time. Limited anthropogenic activity did, however, result in the formation of Zone Q1a, and other ephemeral zones (probably burned surfaces) in the back of the cave. Considering the overall significance of anthropogenic sediments in the depositional history of Dust Cave, this relative paucity of anthropogenic tertiary zones may point to a reduced sedimentation rate related to Zone Q. The question is why?

Several characteristics of Zone Q suggest a wet microenvironment during the zone's formation. The scale of slope wash (based on the size of material transported) must have brought saturated deposits into the cave. The presence of ceiling rain, sand-sized travertine and éboulis, as well as micro-features including micritic capping on larger grains, iron staining of secondary calcite, and limited decalcification, all suggest a moist microclimate. This microclimate included attrition of the ceiling and walls due to increased chemical/mechanical weathering, and the movement of calcium carbonate charged waters downward through the sediment.

The relatively high frequency of calcite precipitation may be a result of both a wet microenvironment and the length of time Zone Q was exposed. The overlying sediments, as the discussion of Zone P puts forth, have far fewer secondary carbonate features, even though it is a calcareous environment (high frequency of ash). In addition, the sediments in Zone P appear to have accumulated over a shorter period of time with less vegetation than was clearly associated with Q. All these features and processes suggest that the long-term exposure of Q in a wet microenvironment, resulted in considerable carbonate precipitation.

In light of the above, the generally limited and localized aspect of primary anthropogenic deposition suggests minimal human activity due to inhospitable conditions inside the cave. A wet microenvironment is further supported by the material selectioned to construct Q1a. The prepared surface is created out of material from outside the cave, a well-sorted (possibly aeolian) silt. Typically the prepared surfaces in Dust Cave were collected from a source inside the cave (see Chapter 6). Zone Q1a, however, lacked any of the signature autochthonous sediments. This unique source for a prepared surface suggests that the usual endogenous source was not suitable, perhaps too wet, making an exogenous source necessary.

Zone Q underwent relatively extensive post-depositional modification. The aggregated structure and void microstructure both suggest extensive worm burrowing and root activity in conjunction with secondary carbonate deposition. It is unclear which came first but I suspect the processes occurred repeatedly. Such extensive bioturbation could not occur in a saturated deposit, so the sediment had to be sufficiently dry (perhaps seasonally) for this process to occur. The biological aggregates vary in size suggestive of variable soil fauna. Plants, based on the high percentage of channel voids and the presence of rhizome features, also contributed to the turbation of the matrix. Three to 4 m of vertical open space still remained at the entrance of the chamber, providing ample sunlight much of the year to support plant life. .

It is not clear if the bioturbation occurred between slope wash events or if it occurred after the bulk of Q had been deposited and stabilized. The extent of bioturbation suggests that the sediment was both stable enough and dry enough to make the entrance chamber suitable for human habitation. There is no real evidence for large scale burrowing that might relate to the habitation of the cave by other mammals during this time. The limited time required for worms to turbate a site is well documented (Stein 1983), so perhaps the bioturbation took place over a short period of time, towards the close of that 1000-year period. The implication of this is that the cave remained wet for a long time, with limited deposition and only brief periods dry enough for human habitation. When it was finally dry, around 8,500 B.P., the sediments were bioturbated and intensive habitation followed with the introduction of the Zone P deposits.

There are two primary problems with this scenario that need to be addressed during subsequent analyses. These are the relatively low sedimentation rate in the cave and the absence of features relating to phreatic water in the cave during this time. The relatively low sedimentation rate may be accounted for in the limited human activity, and a consequent absence of anthropogenic sediments. It is anthropogenic processes afterall that appear to maintain the relatively high sedimentation rate within the cave.

The lack of macro and micro-features relating to phreatic water in the cave system is more problematic. Wet conditions in the cave system through the increase in drip and slope wash frequency and magnitude should be mirrored in the phreatic drainage systems relating to local groundwater. The apparent absence of this activity and its significance is not clear.

Finally, the consistent charcoal deposit at the boundary between Zone Q and the overlying Zone P seems to be from a massive burning event. The charcoal is a mixture of wood and nut charcoal. Such a massive burning event may be either accidental or intentional. The burning of all the organic material from the surface of a cave entrance could be intentional. Such an activity might be intended to evacuate a potential habitation site, removing various materials in order to make the entrance chamber more habitable. Undesirable materials might include parasite infestations and waste accumulation when carnivores previously occupied a cave. A carnivore den would include the presence of coprolites and therefore micro-bones. Although the sampling area is limited, no such indicative material has been observed. The removal of excess vegetation may also be a prospect. There is little ash associated with the charcoal concentration between Zones Q and P, but this may be accounted for by decalcification. Thus, the exact origin of the widespread charcoal lens remains unclear; however, at this point the most likely source is a extensive burning event, perhaps intentional.

Zone P

Description

Distribution

Zone P represents the most intensive series of anthropogenic deposits represented within the Dust Cave sequence. The stratigraphy is particularly complex with numerous secondary and tertiary zones (Appendix A). I will focus on the main secondary zones and a sample of the tertiary zones. Like the previous zones the western portion of the entrance chamber has undergone more intense scrutiny compared to the eastern portion (Figures 8.2, 8.8, 8.12) where the lower deposits are only exposed in the east profile of the Test Trench (Figure 8.3).

Zone P is identified throughout the entrance chamber and extends into the back passage where it is preliminarily correlated with Zone X10. Secondary zones in Zone P are assigned to tabular zones and large crosscutting pits that are visible throughout the entrance chamber. Zone P3 is a thick tabular deposit that averages ca. 50 cm from approximately 350-60 to 300 cmbd. Directly adjacent to Zone Q is the mid section of S1 at the drip line (Figure 8.3). The center of the entrance chamber continuing to the rear wall is the focus of intensive activity represented in tertiary (and some secondary) zones of thin, localized and truncated lenses of red silty clay and ash (Figure 8.2, 8.3, 8.9). P7 also directly overlies Zone Q. Overlying P7 the secondary and tertiary zones become complex, localized deposits. A representative section of the central tertiary zones are discussed relating to P3e, P4, P4a, P3g and P3q (Figures 8.2, 8.12).

On the western side of the entrance chamber, beginning around W65, the concentrated red silty clay and ash lenses give way to laterally more extensive, yet still thin, lenses of mixed calcareous sediments (Figures 8.6, 8.7, 8.8, 8.9, 8.13). Selected for discussion are Zones P5, P6c, and P7. These zones vary in thickness but generally thin to the west. Trending west across the chamber it is clear that while most of the lateral deposits in the cave are horizontal, P5, P6 and their associated tertiary zones dip downward, to the west, approximately 30° (Figure 8.7).

Also characterizing Zone P are large intrusive pits, some stratified and some indicative of one depositional event. These pits are scattered throughout the entrance chamber. The majority are burials and include P11, P15, P16, P23, and P24 on the west side of the Test Trench (Figure 8.2); and P 25, P19, P17, and P21 on the east side (Figure 8.3). To the west this includes P8 truncating P9 (Figure 8.8); Fea. 314 (Figure 8.7); P26 (Figure 8.6); Fea. 292 and P15 (Figure 8.9); and finally P28, intruded by P16, which is subsequently intruded by P29 and Fea. 351 (Figure 8.13). Further analysis of the function and nature of the fill of these

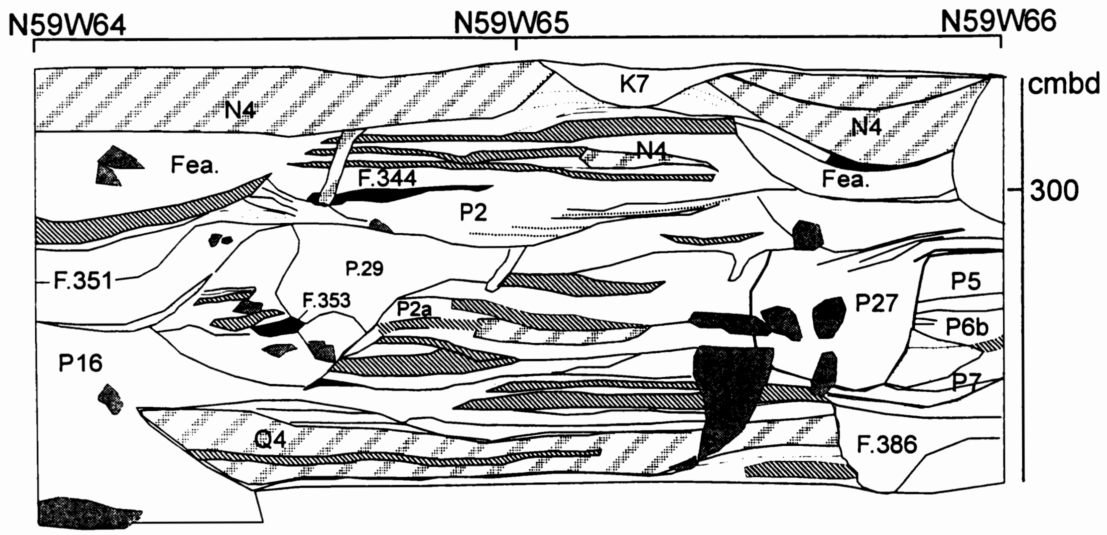


Figure 8.13. Profile N59, W64 to W66, 275 to 360 cmbd.

features is beyond the scope of this study and will ultimately be addressed by L. Homsey in her dissertation research. My attention to these deposits is restricted to their chronostratigraphic characterization and their overall relationship to the lateral Zone P stratigraphy. In particular, the distribution of many of the localized secondary and tertiary zones noted above are truncated by these large pits, giving us only a partial view of the original extent of these distinctive deposits.

Lithology and Structure

Sixteen thin-sections were examined that included Zone P sediments (Appendix C). Zone P7 is described as reddish brown to gray brown calcareous silt with variable concentrations of charcoal ranging from silt- to gravel-sized (Plate 8.69). The majority of the silt fraction is composed of dispersed and articulated ash crystals and 20 – 30% mixed aggregates (in order of highest to lowest frequency: red-brown, light-brown and yellow-brown) (Plate 8.70). Burned microartifacts are scattered throughout.

Zone P3 is designated as the more massive manifestation of P beginning just inside the drip line. This thick zone is composed of dark gray-brown silt loam with varying concentrations of charcoal. As much as 40% of the silt consists of mixed ash that is associated with burned aggregates and light brown aggregates along with burned microartifacts (Plate 8.71, 8.72). Microartifacts include burned shell, fishbone, bone fragments and microdebitage. Biological aggregates and infilled channels are visible in thin-section (Plate 8.73), but in general the zone is patchy and structureless with areas of few voids and others that have numerous voids (channels, vughs, planar voids), resulting in a relatively loose matrix. Micritic coatings and hypocoatings are sparse. The variability in the aggregates includes evidence of burning and several contain microartifacts (Plate 8.74). Between N58 –59 in the Test Trench the massive zone is first cross cut by intrusive ancient excavations originating at the top of Zone P. Note the presence in profile of Fea. 450 indicating burning activity on the surface of Zone Q, prior to the deposition of Zone P (Figure 8.3).

In the western portion of the entrance chamber Zone P7 is overlain by a series of calcareous silt to silt loam deposits including various tertiary P6 zones (e.g., P6a, P6b, P6c) overlain by P5 (Figure 8.8). P5 is adjacent to P3 and the two secondary zones probably correlate, but at this point there are so many intrusive deposits in the 2 m area connecting the western area to the Test Trench that a direct correlation is speculative. The tertiary P6 zones all consist of massive to lenticular calcareous silt loam (with ash accounting for >60% of the silt) and are primarily individuated based on variable frequencies of charcoal, ash and sand- and gravel-sized clasts of hard red silty clay. To the west these zones are cross cut by Fea. 314 and continue, sloping downward to the west. West of W67.50 these deposits become more homogenized making it difficult to distinguish clearly among them (Figure 8.6).

Zone P5, like P3, is also composed of calcareous silt loam (with ash accounting for as much as 80% of the silt) containing granule- and gravel-sized charcoal and various aggregates (Plate 8.75). The structure is chaotic with no consistent microstructure but partially aggregated with limited clasts of articulated ash (Plate 8.76). The frequencies of the voids (all types represented) are relatively low.

Copious complex secondary and tertiary zones represent Zone P from the central area of the entrance chamber to the back wall. I have selected one localized sequence to describe the variability observed. These zones and the related sample locations are represented in Figure 8.12 (from bottom to top) P3e, P4, P4a, P3g and P3q (Plate 8.77).

P3e is a thin tabular zone of calcareous silt loam. This zone overlies a localized dense charcoal lens in turn overlaid by a white ash. These were not given individual zone designations in the excavation but are observed in profile and are noted here because they are probably directly related to the formation of P3e. P3e includes mixed aggregates, charcoal and microartifacts with sediment adhering to several of these sand-sized and larger materials (Plate 8.78). The structure is generally chaotic with few post-depositional aggregates but channel voids are present.

Abruptly overlying P3e is a 3 cm thick, hard, red silty clay stringer designated P4 (Plate 8.79, 8.80). The matrix consists of red brown aggregates mixed with unsorted sand size ceiling rain (Plate 8.81), and sand to gravel size limestone with travertine and weathered chert fragments (Plate 8.82). Several clasts of ceiling rain exhibit evidence of secondary iron staining or impregnations of clay on their outer surface (Plate 8.83). The upper surface is also unconformably sharp (Plate 8.79, 8.80). Micro-cracking is evident throughout the red brown aggregated matrix, especially along the upper boundary.

Above P4 is a series of distinct microstratigraphic ash deposits that are designated P4a. Although various types of ash crystals are present rhombic predominate. Microartifacts include burned bone, shell and minimal charcoal. Portions of the localized ash appear pink grey in color. Within these areas are red brown aggregates (responsible for the pink aspect) randomly mixed into the ash matrix matching P4 below (Plate 8.84). This ash appears remarkably "pure" in the field but in thin-section there were few articulated ash crystals observed; one portion in particular was identified with partially combusted plant material (Plate 8.85), while in others ash crystals are mixed and completely disarticulated with no organic matter present. In addition to channel voids there are also vertical and horizontal planar voids (Plate 8.86).

P3g marks a distinct calcareous ash zone above the microstratigraphic ash of P4a with an abrupt clear boundary. This deposit is coarser grained than that below with more microartifacts (burned shell, bone, travertine, microdebitage) and charcoal. P3g varies microstratigraphically in the density of the matrix (it is more compressed at the base) and in the concentration of aggregates. The type and presence or absence of articulated ash varies (Plate 8.87, 8.88). Secondary phosphate is visible in lenticular shapes but does not appear to be associated with mammal coprolites (Plate 8.89). Aggregates include approximately 10% red-brown and yellow-brown types. The yellow-brown are not present in P4a below and are more angular and significantly larger than the red-brown aggregates in P3g (Plate 8.90).

P3q abruptly and unconformably overlies P3g. P3q is described as an approximately 3 cm thick red stringer truncated by pits at both the northern and southern limits of the deposit. Characterized as soft dark brownish red silty clay it varies in color and consistency from P4 below. In thin-section the silty clay is dense, well sorted, with quartz silt and ash crystals and red amorphous clay (Plate 8.91). Single or aggregated ash crystals are randomly distributed throughout the matrix. Sand is unsorted and consists of 2-10% quartz, quartzite, and ceiling rain, along with granule-sized highly weathered chert. The structure appears to have been aggregated originally (~0.25 – 2.00 mm), but the aggregates are no longer clearly defined.

<u>Interpretation</u>

After the period of relative inactivity represented by Zone Q, Zone P depicts a depositional sequence resulting from intense human activity.

Conventional radiocarbon dates place Zone P formation at roughly 8,500 B.P. (possibly as old as 8,800 B.P.) to 7,000 B.P., with diagnostic artifacts supporting this temporal placement with Early Archaic Kirk Stemmed Points well represented.

The primary source of both P3 and P5 is human burning activity. A relatively high frequency of burned microartifacts and the absence of micromorphological features associated with fluvial transport indicate the burning was probably related to hearths inside and/or at the mouth of the cave. The aggregates were probably incorporated into ash as it clung to the material being burned. This in particular refers to the yellow-brown aggregates. The lack of sorting and the presence of aggregates of intact ash crystals suggest minimal transport and probably a combination of mixed *in situ* burning and fireplace rake-out. The southern edge of Zone P3, like most of the deposits along the drip line, represents a weathering interface more than a lithologic boundary. Ash probably once continued out of the cave entrance into Zone S1. The highly soluble ash has most certainly long since leached along with fragile bone and shell microartifacts. Post-depositional alteration in the form of decalcification appears to be minimal. Bioturbation was localized and did not affect the entire zone. This may be in part due to the relatively rapid accumulation of these sediments.

Based on the absence of articulated ash in Zone P7, and no burned "surface" beneath, the zone appears to be a mixture of transported mixed ash and disarticulated clasts of a burned surface (sand- to gravel-sized red clasts). The minor "cluster" of horizontally oriented chert debitage suggests a possible surface on top of Zone Q. Burning features and intrusive charcoal pits such as F. 450 further support this notion of an activity surface.

As noted above, P3e, P4, P4a, P3g and P3q represent intensive anthropogenic activity depositing over half a meter of discrete ash deposits, prepared surfaces and pits. The first zone in this representative sequence is P3e. Zone P3e immediately overlies a zone of white ash over a charcoal lens. I suggest that these underlying zones are remnants of in-place burning while P3e is an upper trampled and mixed zone associated with the underlying burning deposit. The trampling is suggested by ash adhering to some clasts such as red-brown aggregates and larger charcoal pieces. No obvious worm or mite excrement is observed, but channel structures and mixed particles suggest at least localized bioturbation.

Laid out carefully over this soft substrate was P4, a prepared surface composed of unsorted red silty clay autochthonous sediments typical of the cave interior. Micro-cracks along the upper boundary are indicative of direct heating and cooling. The hard aspect of the sediment indicates it was subjected to high (>500°C) temperatures or used repeatedly with long burn times resulting in permanent water removal from the sediment.

The variability described in P4a was observed both in the field and in thin-sections. Inconsistent amounts of charcoal, partially combusted organic material, and red-brown aggregates may be responsible for the change compared to the underlying P4. The underlying *in situ* prepared surface suggests these variable ash deposits are the result of both *in situ* burning events and subsequent localized trampling and limited bioturbation. The vertical cracks indicate desiccation, suggesting that prior or during trampling the deposits became wet, possibly compressed, then dried out. No structures are present suggesting fluvial deposition. These calcareous microstratigraphic deposits are overlain by a similar deposit designated P3g.

P3g is composed of very unlike material suggesting a different burning event that may represent either a distinct fuel and/or activity. This zone has significantly greater phosphate, which may be secondary, but the lenticular or distinct shapes of the phosphatic material suggest the alteration of bone or organic matter. Bird guano may be a possible source; this is suggested only on the basis of the tentative interpretation of burned eggshell in the deposit (recognizing that the guano and eggshell may be totally unrelated). So far no data are available to further investigate the issue of phosphate diagenesis.

Based on the excellent bone preservation in the cave, phosphate diagenesis is not an immediate concern. This issue is, however, central to archaeological interpretations in sites where bone distributions are a direct result of variable preservation. In such cases the identification of various mineral forms can be used to reconstruct bone distributions that are no longer clearly defined (see Karkanas et al. 2000, and Weiner et al. 1995).

The distinct presence in P3g of yellow-brown aggregates at various sizes suggests that the activity incorporated upland soil from the Bt horizon. This soil could have been derived from colluvium, but the purity and angularity may represent soil adhering to plant roots introduced as those plants were burned. Goldberg has observed similar features in ash deposits associated with ancient hearths in caves in Israel (Goldberg, personal communication). At this point there is not enough known about plant ash and its direct relationship to specific plant species to speculate on what was being burned (c.f. Wattez and Courty 1987). Future actualistic studies at the site should better qualify this material.

Zone P3q is another prepared surface, but it is markedly different than P4 below. It is soft, suggesting the fires never reached a temperature to permanently drive the water out of the matrix. In addition, the two prepared surfaces have different lithologies; P4 is predominantly clay whereas P3q is mostly silt (quartz and ash).

This sequence represents concentrated and repeated use of the cave for burning activity during the formation of Zone P. Sediments were collected from an autochthonous source and surfaces were prepared following consistent specifications of thickness and basic composition. These surfaces were used repeatedly for intensive burning resulting in ash concentrations. The variability in the ash deposits appears to result from the fuel used, possibly the overall function of the hearth, and post-depositional processes (trampling, bioturbation and saturation).

The P5, P6a, P6b, P6c sequence representing the massive ashy deposits to the west indicates a depositional history different from those concentrating in the center of the chamber. The structure and contents of these western deposits point to this area of the cave functioning primarily as a "toss zone" for fireplace rake-out. There are few to no intact burning surfaces along the west wall and the structure of the deposits is mixed including dispersed ash and charcoal, microartifacts and clasts of burned prepared surfaces. These deposits have undergone only limited bioturbation and appear generally compact with limited void space. This compaction suggests that the ash was saturated and possibly even underwent partial decalcification. This may account for the gentle slope trending downward to the west. Compaction resulting from saturation and limited decalcification could have occurred along the western wall where there is a well-established history of phreatic water being expelled from the cave. Seasonal activity of the aquifer and localized saturation would have been enough to invoke localized subsidence and compaction resulting in the observed slope.

Many of the large intrusive pits functioning as burials typically originate at the top of Zone P/base of Zone N and relate to Eva/Morrow Mountain components (7,000 B.P. to 6,000 B.P.). The pit outlines are difficult to detect in the complex sequence, and during the testing phase lighting was poor in the cave. As a result several of these pits were not initially identified. One of the radiocarbon dates supposedly related to Zone P (Beta 48755) is indicative of this problem with a conventional date of 6,050 +/-100 (Figure 8.4). Closer inspection of the excavation records and their correlation with our current vertical profiles indicates this charcoal sample was derived from intrusive burial fill, probably relating to surfaces associated with Zone N above. Due to these circumstances and the lack of burial goods to clearly associate burial component affiliations, many of the burials recovered in the cave are not yet dated. Aspects of the preliminary artifact and human skeletal analyses should be reassessed to determine the precise context of the materials.

Zone N

Description

Distribution

The Zone N designation is generally used to refer to the distinct red zone that is located between Zone K and the ashy deposits and red stringers associated with Zone P. This massive zone might have been included with Zone P except that the large intrusive pits that cross cut Zone P appear to begin at the base of Zone N suggesting both a shift in activity within the cave and a later chronostratigraphic association.

Zone N at its thickest measures approximately 20 to 30 cm thick from 270 to 300 cmbd. This zone was excavated under several designations (as it was observed in different portions of the entrance chamber) (Figure 8.2, 8.3, 8.7, 8.8). N4 extends from the drip line towards the rear of the cave where intrusive pits create the northern limits around N62. It is not clear if the zone ever extended to the rear wall, but this appears doubtful since it thins and fades in Profile N63 (Figure 8.9). Also to the west N4 thins significantly until it is truncated by several intrusive pits and is no longer visible along the W68 profile (Figures 8.6, 8.7).

N is the first zone that can be discussed in the context of the east side of the Test Trench. The upper excavation on the east side currently covers an $8m^2$ area extending from N59 to N63 and W60 to W62 (Figures 8.14. 8.15, 8.16). The

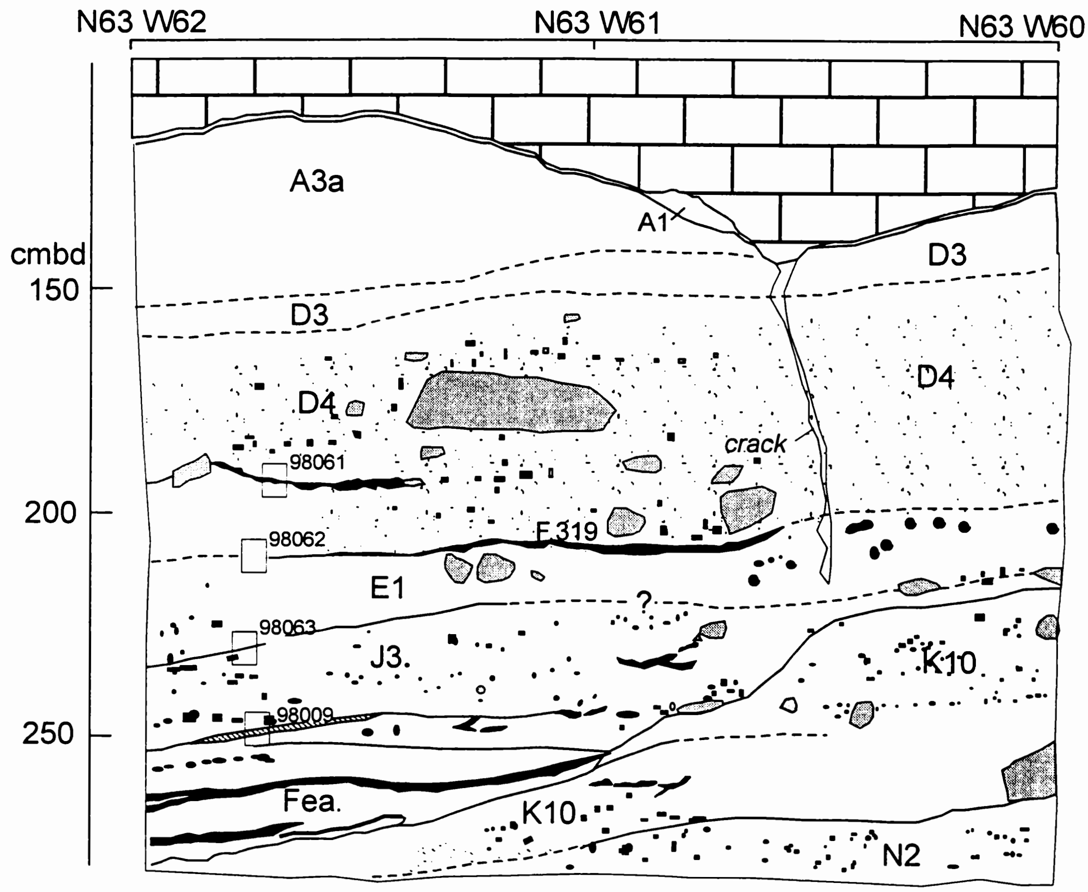


Figure 8.14. Profile N63, W62 to W60, Surface to 280 cmbd.

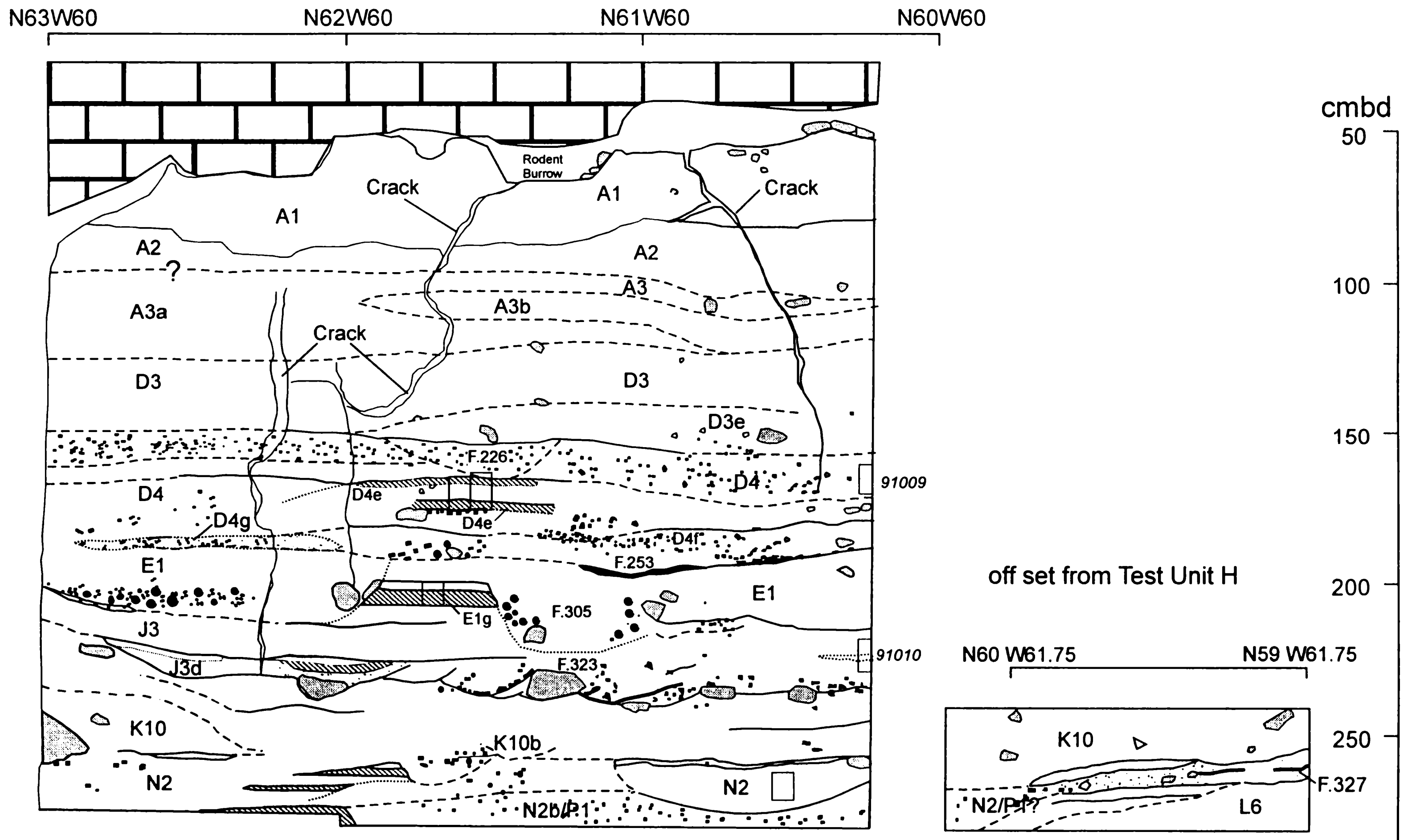


Figure 8.15. Profile W60, N63 to N60, Surface to 280 cmbd. Offset Profile Section N60 W61.75 to N59 W61.75, 240 to 280 cmbd.

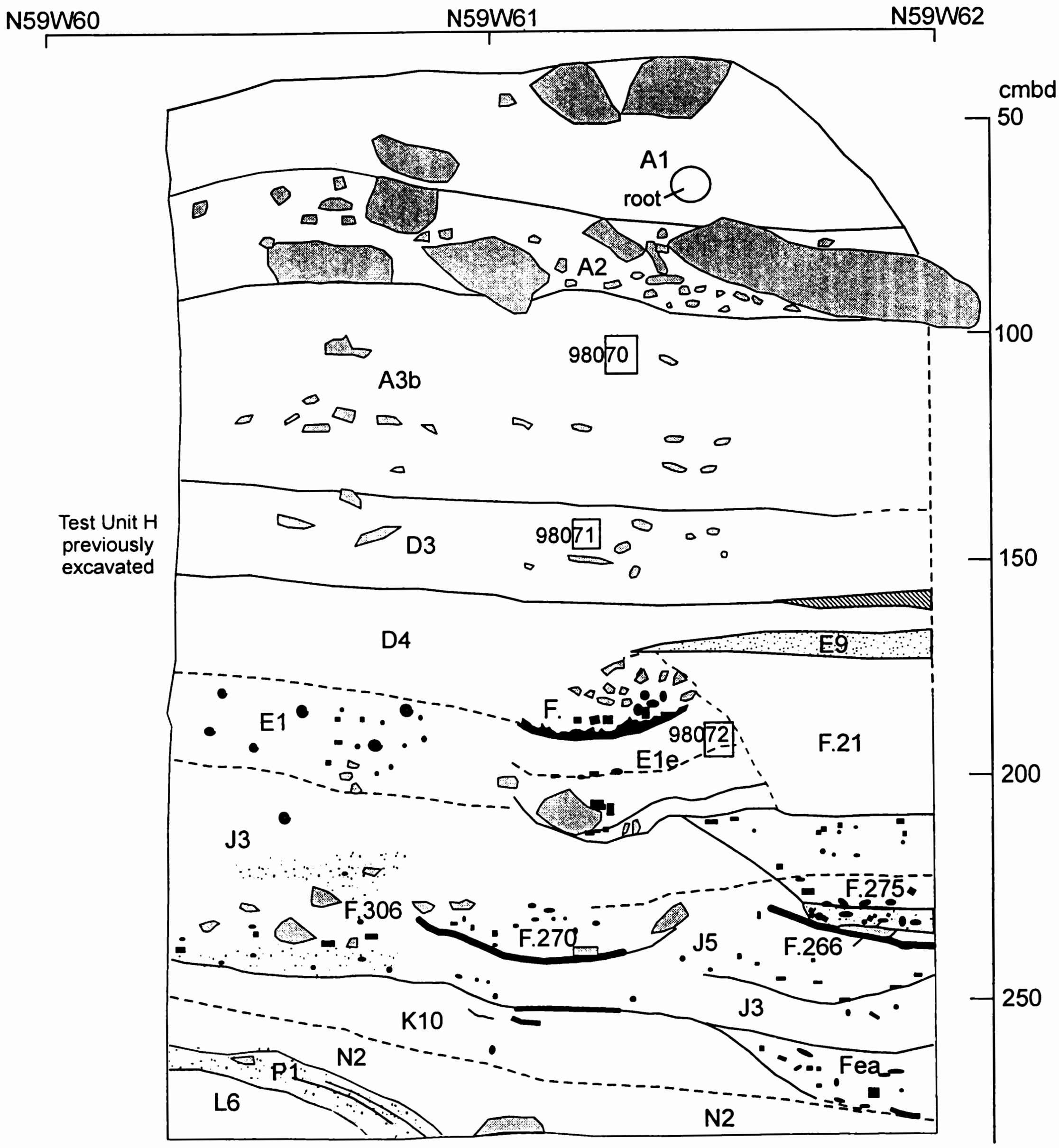


Figure 8.16. Profile N59, W60 to W62, Surface to 280 cmbd.

top of zone N is present, though not well defined, at the base of this excavation area at ca. 275 cmbd. Zone N2 is the principle secondary unit defined on the east side. The east-west profiles show that N appears to slope downward into the cave from the entrance (Figures 8.14, 8.16). Along the southern extent, just inside the drip line, these zones were exceptionally hard to follow and correlate. Using the east-west profile from the north wall of test unit H is, as noted previously, of little benefit as the profile drawing predates the establishment of zones in the excavation.

Lithology and Structure

Macroscopically the lithology and structure of N is very homogeneous. N4 directly overlays the complex stratigraphy of Zone P that consists of red prepared surfaces and innumerable ash deposits. The boundary is abrupt and unconformable. To the west there are several tertiary zones along this boundary. These were excavated as Zone N but may be part of the P sequence. Regardless, N4 lies immediately over these localized zones. N4 is described in the field as a tabular soft red silty clay to clay with localized variability. The local variability includes intensity of the red color, more coarse texture, and cementation. In addition to the variable color and texture is a complex intrusion or series of tertiary deposits visible in the W64 profile along N60 (Figure 8.2). This area is comprised of hard red stringers and ash similar to those in Zone P. The micromorphology samples from this area were not successfully processed so it is difficult to determine the sequence of events that lead to these complicated deposits.

I have only two representative thin-sections of N4, collected from the east wall of the Test Trench (Figure 8.3, 93010). In thin-section N4 is composed of complex silty clay that is calcareous only in "patches". The clay is very red and appears both as amorphous clay among the silt grains and red silt-sized papules. The silt is generally well sorted, comprising over 50% of the matrix with some "patches" of single ash crystals and possibly ceiling rain: other silt concentrations are noncalcareous with laminated clean quartz and papules with some preserved graded bedding (Plate 8.92). Sand is poorly sorted but appearing both random and clustered probably accumulating in voids (Plates 8.93, 8.94).

Two attributes of the Zone N4 sediments stand out. First and foremost is the extensively aggregated matrix with numerous planar, channel and packing voids (Plate 8.95). The second attribute comprises concentrated but localized hypocoatings where up to 40 to 50% of the matrix is embedded in secondary carbonate (Plate 8.96). Calcite rhizolith structures were observed in these portions of the matrix (Plates 8.96, 8.97)

Zone N2 characterizes the eastern manifestation of N4. It is described as red brown silty clay with as much as 5% gravel-sized charcoal fragments. In thin-section the matrix consists of an aggregated structure (packing, vugh, and channel voids) with dispersed ash and microartifacts (Plate 8.98). Micritic coatings and hypocoatings are few. In general, the zone is massive with no clearly defined micro features revealing distinct depositional processes. Of the 10% sand composing the sediment in thin-section, partially decalcified limestone and ceiling rain represented a small but consistent portion (Plate 8.99).

Interpretation

The deposition of Zone N post-dates the intensive Eva/Morrow Mt burial activity in the cave that intruded into extensive anthropogenic zones of Zone P. Zone N in general appears to date to a brief 200-year period between roughly 7,000 B.P. and 6,800 B.P (Table 1.1). Human habitation during this time was limited and the majority of the sediment appears to be the result of slopewash events combined with colluvium.

Zone N2 and N4 were extensively bioturbated resulting in an overall homogeneous appearance. In several locations Zone N4 overlays hard red stringers assumed to be prepared surfaces (e.g., P30). These surfaces would have impeded biological activity and restricted it to the layer above. The history of the intrusion along the N60 section W64 profile is not clear and could be the result of burrowing combined with subsidence of the prepared surfaces as the underlying pit fills settled.

In thin-section N4 has only small areas of remnant structures that indicate transport mechanism(s). The source appears to be a combination of anthropogenic sediments, most likely already mixed or transported (based on the dispersal of the ash), and autochthonous materials. The predominance of quartz silt with little to no mica draws an alluvial source into question. The material appears to have been derived from slope wash based on the isolated areas of graded bedding and slaking crusts. Extensive bioturbation followed, nearly obliterating most of the transport features. The fecal pellet size varies significantly suggesting various types of soil fauna. Root activity appears to be responsible for the localized cementation, based on the presence of calcite rhizoliths. The localized variability in the zone consists of distinct bioturbation features next to cementation. This variability does not support a massive depositional event but rather numerous deposits that were subsequently bioturbated. The origin of the red color must be a combination of concentrated clay and calcite cementation.

Based on preliminary exposures of N2, the eastern manifestation of N4, the zone character changes as it takes in increasing amounts of colluvial sediments, coarser grains, and charcoal. This allochthonous material in concert with the downward slope trending from the entrance into the interior suggests concentrated input from outside the cave along the eastern side. Localized remnants of hard red superimposed tertiary zones (possibly burning surfaces), exposed in the eastern most profile W60 (Figure 8.15), suggest periodic stability.

Zone K

Description

Distribution

Zone K is represented by a few major secondary zones containing tertiary zones and complex intersecting pit features. Unfortunately the K zones fall along the arbitrary boundary of the ending and beginning of different dig seasons and as a result the notes are not as congruent as for many of the other zone groups. To further complicate the interpretation of Zone K, when the upper portion of Test Unit A collapsed, prior to the practice of intensive shoring in the cave, the upper portion of the profile was lost from the base of Zone K upward along W66 (Figure 8.8). This limits the discussion somewhat of Zone K on the western side of the entrance chamber. On the east side of the chamber Zone K is exposed, though difficult to delineate, sloping downward from the east-southeast from the entrance (Figure 8.14, 8.15. 8.16).

Zone K3 is a thick tabular zone from ca. 270 to 230 cmbd. The drip line around N57 marks the southern boundary, adjacent to the upper portion of Zone S1 (Figure 8.2, 8.3). K3 is truncated to the north by distinct anthropogenic deposits and concentrates at the center of the entrance chamber (Figure 8.3). K2 overlies K3 to the west and P2 and N2 in the center. Along the east wall of the

Test Trench, between N59.50 - N60.50, more complex tertiary K zones and pit features intrude or replace Zone K2. This area of intensive activity horizontally mirrors that of the lower zones. Zone K3 extends into the eastern portion of the chamber, thinning east of W67 where several tertiary zones and pits intrude this tabular zone (Figure 8.7), and the zone can no longer be identified past this point (Figure 8.6). K3, along the western side of the chamber, thins toward the rear of the room (to 10-20 cm thick) where it overlies N8 and is again difficult to follow due to numerous poorly-defined tertiary zones and intrusive pits (Figure 8.9).

Zone K2 is a discontinuous "red zone" overlying K3 that first appears inside the drip line at ca. N59 and continues, measuring approximately 10 cm thick, across at least a 4 to 5 m^2 area from N59 to N63 and W62 to W65. Numerous pit features, some rock filled hearths, intrude through K2. Zone K1 appeared to be another massive tabular zone (> 20 cm thick) that overlies K2, in the center of the chamber, and K3 and various tertiary zones to the west, possibly correlating to K10 on the eastern side of the chamber. The eastern side is sampled microstratigraphically along the N58 profile where the intensive tertiary zones representing remnants of human activity are preserved inside the drip line. Here a confined soft red zone, K2g, was sampled as a tertiary zone between K3 and K1. Zone K2 could be contemporaneous but is confined immediately to the east (Figure 8.17).

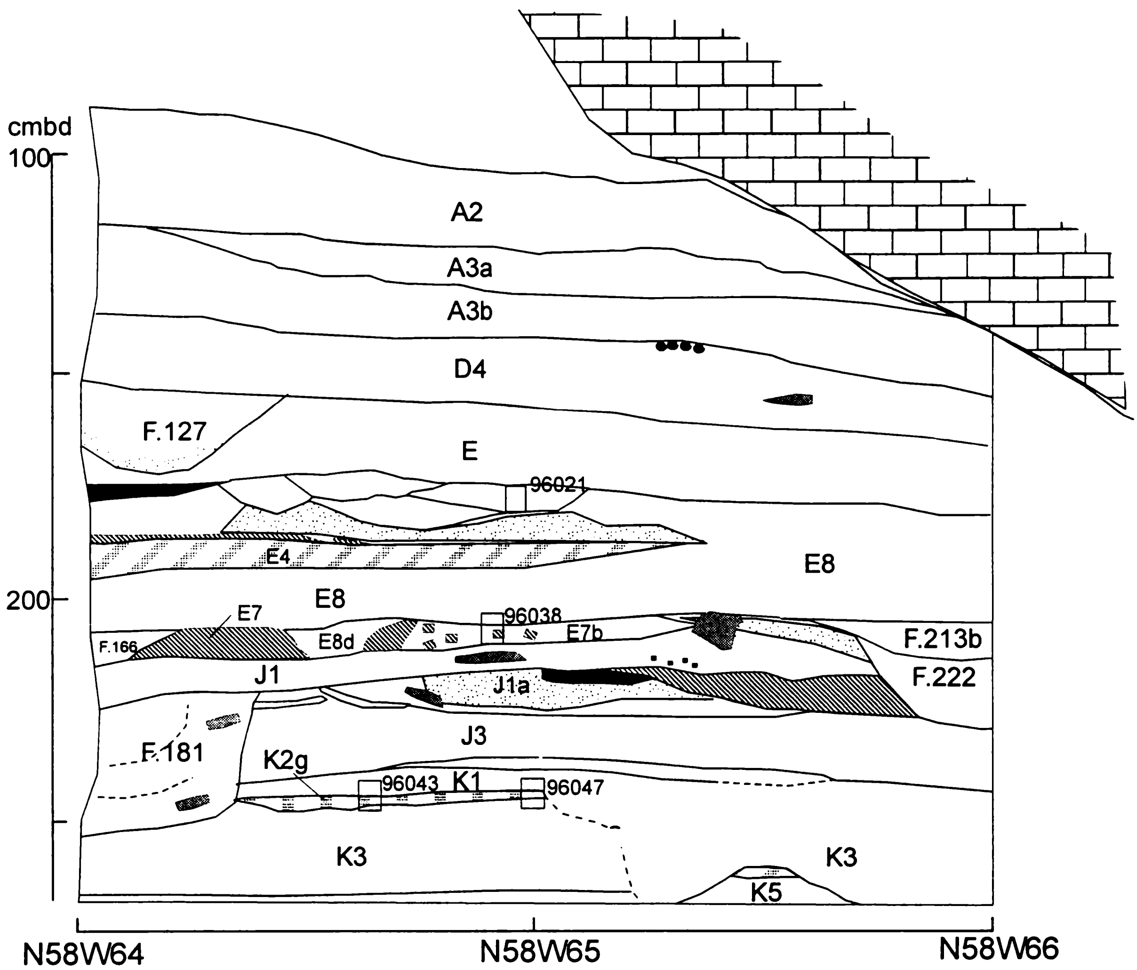


Figure 8.17. Profile N58, W64 to W66, Surface to 270 cmbd.

K10 is a massive tabular deposit, overlying N2 that slopes downward into the cave from the direction of the entrance. Intruding K10 are pits from Zone J on the east side (Figure 8.17), and to the west by other complex series of pit features also originating in Zone J (Figures 8.7, 8.14).

Lithology and Structure

Zone K3 is a massive unsorted grayish brown calcareous deposit(s) composed of ash with various aggregates, burned microartifacts (shell, bone, charcoal), and a variety of sand-sized materials (Plate 8.100). Though generally homogeneous, there are localized cemented areas resulting in a hardened aspect. The structure varies, but extensive channel, vugh, and packing voids (various sizes) and partially infilled channels and chambers indicate extensive biological activity. Dense but localized micritic coatings and hypocoatings appear throughout the matrix (Plate 8.101).

The upper boundary of K3 is abrupt, with the unconformable deposition of Zone K2. K2 was described in the field as red silty clay with localized ash concentrations having a hard aspect that varied laterally. Like K3, K2 in fact appears to be several deposits that emerge as one continuous, red massive deposit in the field. The lateral variation does not appear to be solely the result of post-depositional processes but due primarily to variable lithologies. Every thin-section examined revealed a completely different lithology. The only consistent aspects included a poorly sorted sand- to gravel-sized fraction that consisted of microartifacts (~5%), and abrupt unconformable boundaries at the top and bottom of the zone. Some of K2 was composed of well-sorted silt and poorly sorted sand in an aggregated structure with no secondary calcite deposition. Approximately 40 cm from this sample (horizontally) is a completely different lithology associated with K2, with compacted, well-sorted calcareous silty clay with clusters of sand composed of rounded papules, quartz and chert. Planar voids are visible but again no post-depositional secondary calcite (Plate 8.102). Still other thin-sections reveal a dense massive to aggregated structure of red silty clay with various aggregates with micritic coatings and hypocoatings associated with >60% of the voids (Plate 8.103). Again less than 40 cm away is a more densely packed manifestation of the red zone with nearly the entire matrix embedded with secondary calcite (Plate 8.104). An interesting feature in this thin-section (93028a) is the presence of 1.0-2.5 mm red-brown aggregates that contain no micritic coatings suggesting that these were previously heated to the point where they will no longer hydrate (Plate 8.105).

To the east of K2, K2g consists of a soft red lens or stringer that has only been partially excavated but appears to cover a ca. 70 cm^2 area. This zone lies on top of K3, beneath K1. It is made up of clayey silt composed primarily of quartz and mica (Plate 8.106). There is approximately 10% poorly sorted sand of mixed quartz, mica and miscellaneous heavy minerals. There are no secondary features of calcite precipitation observed in association with K2g.

The upper part of K2g is abruptly overlain by K1, composed of numerous microstratigraphic deposits of laminated ash with graded bedding. Along the eastern wall, these micro-lenses composing K1 consist of an ash matrix but vary in the presence of several features and components including aggregates and slaking crusts (Plate 8.107, 8.108), dusty clay intercalations within ash (Plate 8.109), dendritic manganese dioxide (Plate 8.110), and ash with variable amounts of aggregates. The presence and degree of secondary calcite precipitation varies and includes concentrated rhizolith features, in this case disturbing *in situ* slaking crusts (Plate 8.111).

Zone K10 consisted of a massive deposit with varying concentrations of charcoal. In thin-section the matrix is a calcareous silt with ~20% ceiling rain as well as dispersed ash single crystals (Plate 8.112). The sand fraction includes charcoal, burned shell and bone, various aggregates (only ~3%) and chert and limestone. The structure is aggregated with very few micritic coatings on channel and packing voids (Plate 8.113). K10b is a thin red zone that was observed overlying K10 along the upper eastern excavation block in the N63 profile (Figure 8.15). The lens measures 1.5 cm thick across an area approximately 40 cm^2. It is composed of an aggregated well-sorted silty clay matrix with approximately 20% angular chert and limestone granules (~0.5 cm)

(Plate 8.114). The real significance of this zone is its 20° to 30° dip to the southeast.

Interpretation

Zones J and K are ethnostratigraphically (*sensu* Stein 1990) associated, with Zone N and are dated to roughly 6,000 to 7,000 B.P. This chronostratigraphic designation is based on several radiocarbon dates (Table 1.1) and the presence of diagnostic Middle Archaic Eva/Morrow Mt. Projectile Point styles (Driskell 1994).

The massiveness of K3 and the mixed, unsorted nature of the lithology, suggest that it is in fact a result of numerous dumping episodes that were probably derived from human burning activity. The matrix is primarily composed of ash (some articulated), and numerous burned microartifacts. Throughout the zone are variably defined biological aggregates (various sizes); this microfabric along with the general absence of any clear sedimentological features suggests that the zone is extensively bioturbated. This is further supported by the concentrated micritic rhizolith structures. These calcite root structures further suggest that roots carrying carbonate rich waters are primarily responsible for the localized cementation.

Zone K3 is interpreted as a massive zone of fireplace rake-out perhaps resulting from extensive burning activity at the entrance of the cave, coupled with burning surfaces on the top of Zone N. The source cannot be further secured beyond that of anthropogenic sediments that have been extensively post-depositionally altered.

The lithostratigraphic unit referred to as Zone K2 is interpreted as a compilation of unique deposits. In the field, however, due to its relatively uniform hardness, the zone was treated as one large depositional unit, initially believed to be a burned floor where numerous small pit features and a large rock hearth originated. Microstratigraphic analysis of this zone, considering the nature of the prepared surfaces studied in other zones, indicates that it is actually a series of prepared surfaces that both coalesce and are divided by thin localized ash deposits. At this point it is impossible to isolate these surfaces as tertiary zones. But based on the variable lithology (all similar to various other prepared surfaces) the presence of unsorted micro and macroartifacts, their unconformable and abrupt contacts and universal hardness, K2 is regarded as a series of prepared surfaces. Some appear to be hardened due to heating while others appear to be hardened due to secondary calcite cementation.

Noted is the presence of the relatively large red-brown non-calcareous aggregates though they were in a dense micritic matrix. This phenomenon explains why some adjacent areas in K2, though probably exposed to carbonate rich waters, did not absorb the water or result in carbonate precipitation. A similar feature supporting this interpretation was noted in thin-section 93013, revealing the upper boundary of K2 with a dense ash deposit on top. The ash is composed of mixed aggregates and microartifacts, typical of a mixed burned deposit. The ash contains secondary calcite as micritic coatings and hypocoatings, with dense micritic rhizolith structures along the contact (Plate 8.115). This implies that while carbonate rich waters moved through the ash zone they could not penetrate this area of K2 nor could the roots that concentrated along the top of the zone. This suggests that here K2 had been heated to the point where the matrix would not absorb water, resulting in a miniature perched water table of sorts.

Zone K2g is interpreted as another isolated prepared surface. K1 varies throughout the entrance chamber but, along the eastern front of the cave described above and overlying K2g, Zone K1 is clearly a series of episodic slopewash deposits. These microstratigraphic lenses incorporate various fine grained materials and may be the result of periodic drip, with slope wash and pooling along the brow of the cave suggested in the limited energy and accumulation of fine grained slaking crusts. Clay intercalations indicate brief and episodic stability. The dendritic manganese dioxide points to saturated sediments; further suggesting this was a wet microenvironment. Post-depositional disturbance was limited based on the preservation of the fragile graded bedding and localized articulated ash and appears to have consisted only of limited root activity.

This southwestern portion of K1, near the cave wall, is probably unique compared to the rest of K1 in the entrance chamber. Though no further thin-sections are available to represent the zone, field observations indicate mixed calcareous deposits including various amounts of charcoal (nearly absent in the thin-section described), and potentially bioturbated structures. Zone K1 most likely correlates with K10 representing the more massive upper K zone on the opposite side of the cave. K10 slopes downward into the cave from the entrance, and its matrix contains concentrations of ceiling rain, fine-grained silt and clay, and mixed anthropogenic material that is extensively bioturbated. The matrix, structure and aspect suggest material derived from the entrance (human activity, and colluvium, specifically eroding off the ceiling and brow of the cave) entering the cave probably through slopewash and gravity down slope. Any slopewash features would have been obliterated by the extensive bioturbation. Based on the structures of K1 on the east side, slopewash, perhaps at a different scale, was most likely active.

Further support of the sloping aspect of the K and N Zones in the eastern block excavation is the slope of K10b. This lens is interpreted as a prepared surface. The source area is very different from most of the material in K2 and that of K2g. It contains a higher frequency of chert and quartz fine gravel and a fine, well-sorted silt matrix. The well-sorted quartz silt matrix has been observed in several other prepared surfaces.

The K zones represent continued construction and use of prepared surfaces involved with extensive burning activity within the cave. The numerous pit features that appear to be contemporaneous with K2 further suggest a relationship between the two features. The limited field description of K2, the absence of east-west connecting profile, and the lack of samples that address the potential for vertical "stacking" of these tertiary zones (observed in other area zones) are an artifact of the testing phase of the excavation and the methodology used to remove the Test Trench. A small section profile cross-cutting K2, drawn during the testing phase, does indeed illustrate this "stacked" phenomena and the variable stringers of ash between the tertiary K2 zones.

K1 and K10, overlying K2, suggest continued burning and human activity, perhaps concentrated at the entrance, resulting in anthropogenic sediments and ash washing into the cave from the entrance. Based on the limited area exposed, it is difficult to interpret the slope clearly represented in the K and upper N Zones in the eastern block excavation.

Once east of W62 the deposits appear to level out and become horizontal. There may have been a more peaked talus at the drip line on top of S1 that is no longer present. Zone E in the talus, just below the brow of the entrance appears to be intrusive into E1, J and the top of S1 (Figure 8.3). The general profiles drawn for Test Unit H, mentioned at the beginning of the chapter, offer no indication as to the nature of the deposits along this portion of the entrance.

The upper contact of Zone N has been referred to as an erosional contact. I have no direct evidence of this beyond the impressions of the excavators and the abrupt contact at the top of N. Zone K contains no evidence of high-energy alluvial features or coarse alluvial deposits that might signal a high-energy event strong enough to erode the floor of the cave. There is one other possibility that I would like to propose although I lack the data to test it. At the upper boundary of Zone N as it is observed now, there would have been approximately 2.6 m of head room at the back of the cave and approximately 2 m at the front of the cave. This would be considered by today's standards as "standing height". There is the possibility that in order to make the entrance chamber a more comfortable place, easier to negotiate, the interior could have been partially excavated to provide more headroom. Technological limitations would not have made this an easy task, and there is no evidence to support this other than the slope to the east, the abrupt upper boundary of Zone N and the suggestion of a desirable height.

Zone J

Description

Distribution

Zone J immediately overlies Zone K and represents a ca. 30 cm thick series of secondary tabular units with a few tertiary zones. J3 is the most widespread secondary zone, and is a tabular deposit(s) that can be tentatively traced throughout the entrance chamber. Beneath Zone J3 are deposits that may have directly contributed to J3. These deposits either rest on top of K or intrude into its upper reaches. Representative of these few tertiary zones are J3d (Figure 8.15) and J3b (Figure 8.2). These zones are located in the center of the chamber at elevations concentrating at 220 cmbd. Both zones cover at least 1 m^2 with J3d continuing into the W60 profile (Figure 8.15). Features 238 (Figure 8.7), 323 (Figure 8.15), and 270 (Figure 8.16) represent typical shallow basin-shaped features for Zone J. Localized burning areas occur with dense charcoal concentrations often including burned rock.

The massive, widespread Zone J3 is equated with the Talus Zone B2 visible between N56 and N57 in the Test Trench (Figures 8.2, 8.3). This front portion of J3 is clearly truncated by the large intrusive Zone E9 (Figure 8.3). Intrusive complex pits containing concentrated charcoal, burned gastropods, and rocks are clearly concentrated across the forefront of the entrance chamber beginning 1.5 to 2 m north of the drip line (e.g., Fea. 181, 83, 222, 238, 286, 275,

266) (Figure 8.2, 8.3, 8.15, 8.16, 8.17). North of these pits, 4 to 5 m from the drip line, J3 is again clearly discernable to the back of the cave. To the west J3 continues and in the eastern block J3 follows the slope of K10, but it fills in the lower portion of the slope so E1 above - though still slanting downward from the cave mouth - represents far less of a sloping deposit. In profile W66 (Figure 8.18) the first indication is visible that there may have been sloping of the upper deposits along the western side of the entrance as well. This is a limited profile, and it is not clear if the dip of J3 is due to intrusion into K1 or if the subzones of J truly slope from the drip line down into the cave. This aspect is not observed in the W65 upper profile (Figure 8.18).

Zone J1 is identified on the western side of the entrance chamber overlying Zone J3. The J zones in general are slightly thinner on the east side, closer to the entrance. Zone J1 was not observed in thin-section but appears to extend across the western side of the cave towards the rear of the chamber (Figures 8.2, 8.17).

Lithology and Structure

In general Zone J is composed chiefly of ash. Zones J3d and J3b represent tertiary sediment concentrations overlying Zone K composed of concentrated ash and red clay stingers. Typically these types of deposits are segregated in the cave into distinct lenses, but in these zones they are mixed

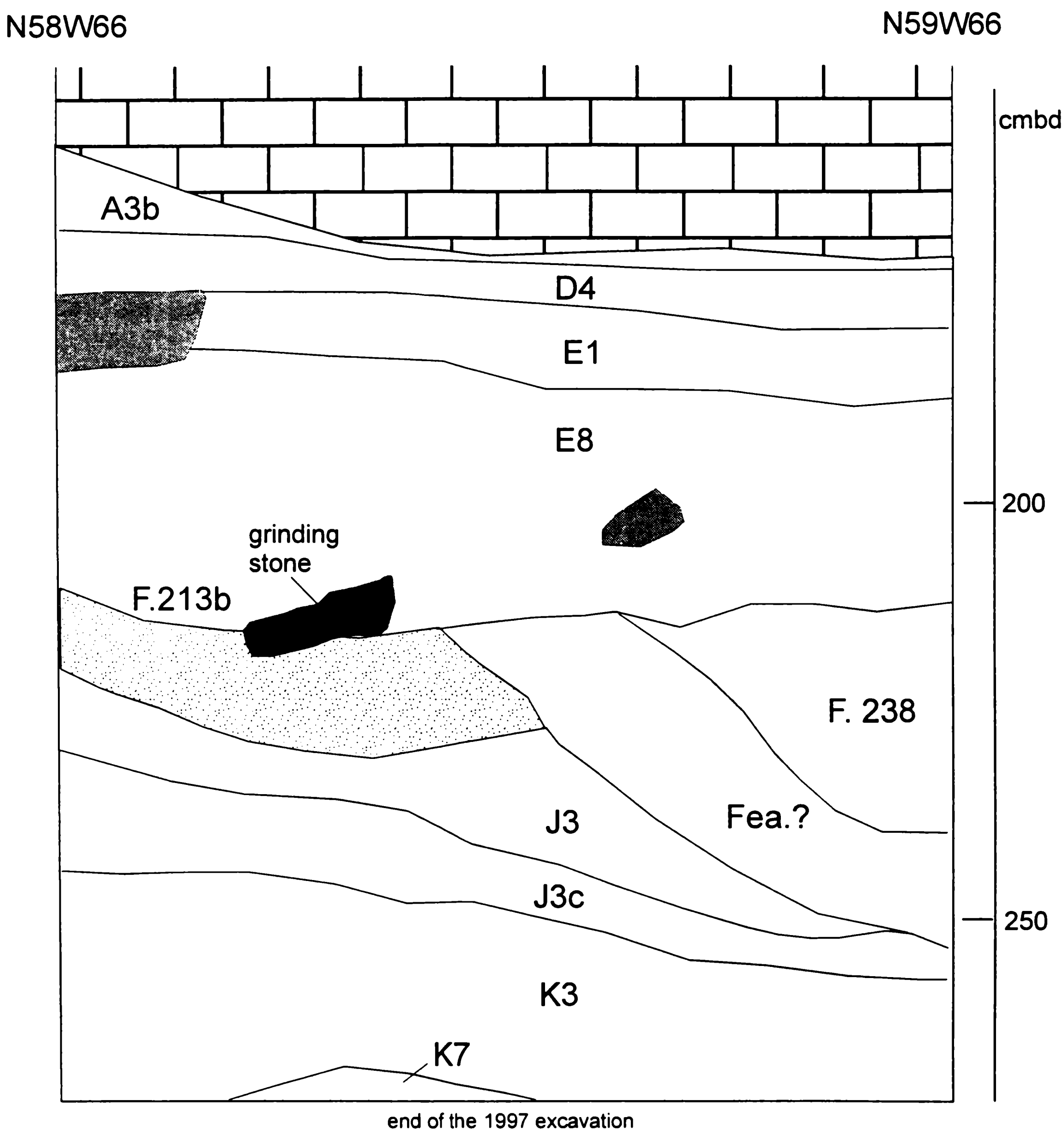


Figure 8.18. Profile W66, N58 to N59, Surface to ~270 cmbd.

together. J3b is described in the field as a silt loam ash containing charcoal and red clasts with a mottled appearance. The zone dips down into the uneven surface of K1 and K2. In thin-section the matrix is compressed with coarse sand-sized aggregates (yellow-brown, red-brown and light-brown) composing approximately 15% of the matrix (Plate 8.116). Burned microartifacts are randomly scattered throughout the ash. Banded concentrations of ash and red brown and/or light-brown aggregates or sand-sized material occur (Plate 8.117). Noteworthy is a 1 cm thick microzone composed of noncalcareous fine sand and silt mixed with variously sized dense papules (~30-40% of the area) (Plate 8.118). The ephemeral nature of the noncalcareous concentrations probably produced the mottled appearance described in the field. Vertical and horizontal planar voids are visible throughout the otherwise dense fabric. The vertical voids contain micritic rhizoliths (Plate 8.116).

Zone J3d was described similarly but with areas of partially cemented "patches". In thin-section, Zone J3d is more mixed than Zone J3b, with the banding not due to distinct ash or concentrated aggregates but slight variations in their density or a change in fabric suggestive of laminar deposits (Plate 8.119). Thin dusty and birefringent clay coats horizontal planar voids and several aggregates. Micritic coatings are thin and appear as localized fine crystals in fine voids, basically embedding areas of the matrix. Bioturbation appears as locally concentrated aggregated structures adjacent to large cracks (Plate 8.120).

Zone J3 is described in the field as a relatively homogeneous zone with scattered charcoal in a gray brown calcareous matrix. In thin-section the matrix is a silt loam of mixed ash with localized clusters of sand-sized material (Plate 8.121) including microartifacts, variable aggregates (including ash aggregates), and concentrated charcoal (as in the nutshell charcoal in 93012, see Appendix D) in a chaotic fabric. Concentrations also include highly localized, dense micritic coatings among concentrated channel voids (Plate 8.122), while other areas are densely compacted.

Zone J1 was not examined microscopically, but it also appeared as ashy matrix with charcoal and patches of concentrated ash with localized cementation. J1 is described as containing noticeably less charcoal and more ash relative to Zone J3.

Interpretation

The division of Zones J and K is based on lithology and not chronostratigraphic or ethnostratigraphic divisions. Most likely the variable lithologies represent different manifestations of the same type of activities, specifically intensive burning. K may represent the surfaces where these activities occurred and J the byproduct of the activity, massive amounts of combusted material, particularly wood ash. Zones J3d and J3b, as well as several shallow basin shaped pits of concentrated charcoal, are a continuation of the type of activity conducted in Zone K. The difference is that the tertiary zones in Zone J do not represent clearly defined prepared surfaces. The sediments are mixed and appear to have been extensively saturated, probably post-depositionally and due in part to the "perched water table" resulting from the relatively impermeable layers related to Zone K2.

It is unclear if the clay micro-lenses in Zone J3d are intercalations or post-depositional coatings. They seem to concentrate in planar voids or surrounding aggregates and clasts with none present in vughs or channels (Plate 8.123). The propensity toward vertical and (specifically in the case of J3d) horizontal planar voids in the lower tertiary zones suggest saturation followed by drying. The nearly total lack of charcoal in these ash zones suggests intensive burning and total combustion unlike the larger subzones where charcoal is abundant and includes localized dense concentrations. The variable calcite structures suggest that localized precipitation of micrite appears to be the result of both roots and saturation.

Zone J3 emerges as the result of numerous depositional events and source materials, consisting primarily of anthropogenic sediments. Due to various post-depositional processes including trampling, bioturbation, periodic slopewash, and localized saturation, the depositional events can not be delineated, at least in lithologic units isolated for excavation.

With Zone J we see a shift from concentrated human activity in the center of the entrance chamber to activity in the front of the cave. The rear of the cave was still in use but not as intensively as in the past. There are pits in the back of the cave during this time but they are larger than earlier ones and appear related to either storage or burial activity, not active burning. Some of the charcoal concentrations may relate to rake-out deposits tossed towards the rear of the chamber. The ceiling height was greatly reduced by now, less than 1.5 m at the back of the cave and less than 2 m at the front. Thus, by this time the rear of the entrance chamber was no longer "standing room" and may have served not as an activity area but a disposal area.

The presence of J1 along the western side of the cave, extending into the rear of the chamber, and the overall thicker aspect may be a direct result of the kinds of activity taking place. This seemingly increased accumulation may not suggest a higher sedimentation rate but rather a "typical" marginal activity area where large pits are excavated and rake-out is dumped. Now, however, the restrictive ceiling height diminishes compaction due to trampling.

Zone E

<u>Description</u>

Distribution

Zone E overlies Zone J3 but also includes intrusive pits penetrating the top of J. Zone E correlations across the Test Trench are not clear, making east to west associations difficult. Zone E appears to be thicker in the western portion of the entrance chamber with more subzones associated and complex tertiary zones and features compared to the eastern side, where there are both fewer and slightly thinner deposits. At the rear of the chamber, adjacent to the back wall, Zone E dips downward to the north and west and thins noticeably (Figures 8.2, 8.3).

Zone E, similar to Zone J, differs significantly from the front of the cave to the back. There are large intrusive pits that appear to originate in Zone D that first appear at the drip line and extend ca. 2 m into the cave (Figure 8.2). These crosscutting zones truncate E and J and perhaps portions of K to elevations of approximately 230 to 250 cmbd.

Zone E is more complex and thicker on the west side of the entrance chamber. Subzone E8 and the overlying E5, are tabular zones that are clearly represented beyond massive intrusive deposits at approximately N58 in the W64 profile (Figure 8.2). E8, prior to being truncated, appeared to follow a gentle slope down from the west side of the entrance. Based on the east profile, the zone is wedge shaped sloping from the entrance, thickest near the west wall and becoming thinner as it extends toward the rear of the western side of the chamber (Figure 8.19). E8 overlies J1 as well as numerous intrusive pits just inside the eastern entrance of the cave (Figures 8.17, 8.19), and E5 overlies E8 after the thick southern extent of the wedge as it extends to the north. Moving

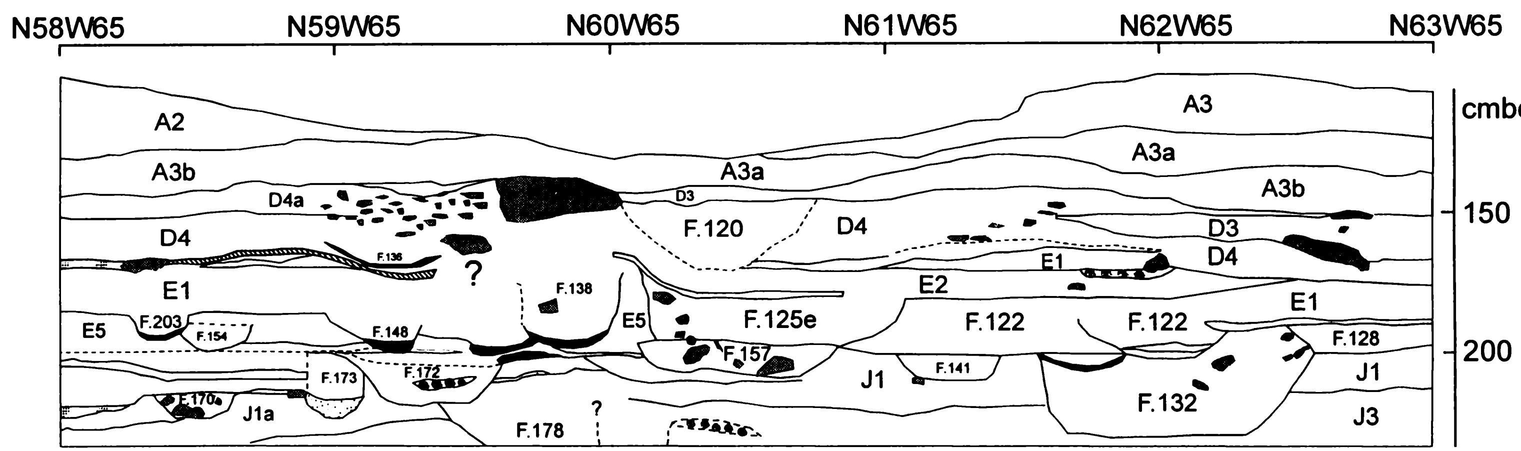


Figure 8.19. Profile W65, N65 to N63, Surface to 270 cmbd.

towards the rear of the cave, in the vicinity of N62 these subzones begin to pinch out with E5 crosscut by Fea. 125 and E8 thinning from its original 20+ cm (including the grouping together of several tertiary zones) to approximately one homogenous 10 cm subzone directly overlying J1 (Figure 8.2).

On the east side of the Test Trench E1 is the primary subzone, ca 50 cm thick, cross-cut at the front by E9, and almost immediately intruded by complex pits and prepared surfaces beginning at the base of D4 and extending into the top of J (Figure 8.3). These include Fea. 266, 21, 265, and numerous prepared surfaces concentrating between N59 and N62 (Figure 8.3). Beyond this point E1 thins to ca. 30 cm and again appears as a homogeneous tabular zone. On the opposite side of the trench the intensive activity occurred from roughly the same central, slightly forward, location in the entrance chamber.

Lithology and Structure

There are features and localized tertiary deposits that originate in Zone E and either lie on top of J or intrude into the surface. Sampled zones include E7 and E7b (Figure 8.17), E1g (Figure 8.15), E1a and E1o (Figure 8.3), which are discussed below. Zone E8 overlies these zones, and most of J on the west side of the chamber. It is considered a low wedge-shaped heterogeneous zone in the field, incorporating variability that was too ephemeral to be isolated for excavation. Overall the zone is described as soft red silty clay with artifacts and gravel-sized charcoal scattered throughout. Zone E8 becomes thinner with less localized variability and massive at the back of the cave with fewer anthropogenic sediments. Unfortunately the zone has yet to be sampled microstratigraphically.

Zone E5 overlies E8 on the west side, but surpasses the wedge shape to the north and levels out into a thin dark reddish brown, ca. 10 cm tabular zone. Again localized variability is represented by concentrations of ash (more dense closer to the entrance) with charcoal and other artifacts.

Zone E1 is described in the field as a generally homogeneous brown to gray-brown silt loam with as much as 10% in charcoal fragments. E9 was distinguished along the southern boundary of E1, at the drip line on the east side of the entrance chamber, both by the unconformable contact and significantly higher concentrations of charcoal and other anthropogenic sediments. Approximately 2 m inside the entrance, in a forward but central location in the entrance chamber, Zone E1 is crosscut by complex pit deposits and by stacked accumulated prepared surfaces. Along the western portion several aspects of these tertiary zones were sampled.

Zone E1a represents one of the deeper surfaces within the E sequence and overlies concentrated rock hearths (Figure 8.3). Zone E1g, at a similar elevation immediately to the northeast, is the same distance from the entrance as E1a. Based on the absence of stacked red tertiary zones in this area, this may represent the western limits of this concentrated activity location. E7 is a hard red silty clay zone representative of the concentrated anthropogenic activity overlying or intersecting the top of Zone J (Figure 8.17). E7c is a truncated red zone that underlies E8. My sample comes from an adjacent tertiary zone designated E7b and the overlying ash zone designated as E7. E7b is an extension of E7c and is composed of gravel-sized red silty clay clasts, clearly fragments of E7c.

E1a is made up of aggregated red-brown silty clay matrix that is noncalcareous except for a few sparse and dispersed ash crystals and sand- to gravel-sized weathered chert (Plate 8.124). The packing, vugh, and channel voids display limited dusty clay coatings. The lens is approximately 2 cm thick and unconformably overlies a gray brown calcareous ash deposit (E1p). The same type of contact is visible on top of E1a where the concentrated, dense ash of Zone E1o creates a sharp contact (Plate 8.125). This ash is mixed with ~5% light-brown aggregates, microartifacts and ash with red-brown aggregates from E1a below. The lens is dense with horizontal and vertical planar voids, some with micritic and clay coatings and rhizolith structures (Plate 8.126).

E1g is more similar to the J subzones below it than it is to E1a to the east. In the field the zone is a combination of concentrated patches of red silty clay and grey ash. The zone has a hard and dense aspect with the concentrated red portion of the zone measuring 3 cm thick. The zone appears to have lots of local micro variability, with fine-grained laminations including well-sorted silt and papules and well-sorted bands of fine sand runoff (Plate 8.127, 8.128). Post-depositional alteration included localized secondary calcite precipitation in the form of micritic rhizoliths, coatings and hypocoatings (Plate 8.127). Though the ash and red clay are locally mixed, there are clear areas where the two deposits are distinct: the clear upper contact where the concentrated ash overlies the red surface (Plate 8.129).

Though generally homogeneous at the macro scale at the front and rear of the chamber, intensive anthropogenic activity produced micro-variability in E1 in various portions of the entrance chamber. These include the aforementioned pit features, and prepared surfaces concentrating between N59 and N62 (Figure 8.3). These variable descriptions are limited to the upper portions of E1.

Interpretation

Zone E contains artifacts marking the uppermost Eva/Morrow Mountain projectile points, diagnostic Late Middle Archaic artifacts (Driskell 1994). Uncalibrated radiocarbon ages concentrate around approximately 6,000 to 6,700 B.P.

It is not clear if the intrusive zones/pits at and just inside the drip line are due to human activity or perhaps rodent burrowing. There is no clear evidence to support burrowing, and the fill inside the pits is decidedly mixed with anthropogenic sediments. In the case of Zone E9 the fill could be related to the excavation of complex pits between N59 and N61, and intrusive into E1, followed by removal of the material outside the cave (Figure 8.3). Weathering along the drip line has made it impossible to identify any tertiary zones within these now massive strata. The cross cutting relationships and overall mixed charcoal matrix, however, lend themselves to this interpretation. In addition, radiocarbon sample Beta 58898 is clearly related to such an intrusion and produced an uncalibrated age of 5,670 +/- 120, clearly post-dating Zone E.

Zone E8 and E5 are interpreted based on their field descriptions and spatial distribution. The location and overall shape of Zone E8 suggests that it is the result of slopewash processes related to the colluvial drape coming around the western edge of the entrance, similar to R9 and N4, deeper in the profile. Localized variability relates to concentrated anthropogenic activity. In particular Zone E4 probably functioned as an interim surface, perhaps a prepared surface (Figure 8.17).

Concentrated ash distinguished Zone E5, leading to its interpretation as a mixed burning zone generated from activity associated with Zones E8 and E4 in particular. To the south the zone is compressed significantly, probably due to drip and trampling and perhaps some decalcification. The rear of the cave is generally devoid of human activity beyond that of large-scale pit excavation.

Zones E1a and E1g reveal very different post-depositional histories, even though they are a mere 2 m from one another. E1a is the lowest prepared surface in a stacked series concentrating in the central portion of the entrance chamber. These prepared surfaces are nearly identical to other prepared surfaces in the cave. E1a is derived from typical red-brown noncalcareous autochthonous aggregated sediment. Interestingly E1a contained dusty clay coatings that based on the absence of such features in the adjacent zones, suggest these coatings were derived from the original source area. The fact that they remain intact following transport gives an indication of the expedient processes involved in the preparation of such surfaces. Preparation may involve little more than leveling and smoothing the selected material to a desired thickness and surface. E1o is interpreted as mixed fireplace surface that was subsequently saturated and dried, resulting in its planar void structure. Post-depositional processes also include root activity based on the presence of concentrated micritic rhizolith structures.

E1g, which shared a similar preparation and function to Zone E1a, appears very different in thin-section due to post-depositional processes and ancillary microstratigraphic deposits that probably occurred during wet, non-occupation periods in the cave. The saturation that occurred following the burning was probably derived from both drip and slopewash. Zone E1g is located immediately beneath a northeast-southwest trending ceiling joint. This formidable ceiling crevasse would have acted as a pathway for water entering the cave through the karst system and the bluff above. This pathway resulted in concentrated, but highly localized, drip resulting in a saturated floor and ultimately localized cementation. Highly localized, small-scale slope wash probably resulted in the formation of the laminated fine sediment. The localized fine graded bedding, dusty clay coatings and compressed deposits support a combination of processes.

Zone D

Description

Distribution

In general, the subzones of Zone D form a tabular, <50 cm thick series that articulates at the drip line with the talus Zone B from ca. 150 to 200 cmbd. From the interface Zone D follows a gentle slope into the cave interior towards the back wall. The subzones are primarily anthropogenic and concentrate in the front and central portions of the cave. At the rear of the entrance chamber, north of N61-N62 the subzones thin and become massive tabular deposits at elevations of ca. 150 or 175 to 200 cmbd.

Lithology and Structure

Zone D is composed of noncalcareous silty clay with a predominantly well sorted quartz silt. In the test excavations, Zone D was only divided where distinct lenses of cultural material or burned sediment and ash were encountered. Thus, the W62 profile displays D at the entrance as a massive tabular zone unconformably overlying E1. D contains éboulis that concentrate at the drip line. Subsequent excavations and profile examination have distinguished two major subzones - D3 and D4 (Figures 8.2, 8.3).

Zone D4 is typically described as reddish brown, slightly coarser grained (relative to D3) tabular clay loam with increased charcoal relative to D3 above. Inside the entrance chamber the zone is generally noncalcareous and consists primarily of well sorted quartz silt with a 10-15% sand frequency composed of poorly sorted quartz and weathered chert, and lesser amounts of microartifacts, organic matter, and charcoal (Plate 8.130, 8.131).

Zone D3 is dark red, fine grained, and is generally considered the lithologic transition between Zone A3 and D4. D3 contains a few tertiary zones, but these are not well defined and poorly preserved. At the rear of the entrance chamber (Figure N63) D3 thins to less than 15 cm.

The structure of both Zones D3 and D4 is extensively aggregated. I avoid using the term granular here due to the variable sizes and shapes of the aggregates. There are packing voids clearly defined but spongy voids predominate. These void spaces are almost consistently coated with translocated clay (Plate 8.130).

The tertiary zones in D4 are better expressed than in D3 and consist of few but distinct hard red zones and concentrated ash lenses. These distinct tertiary zones are concentrated in the center of the entrance chamber and to the east. There are very few pit deposits in Zone D and some of them may be related to burrowing.

A distinct trend is noted in some of the other zones and plays out in Zone D as well: the systematic decalcification from the northwestern portion (back) of the entrance chamber to the southeast and the entrance. This situation reflects preservation of carbonate at the rear of the cave decreasing towards the entrance where decalcification dominates. The variation is only present where phreatic water movement in the rear of the cave does not appear to significantly affect diagenesis among the sediments. The D4 tertiary zones on the east side of the test trench are either noncalcareous or show the initial stages of decalcification, while those on the west side contain well preserved ash. In addition carbonate clasts are observed mixed into the matrix of D4 in the western portion of the entrance chamber.

The tertiary zones to the east of the test trench include localized hard red zones such as D4d and D4e, both approximately 3.5 cm thick (Figure 8.15). Zone D4d consists of a hard red deposit distinguished by a change in grain size at an abrupt boundary to a dense, well sorted quartz silt (Plate 8.132). There are actually two distinct introductions of matrix into D4d. They were clearly defined macroscopically on the basis of color and texture differences, and micromorphologically their separate surfaces are distinct. These surfaces consist of concentrated birefringent clay along a series of interconnected planar voids representing the horizontal surface (Plate 8.133). These distinct deposits contain no substantial micritic deposits.

Zone D4e is the same type of zone as D4d, based on hardness, color and overall morphology, but the lithology is different and far less homogeneous. Aggregates are variable and distinct, and ash is present throughout the tertiary zone, both as dispersed single crystals and aggregated crystals. The void structure consists primarily of packing voids that increase in area and frequency with depth, suggesting compression. There are unique vughs that appear to be burned plant material, based on the remnants of organic matter and their rubified walls (Plate 8.134, 8.135). Rip-up clasts are present, in a uniquely inverted position suggesting *in situ* disturbance. The position is determined based on the thin clay coating on what would have been the top of the clast (Plate 8.136). The upper boundary of Zone D4e is sharp with a clearly defined surface.

Those few tertiary zones identified west of the test trench are undergoing decalcification as shown by the presence of etched limestone clasts and the reduction in the ash mass. For example, Zone D4b is slightly different but consists of concentrated red-brown aggregates and microartifacts in a mixed calcareous silty clay matrix (Plate 8.137). This tertiary zone is located in Zone D4, which in this portion of the cave has become far more calcareous and rich in charcoal. In thin-section the charcoal observed was predominantly nut charcoal.

Interpretation

Zone D represents the final period of human occupation in the cave related to the Seven Mile Island Phase component, roughly 5,200 to 5,900 years B.P. Though human activity and the deposition of anthropogenic sediments were still underway in the cave, compared to the zones below the intensity of this activity significantly decreased. The distribution of anthropogenic sediments is probably directly related to two conditions. The first, and probably most significant, pertains to the limited vertical area remaining in the entrance chamber. The decreasing artifacts and anthropogenic sediments, relative to those buried below Zone D, is probably a direct reflection of a decline in occupation of the cave due to the decreasing habitable space.

The second condition affecting the presence of anthropogenic sediment in Zone D is preservation. The microstructure of the Zone D matrix indicates that both extensive bioturbation and decalcification were actively reworking the sediments. In addition, the trend in decalcification from back to front reduces our ability to identify and isolate lenses of anthropogenic sediments, specifically those rich in ash toward the front of the cave. Those tertiary zones preserved in the eastern portion are burned. The burning process makes the sediments more resistant to both weathering and possibly bioturbation resulting in their preservation.

The tertiary zones discussed above are all interpreted as prepared surfaces based on their unique lithology, sharp boundaries, and field aspect. The inverted rip-up clasts in Zone D4e further suggest the importing of sediment to the location in order to create a surface.

In general, Zone D is composed of colluvial material that, based on the absence of mica, appears to have no relationship to fluvial deposits outside the cave. The well-sorted quartz silt is typically noncalcareous except where directly affected by human activity and where conditions favor preservation. Bioturbation is heterogeneous throughout the main subzones. Decalcification probably occurred both during and after the reworking of the sediment by worms and other organisms. Following the bioturbation, vadose clay was deposited throughout the matrix. The horizontal planar void coatings of Zone D4f suggest this suspended clay was deposited in part as intercalations, localized slopewash deposits moving laterally across the surface. The overall shape of Zone D as it dips to the back of the cave suggests this process is related to the micro-topography from the drip-line and talus at the front of the cave to the rear.

Zone A

Description

Distribution

Zone A is assigned to the culturally sterile deposits at the top of the Dust Cave sequence. In general these zones span inside and outside of the entrance chamber. Zone A3 is the thickest culturally sterile layer in the cave and abuts Zone A2 where it continues north from the drip line and extends throughout the entrance chamber. Zone A2 is confined to the front of the entrance chamber along the drip line continuing to the north approximately 2 m in the western half of the entrance chamber (Figure 8.2). Zone A1 is a tabular deposit that represents the top of the sequence and is confined to east of the W61 line and south down the talus (Figure 8.3).

Lithology and Structure

Zone A3 is tabular with a dense dark red clayey silt matrix containing few sporadic pebble-sized éboulis and an abrupt boundary over Zone D. In the excavations that have followed the testing phase, A3 is subdivided into A3a overlying A3b (Figures 8.2, 8.3, 8.14, 8.15, 8.16). The distinction is primarily based on a subtle change in texture and color. A3a is characterized as dark red clayey silt with few éboulis, and A3b is characterized as dark reddish brown silty clay concentrated near the cave entrance. A3b is noted in the field for its increased charcoal and clear evidence of bioturbation in the form of burrows (also present in A3a), roots and worm casts.

Zone A3b is distinguished microscopically from A3a by an increase in isotropic organic matter and a decrease in the pore area resulting in a denser matrix. The development of dusty clay coatings slightly increases both in area and thickness. Other aspects of the zone are similar to Zone A3a above.

The micromorphology for Zone A3a is described from two thin-sections representing the eastern portion of the entrance chamber; for A3b, three thin-sections are used representing the eastern, central, and western portions of the entrance chamber. Microstratigraphically the zones are very similar with a decalcified silty clay matrix containing poorly sorted sand composed of quartz, weathered chert and feldspar. Less than 2% of the matrix includes charcoal, sandstone, and Fe/Mn concretions. There is limited clustering of sand grains associated with channel infilling. The silt-sized grains are composed of the typical well-sorted mixed quartz with lesser amounts of feldspar, weathered chert and some mica (Plate 8.138). The microstructure is entirely composed of biological aggregates, channel and chamber voids (some with thin dusty clay coatings), and areas of infilling, to the point that the matrix is completely homogenized.

In the field, Zone A2 is distinguished from A1 above and A3 and B1 below by an increase in the frequency of éboulis and in clay content. The zone is described as dark reddish brown silty clay with a granular to massive structure. Only one thin-section represents A2, and it was collected at the cave entrance just inside the drip line. The zone was difficult to sample due to the high frequency of éboulis. The matrix consists of decalcified silty clay, again primarily composed of quartz silt with minor amounts of weathered chert, feldspar and organic matter (Plate 8.139). Poorly sorted quartz, weathered chert, and feldspar constitute the majority of the sand. Rounded papules and moderately formed Fe/Mn concretions composed <2% of the sand-sized material. The voids cover approximately 10-15% of the area and are composed of vughs, packing, channel, and chamber voids. The chamber voids and some of the channel voids are partially infilled with worm excreta, and approximately 30% of the voids are thinly coated in dusty clay. Root tissue is visible associated with some of the channels (Plate 8.140).

Zone A1 is described as red clayey silt with a granular to weak subangular blocky structure. Organic matter, and limestone granule to cobble-sized éboulis, are visible throughout the zone. The organic material and active pedogenic development increase as the zone extends down the talus beyond the mouth of the cave. Discussion of Zone A1 outside the drip line is presented in Chapter 9.

Interpretation

Zones A1, A2, and A3 were all deposited following human occupation of Dust Cave after 5,200 B.P. These zones contain very limited evidence of cultural activity and appear to represent a dry, relatively static phase in the cave's depositonal history. The zones are all related to limited weathering within the cave (due to limited moisture available) and colluvial processes including the natural mass wasting of soil material off the bluff and the weathering of the bluff face outside the cave. Based on the presence of Unknown Silt signature sediments some of A3 in particular may be due to slope wash of colluvial and old alluvial materials from the talus into the cave. Sedimentological features required to support this hypothesis are absent in thin-section. The extensive bioturbation evidenced in the microstructrue have obliterated any such features.

The completely noncalcareous matrix and the absence of any ceiling rain suggest the entrance chamber has been dry over at least the last few hundred years and probably thousands of years. Enough time has passed so that bioturbation as well as general diagenesis probably resulted in the thorough decalcification of the matrix. The process was enhanced by the extensive and varied bioturbation of the sediment. The low ceiling height of less than one meter would have made it a reasonable shelter for burrowing animals.

Though extensively dry (hence "Dust Cave"), the dusty clay coatings throughout Zone A attest to periodic wet conditions in the cave. Even during the last several years of excavation, localized active drip areas in the rear of the cave have become inactive. Localized wet clay areas are now completely dry, indicating that conditions, at a microscale, can vary from year to year not necessarily related directly to seasonal moisture regimes. The continuation of Zone A down the surface of the talus relates directly to the development of soil outside the cave. Additional discussion of the depositional history of Zone A in relation to the talus is presented in Chapter 9.

This discussion has presented narrative descriptions and interpretations of the stratigraphy observed in the entrance chamber of Dust Cave. The entrance chamber contains the best preserved microstratigraphy and artifacts at the site. The sequence of zones is composed of a complex series of superimposed lithostratigraphic units beginning with the zones resting on bedrock and continuing up to the latest deposits following the abandonment of the cave. The source for the zones include geogenic and biogenic processes with anthropogenic processes contributing the bulk of the sediments. Most of the primary zones continue past the drip line to the massive talus at the entrance. This stratigraphic sequence varies significantly from the interior of the cave and is presented in Chapter 9.

[1] these T3, T3a designations are examples of secondary and tertiary zones that were initially designated but later found to be different types of units within the zone system (i.e., T3a is not a tertiary zone but correlates with T3).

CHAPTER 9

TALUS STRATIGRAPHY:

ZONE DESCRIPTION AND INTERPRETATION

Introduction

The narrative descriptions and interpretations for the zones observed outside the cave are presented in this chapter. Outside refers to the stratigraphic sequence beyond the drip line, extending south-southeast of the entrance, represented in the southernmost extent of the Test Trench (Figure 9.1).

The outside portion of the Test Trench produced a profile very different from its northern extension inside the entrance chamber. The discrete, complex series of zones inside the cave changes at the drip line and interfaces with a relatively homogeneous series of talus deposits. These zones contain soil material, support vegetation, and contain numerous pedogenic features but should not be considered as a soil. Due to the aspect of the talus and the unique hydrological conditions associated with the cave, no discernable soil horizonation has developed.

The descriptions are organized by primary zones and summarized in detail in Appendices A, C, and D. The zone interpretations are based on field and microstratigraphic observation. The descriptions begin with the lowermost zones in the Talus sequence, closest to bedrock, and work upward by primary

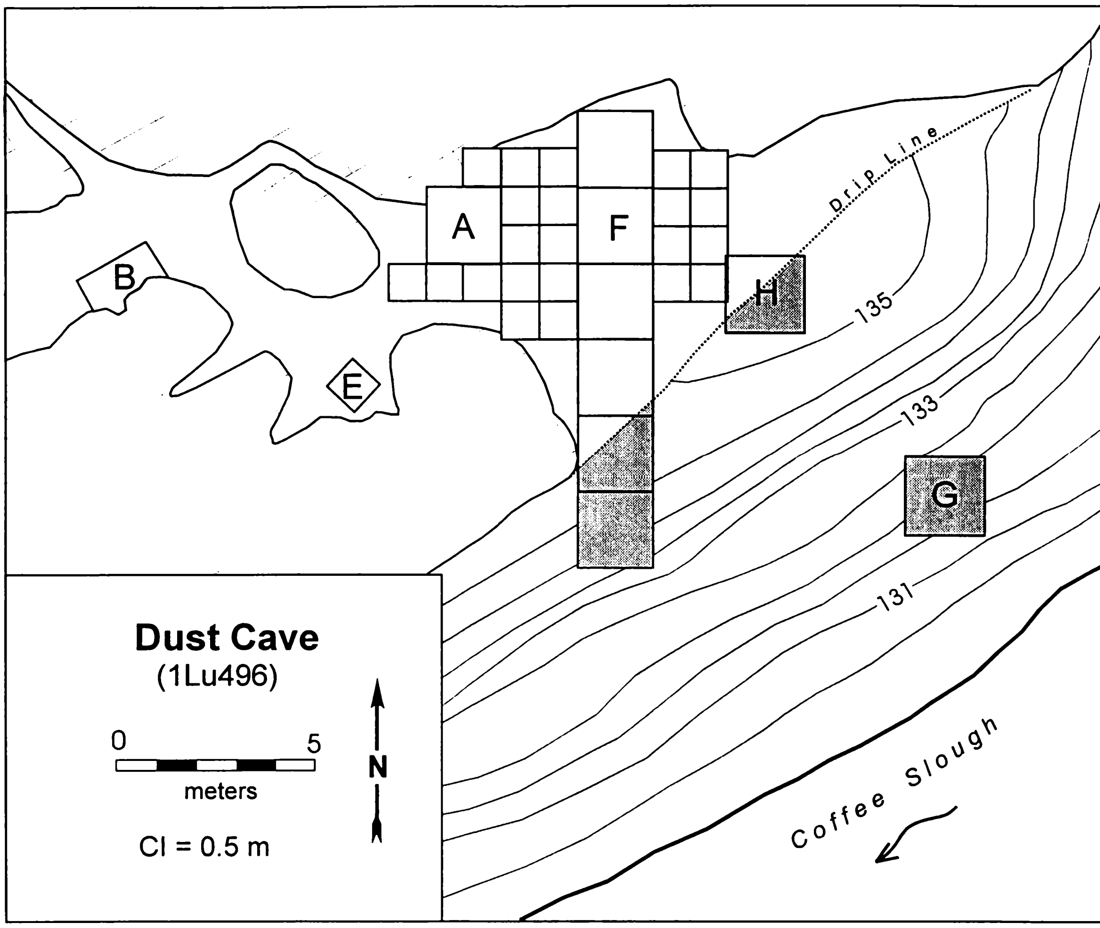


Figure 9.1. Dust Cave Plan Map Emphasizing the Talus Area.

zone group to the surface. There are currently only two radiocarbon dates for the talus. Most of the chronostratigraphic units are defined based on their direct spatial correlation with dated units inside the entrance chamber.

The profiles of three excavation units display the talus stratigraphy: Test Unit G (a 2 x 2 m unit between the cave entrance and Coffee Slough), Test Unit H (a 2 x 2 m unit crossing the drip line), and the south end of the main Test Trench (Figure 9.1). Test Unit G produced no artifacts or stratigraphic variation so it is not discussed here. Test Unit H (N60.20 W59.80) is referred to in the entrance chamber discussion in Chapter 8, specifically those samples collected by Goldberg in 1992. The north profile, where the 1992 samples were collected, falls inside the drip line so they are not discussed with the talus stratigraphy.

The Test Trench was excavated within the site grid system set to magnetic north resulting in a 45-degree angle to the entrance. The resulting profiles present some perceptual challenges that should be noted. As a consequence of the oblique angle across the drip line, the opposite profiles of the Test Trench (across 2 m) represent different portions of the talus. The talus zones in the test trench begin at the drip line along the east profile at N57 W62 in Figure 9.2 and on the west wall at N55 W64 in Figure 9.3. The western profile (W64), was not as extensively documented (no thin sections) and the interface between the inside zones and the talus zones were apparently not as

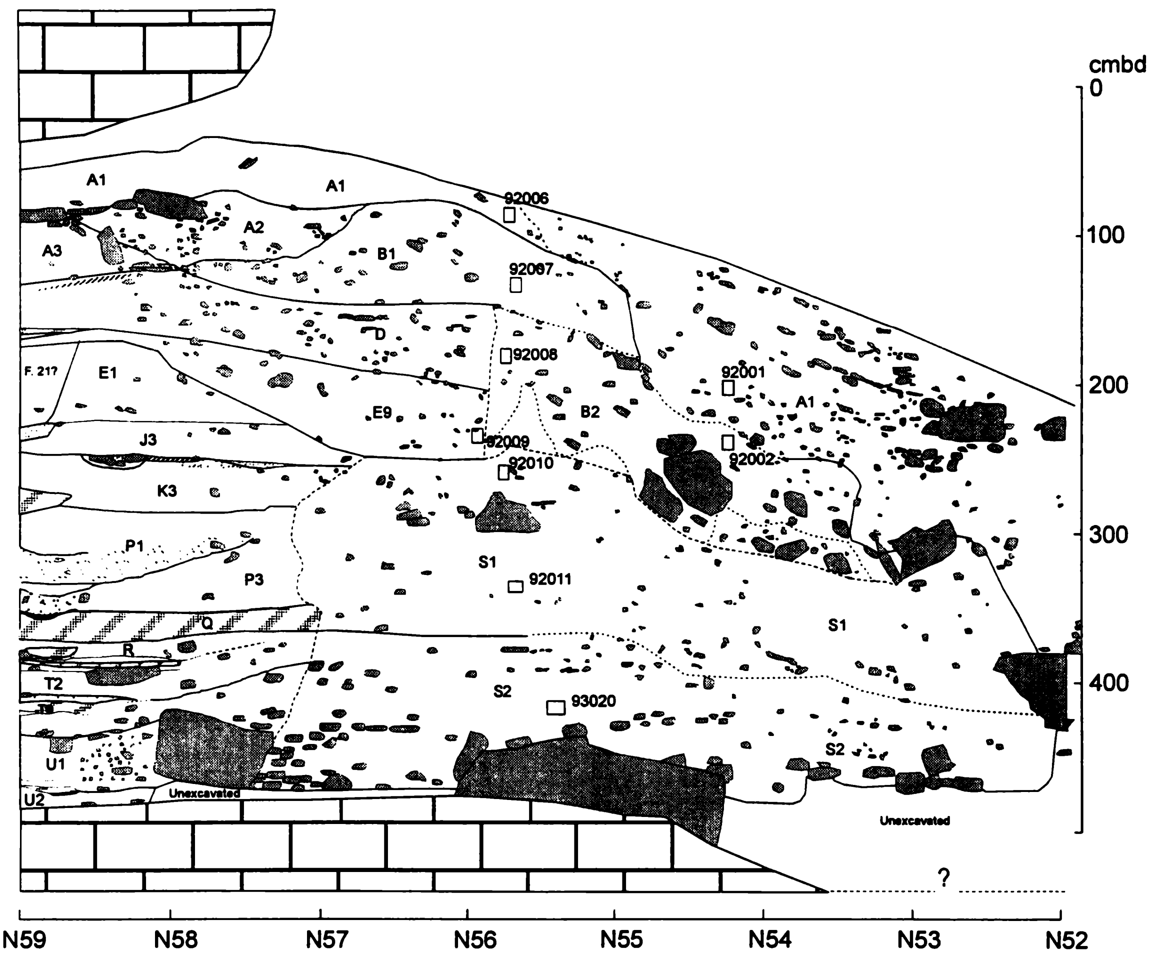


Figure 9.2. Test Trench Vertical Profile W62, Talus Section.

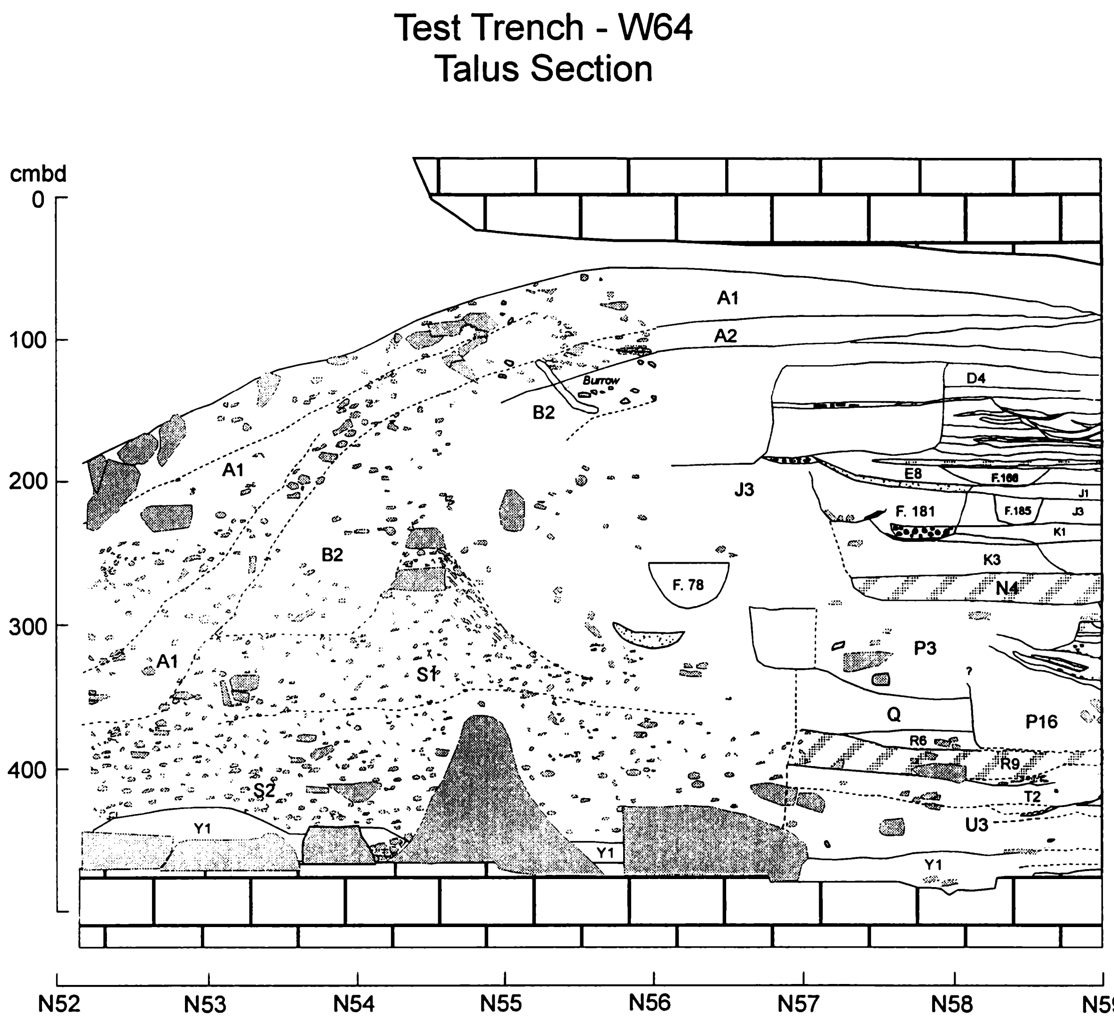


Figure 9.3 Test Trench Vertical Profile W64, Talus Section

clear. For all these reasons, the majority of my discussion here is based on the profile in W62 (Figure 9.2)

Talus: Zone S2

Description

Distribution

Zone S2 is a tabular deposit limited to the cave exterior. The unit is relatively massive and measures approximately 1m thick. At the northern extent of Zone S2, in association with the drip-line at grid point N57.50, the deposit interfaces with interior Zones T and U (Figure 9.2). Along the western profile of the Test Trench, Zone S2 overlies isolated areas of Zone Y1 between large boulders over bedrock. Zone Y1 was discussed in Chapter 8 in the context of the entrance chamber.

Lithology and Structure

The zone is described as a dark red silty clay matrix with a subangular to blocky structure surrounding concentrations of angular limestone rock ranging in size from pebbles to cobbles with occasional boulders. The base of this zone was reached at its northern extent, in Unit W64 N58, where bedrock was encountered at ca. 480 cmbd. Units excavated to the south, further from the cave entrance, stopped at or above this elevation when culturally sterile deposits were encountered and the rock concentrations impeded further digging.

The description of the zone S2 microstructure is based on one thin section from the east wall of the test trench ca. 2m beyond the current drip line. The thin section is predominantly composed of highly oxidized noncalcareous well-sorted silty clay containing approximately 15% poorly sorted sand (Plate 9.1). The silt fraction is primarily comprised of quartz and weathered chert. There are localized clusters of sand containing very little silt and clay. The sand frequency is dominated by quartz, chert, feldspar and lesser amounts of biotite and muscovite mica (Plate 9.2). Pyroxene/amphibole is also represented in the fine sand fraction. The matrix supports pebble- and granule-sized clasts of limestone and chert that represent 20-30% of the thin section area. The principal void type is vertically trending planar voids associated with the blocky ped structure. Only about 5% of these vertical voids contain illuvial clay coatings. The remainder of the microstructure is composed of slightly deformed channel and packing voids relating to relic biological features including fecal pellets. The fecal pellets appear only under cross polarized light where finer, slightly brighter clay can be observed outlining uniformly rounded aggregates (Plate 9.3).

Other features include secondary carbonate masses that appear as a result of micritic and microsparitic coatings, where hypocoatings coalesce. These patches make up less than 5% of the area but are very dense (Plate 9.4). Some of these features have layered dusty clay associated with secondary calcite. This form of calcite precipitation is very different from the finer crystalline structures that form inside the cave.

Interpretation

To construct a comprehensive interpretation of Zone S2 is difficult since only a small portion was exposed. Based on the profiles revealed in the test trench, a combination of source primarily composed of colluvial debris and limestone éboulis contributed from the retreat of the the bluff face with intermixed Tennessee River alluvium is indicated. The sediments were extensively bioturbated but only relics of this microstructure remain. Time and diagenesis have resulted in the highly oxidized blocky structure present today. Some of this structure may be inherited from the colluvial material from the soils above.

Based on spatial, lithologic and radiocarbon associations with Zones U and T and a radiocarbon assay derived from Zone S2 (10,450 BP ± 50), the deposit appears to date to the end of the Pleistocene/Holocene transion around 10,500 BP. The presence of lithic artifacts in the zone suggest that human activity took place outside the cave but that soil formation and bioturbation have blurred the original microstratigraphic detail that is preserved inside the entrance chamber.

The limited amount of Tennessee River alluvium may be the remnants of the proposed flushing of the cave interior during the end of the Pleistocene.

Zone Y which appears in the lowest portions of the cave floor associated with floor joints, is primarily composed of sandy Tennessee River alluvium. The lithology of S2 contains more fine material. This finer matrix may be the result of intermixing due to bioturbation at various scales.

Talus: Zone S1

Description

Distribution

Zone S1 overlies Zone S2 and varies in thickness from approximately 200 cm to 75 cm. The top of this zone follows the acute angle of the current talus, reaching its highest elevation around 250 cmbd and dipping at the southern limit of the Test Trench to an elevation of nearly 380 cmbd. The downward slope begins at N54 on the west side (Figure 9.3) of the Test Trench and at N55 on the east side (Figure 9.2). At the northern extent of Zone S1 along the drip line, this massive tabular zone abutts (from bottom to top) interior Zones R, Q, P/P3 and K. In the west profile (W64) of the Test Trench the contacts with the interior zones are not as clear and more difficult to correlate. On this profile only R9 appears to clearly correlate with S1 (Figure 9.3)

Lithology and Structure

In the field S1 was described as a dark reddish brown noncalcareous clay to silty clay with a variable structure from granular to subangular. The finer matrix supports limestone and chert éboulis. The éboulis averages around 10%

and varies in size and roundness. The mica content was noted as less than S2 but

decreased from bottom to top. Tree roots and krotovina were observed throughout the zone. There are isolated areas of secondary carbonate impregnation visible in the field. These appear as crystalized "veins", some concentrated in circular areas as large as 80 cm across and 8 cm thick.

Three thin sections were examined representing the top and middle portions of Zone S1 along profile W62 (Figure 9.2). The zone varies with depth. The matrix is generally composed of a coarse silty clay with a weakly granostriated bfabric in a loose porphyric related distribution. The silt fraction is predominantly quartz and makes up at least 30 to 40% of the matrix. Sand is far less common than in Zone S2 below and makes up < 10% of the matrix. The sand consists mostly of quartz and chert with lower amounts of feldspar and <1% mica. Weathered chert granules are also present in about 5% of the thin section area. The majority of the zone is decalcified but the top of the zone contains partially decalcified carbonate sand- and granule-sized fragments. The clay is noncalcareous throughout the zone. The high silt content suggests Unknown Silt signature material (Plate 9.5).

The microstructure reflects extensive relic biological activity. Voids, consisting of partially infilled chambers, channels, and vughs, cover 5 – 10% of the thin section area. More spongy voids are visible toward the base of the zone and are probably directly related to biological activity. Vertical planar voids are also present, cross-cutting channels and chambers. Dusty clay coatings relate to only 2 - 5% of the voids. Some such coatings appear as fragments in the matrix or related to relic biological aggregates.

Localized areas of secondary calcite in dense micritic and microsparitic crystaline forms coat voids and embed the adjacent matrix (Plate 9.6). These cemented features increase significantly in comparison to Zone S2 and extend into a little over 5% of the matrix area.

<u>Interpretation</u>

The northern extent of Zone S1 represents a weathering interface of the discrete interior zones and the influx of several other source materials. Moving laterally from this interface to the south and down the talus, Zone S1 becomes less influenced by acitivies in the cave and more a product of ongoing colluvial deposition, diagenesis and pedogenesis. The result is a massive, homogeneous talus unit with slight texture changes.

Similar zones or continuations of the same archaeological deposits inside the entrance chamber probably extended beyond the dripline. A combination of weathering, beginning along the dripline, has obliterated the original contacts between microstratigraphic units and reduced the zones to a massive unit. In addition, the more fragile anthropogenic sediments, such as ash, are not present suggesting extensive weathering. It is unclear how far the interior zones extended beyond the dripline.

Other sources of sediment in S1 include colluvium from the weathering bluff face and/or possible Unknown Silt. Some of this same sediment is associated with Zone N (although N inside the cave is not decalcified and contains dispersed ash). The exact source of the Unknown Silt is unclear, however, these sediments appear to be a combination of colluvial loessial soil from the top of the bluff or Unknown Silt from the base of the bluff. It is unclear if contemporary wind blown sediment could have contributed to the upper reaches of S1 and in turn Zone N.

Other sources of sediment contributing to S1 include carbonate-rich water running off the slope and alluvium from Cypress Creek and the Tennessee River. Related to the bluff and the drip line is an influx of calcium carbonate-charged runoff that clearly had an effect on the zone in the form of calcrete deposition. Overbank alluvial deposition from both the Tennessee River and Cypress Creek appear to be a sporadic source contributer. The reduction in the amount and size of mica and the decrease in sand, however, indicate that the introduction of overbank deposition from the Tennessee River was rare if it occurred at all at this time.

Along the western profile of the Test Trench (W64) (Figure 9.3) the increase in éboulis and the poorly defined interfaces at the dripline are probably a product of the west profile's articulation with the edge of the cave entrance. The exact western edge of the entrance is is not yet clear, but based on the curvature of the brow or the opening of the cave and the adjacent continuation of the talus along the bluff, it would appear that the wall may be just west of W64.

The void structure suggests that during deposition the upper portion of the zone, the sediment was extensively bioturbated, both by plants and animals. Worms and other burrowing insects are probably reponsible for the micostructure based on the relic aggregate sizes. The sediment would have been unsaturated providing a microenvironment attractive to worm activity. This dryer condition is further supported by the overall rarity of dusty clay coatings.

Secondary calcite exhibits vertical changes down the profile. In Zone S1, potentially temporally distinct precipitation phases of varying sizes and morphology coat voids and embed the adjacent matrix (Plate 9.7). Crystal forms include micritic masses and bladed sparite. The bladed sparite nucleates in several locations into a microsparite. The resulting deposits might be referred to as calcrete. The dense accumulations of secondary calcite forms and the "veins" described in the field suggest a unique depositional environment with tree roots and carbonate charged vadose water derived from both inside the cave and off the bluff. The large concentrations of ash associated with Zone

P in particular contributed to Zone S1. Subsequent leaching of these carbonate particles also charged the groundwater.

The bottom of S1 was not examined micromorphologically. This portion of the zone is a direct, though weathered, extension of interior primary Zones Q and R. Both of the latter appear to have substantial sediment contributions from Tennessee River alluvium, perhaps related to alluvial overbank deposition or perhaps reworked from previous deposits in the talus. Based on the absence of signature Tennesseee River alluvium in the thin sections examined from the upper half of the zone and the correlation to interior P1, P3, and K3, the river appears to have contributed little to deposition after roughly 8,000 years ago, during the later phase of Zone S1's development. This general time period is also associated with extensive human activity in the cave, as based on the concentration of hearth and pit deposits, and artifact frequencies in these zones. The extent of secondary calcite and krotovina may further indicate a period of relatively low sedimenation at the cave entrance.

The general fining upward and the variable structures observed in thin section combined with field observations, suggest that there are two units make up Zone S1: the upper portion dominated by terrestrial sources and the lower portion derived from alluvial source(s). Radiocarbon dates from the adjacent interior zones suggest a time after 10,000 BP for the intial deposition of Zone S1 followed by a drier time of extensive human activity in the cave around 8,000 to 6,000 BP.

Talus: Zone E

Description

Distribution

Zone E extends from inside the cave beyond the drip line into the talus. The interior zones and the majority of Zone E were discussed in Chapter 8. Approximately 2 meters of the southernmost portion of the zone extends outside the cave and concentrates along the central portion of the entrance, prominent in profile W62 (Figure 9.2). This zone is designated E9. In the Test Trench, near provenience N56, the interior structure and composition of Zone E9 gives way to exterior weathering and either abuts or grades into Zone B2 (described below). Inside the cave, Zone E consists of charcoal-rich anthropogenic subzones. At the cave entrance the subzones are no longer distinct, and E9 becomes a massive charcoal rich unit with an abrupt boundary marked by concentrated charcoal. Outside the cave Zone E9 slopes downward to the south and averages 40 to 60 cm thick.

Lithology and Structure

Zone E9, extending beyond the drip line, was described during the testing phase as a silty clay matrix with dispersed charcoal and ash. Pebble- to cobble-sized angular éboulis is randomly distributed throughout the layer and represents <5% of the material in the zone. One thin section at the southernmost extent of Zone E9 illustrates the close porphyric, calcareous silty clay matrix in a crystallitic related distribution. Single ash crystals (various forms) are distributed through the matrix with very few articulated pieces. Rounded non-calcareous light-brown aggregates are distributed sparsely throughout the matrix. The unsorted and variably sized sand fraction takes up an additional 10% of the area and includes quartz, chert (up to granule size), feldspar, and microartifacts (~3%), including microdebitage, bone, burned shell and charcoal (Plate 9.8). The majority of the microartifact content was made up of fragmented wood and nut charcoal.

Zone E9 is completely bioturbated. Channel, chamber, vugh, packing and spongy voids take up at least 30-40% of the thin section area. Over 30% of these voids are associated with micritic coatings and their adjacent matrix, with dense micritic and microsparite hypocoatings and bladed sparite crystals projecting into the voids space. Secondary calcite in the form of thin accumulations of acicular crystals is also present along voids, often associated with dusty clay coatings. These crystals are not as well developed as in the adjacent Zone B2 or higher in the profile. It is unclear if these fragile crystals are relatively few due to their erosion or if they are still forming. Regardless, this level of secondary calcite precipitation is probably not associated with the anthropogenic E9 but are a product of the sample location bordering the highly calcareous Zone B2.

Interpretation

Inside the cave, Zone E is composed of numerous secondary and tertiary zones representing discrete burning activity (hearth construction and rake out), pit digging, and prepared surfaces. From just inside the entrance at N58.50 until the zone abuts Zone B2, biological processes and exposure to pedogenic weathering and colluvial process have obliterated distinctions between subzones and mixed the sediment into one charcoal-rich lithostratigraphic unit. The secondary calcite precipitation is associated with the unique hydrological aspect of the cave entrance as noted in the interpretation of Zone S1.

A second explanation for the massive appearance of Zone E9 is possible. The boundary (possibly unconformable) of the zone and the concentrated charcoal might suggest a large intrusive pit or erosional boundary. This portion of Zone E could conceivably be an erosional boundary that removed the southern extensions of the J and E zones (Figure 9.2). This alternative hypothesis for Zone E9 should be carefully considered in the artifact analysis. This possibility cannot be addressed further stratigraphically until the shoring is removed and the boundaries and the lithology are more closely examined.

Talus: Zone B

Description

Distribution

Zone B consists of two lithostratigraphic units related to the talus beyond the cave entrance. Most of this description comes from the east profile of the Test Trench, W62. Zone B is not observed in Test Unit H and appears to relate only to processes outside the cave within the talus. B2 slopes to the south above Zone S1 and varies in thickness with 1 m at its northern limit tapering off downslope to about 60 cm. At the northern end, the zone is distinguished as an interface with outside extensions of Zones E and D at N56.

Zone B1 lies over Zone B2 and is located further upslope towards the cave entrance. The northernmost area of B1 first appears at N58 clearly bounding Zone A2 and overlying the interface between Zone D and B2. It terminates at N55, where Zone B2 dips sharply down the talus.

Lithology and Structure

At the interface of Zone B2 and the southern extents of both Zones E (E9) and D, the lithology and structure change significantly. Zone B2 is as a very dark gray to a dark reddish brown, silt loam matrix supporting 50% éboulis that is gravel to cobble-sized; much of the éboulis is concentrated and significantly weathered. Burrows and roots were also observed throughout the zone. Dark organic-rich sediment with éboulis is observed concentrated in mounded shapes along the base of Zone B2; these are probably directly related to burrowing and root activity. Thin, irregular calcrete deposits are observed in the field coating portions of ped faces and root voids.

Micromorphological analyses of two thin sections, one near the northern interface of the zone and the other approximately 2 m down slope revealed lateral variation in the degree of secondary calcite precipitation (Figure 9.2). Upslope, secondary carbonate deposition is obvious in thin section. The silty clay is organized as peds and biological aggregates in a dense network of horizontal trending channel and planar voids. The voids and the adjacent matrix are coated and partially filled with complex phases of calcite crystals (Plate 9.9). Hypocoatings consist of dense micrite and microsparite while the coatings are made up of thick needle fiber or acicular calcite (Plate 9.10). The acicular calcite is also associated with clay coatings. Some of these coatings are embedded with bands of red clay (Plates 9.11, 9.12). In these instances it is unclear if the clay and calcite precipitation are coeval or if the formations were deposited separately.

The matrix in general contains dispersed ash particles in both the sand and silt fractions. Micritic nodules contribute to about 30% of these fractions. Organic matter (mostly amorphous) is randomly distributed through ca. 5% of the area. Anthropogenic materials are scattered randomly through the limited (~4%) sand fraction and include microdebitage, bone, charcoal (wood and nut), and shell. Granule-sized chert and to a lesser extent limestone are observed in about 2% of the thin section area.

Downslope Zone B2 remains much the same but with a few exceptions. Less calcareous material occurs in the matrix with almost no ash. Microartifact material is generally absent. The micritic nodules are fewer and more oxidized. Approximately half of the 10% sand is composed of fine grained carbonate nodules (possible ceiling rain) that are being reduced, most likely by decalcification but with a unique weathering pattern. There appear to be rounded channel patterns in many of the nodules resembling biological activity (Plate 9.13). It is not known if these nodules are fragments of the dense calcite concentrations observed upslope or if these are ceiling rain nodules from the weathering of the bluff.

Downslope the microstructure varies significantly; more aggregated granular structure without the horizontal channel and planar voids. The dense coatings and hypocoatings observed upslope are generally absent with only a few thin ephemeral dusty clay and acicular calcite crystal coatings.

Zone B1 is a dark reddish-brown silty clay with quartz, chert and feldspar making up the majority of the sand (~10%) and silt (~30%) fractions. Lesser amounts of limestone fragments, papules, concretions, and terrestrial snail fragments are also present. An additional ~2% of the thin section area is composed of weathered chert granules. The clay fraction appears to be higher in B1 than in B2, both in the matrix and as clay coatings.

Clay coatings, primarily of dusty clay, are present on nearly 75% of the pore spaces, which occur as channel, vugh and packing voids. Much of the dusty clay is associated with acicular calcite concentrations as coatings and in dusty clay fragments imbedded in the matrix (Plate 9.14).

Interpretation

Zones B1 and B2 both relate to the formation of the talus slope at the entrance of the cave and the ongoing degradation of the bluff face after 5,000 BP. The talus continued to form with the variable influx of colluvial material including rock debris eroding from the bluff face. Based on the degradation of the limestone in B2 and the concentrations of precipitated calcite, these deposits (like those below), were almost certainly influenced strongly by the influx of carbonate-saturated water. These deposits were saturated seasonally with the influx of carbonate-rich waters coming from two sources. These sources were runoff on the bluff face and phreatic water that moved through the cave as the aquifer in the rear of the cave was recharged, ultimately moving downslope through the talus. When these carbonate-charged waters encountered the high CO_2 concentrations of the soil water in the talus, the carbonates quickly precipitated. The relatively high organic matter content described in the field and observed in thin section would have also contributed to these phenomena.

The conditions required to support this kind of precipitation were fairly restricted in the vicinity of Zone B2. Further down the slope, the secondary calcite precipitation was greatly diminished and appears to be on the other side of the cycle, i.e., with the decalcification and removal rather than accumulation of calcite.

The microstructure throughout these zones suggests that as the deposits were accumulating, worms and other soil fauna were biologically reworking them. This kind of activity was most intense away from the zone of major calcite precipitation.

Zone B1 is probably not related to the long period of human occupation of the cave. Based on the contents (few artifacts) and the location and morphology of the zone, it most likely represents continued talus formation and bluff degradation following abandonment of the cave. The deposit is extensively bioturbated; the embedded clay coating fragments suggest that these bioturbation and clay illuviation processes are ongoing, typical of a depositional surface in which soil development is occurring, but in the absence of a well-developed B horizon.

Talus: Zone A1

Description

Distribution

Zone A1 marks the uppermost deposits through most of the entrance chamber and down the talus. The zone is culturally sterile. It is only approximately 20 cm at the top of the talus but thickens south of N55 to >100 cm as it extends down the talus in an irregular wedge shape. Zone A1 is confined to east of the W61 line and continues south down the talus.

Lithology and Structure

Zone A1 is a dark red clayey silt with a granular to weak subangular blocky structure. Organic matter and granule- to cobble-sized limestone éboulis are visible throughout the zone, some of which are derived from the bluff above. Organic material and active pedogenic development increase down the talus beyond the mouth of the cave. The limestone clast size varies, increasing with the acute angle of the slope. Burrowing activity from various rodents and microfauna (insects) is evident throughout the zone.

The description of the microstructure of Zone A1 is based on one thin section from the east wall of the Test Trench outside the drip line. The thin section revealed quartz silt in a calcareous dusty clay matrix that includes 5% isotropic plant tissues. The silt is primarily composed of well-sorted subangular quartz with lower frequencies of chert, feldspar and micritic nodules. The unsorted sand matrix (~10%) is composed primarily of quartz, but includes weathered chert, feldspar and angular limestone clasts. The sand-sized fraction contains fragments of limestone and micritic ceiling rain that show initial decalcification (Plate 9.15). Snail shell fragments - both aquatic and terrestrial - were also noted. Approximately 10% of the area includes planar and channel voids. There are a few thin clay coatings associated with the void structure along with root sections.

Interpretation

Zone A1 accumulated over the last several thousand years, incorporating limestone clasts from the retreating bluff face. Chemical and mechanical weathering along the drip-line, resulted in the retreat of the entrance and a substantial talus. As the bedrock weathered, a talus deposit built up outside the dripline. Then as the dripline receded, a reverse talus began to form with the wasting of material inward, down the rear slope of the talus cone. This accounts for the development of the rocky A2 behind B1, the earlier southward extension of the evolving talus cone. Essentially the sloping talus moved toward the cave entrance.

Summary and Conclusions

The talus is a dynamic depositional environment representing processes from inside and outside the cave. Sources included colluvium (limestone éboulis and bluff soil) from the retreat of the the bluff face, intermixed

Tennessee River alluvium and Unknown Silt, artifacts from human activity at the cave entrance, and possible loess material.

The initial talus deposition appears to correlate with the proposed flushing of the cave interior at the end of the Pleistocene. Zone S2 is weathered Tennessee River alluvium with intermixed finer material that probably originated from either Cypress Creek or soils off the bluff. Large blocks of limestone may relate to both the retreat of the bluff face and the weathering of the floor at the cave entrance. Zone S2 correlates with interior Zones U and T. Overlying S2 is Zone S1, a massive, homogeneous talus unit with a fining upward sequence of sorts. The lower portion is derived from alluvial source(s) and the upper portion is dominated by terrestrial sources. Radiocarbon dates from the adjacent interior zones (R and Q) suggest an age of 10,000 to 9,500 B.P. for the intial deposition of Zone S1, followed by a drier time of extensive human activity in the cave around 8,000 to 6,000 BP correlated with interior Zones P and K.

A massive deposit with the primary designation of Zone E contains the sediment with the most anthropogenic sources and transport agents of the talus deposits. The depositional history of the deposit(s) is unclear; however, it is most likely the result of human activity. Zone E abruptly ends where Zone B2 begins. Zones B2, B1, and A1 appear to have little to do with the human occupation of the cave and represent the continued degradation of the bluff face after 5,000 BP.

Post-depositional processes include bioturbation in the form of plant growth and burrowing mammals and soil fauna including earthworms and enchytraeids. The degree of bioturbation is greatest from the upper portion of Zone S1 upward, probably representing the depositional environment becoming increasingly less saturated and periodically stable, suitable for tree growth and biological activity.

The carbonate hydrological regime in the talus profile is unique and represents the interface between the carbonate-charged waters associated with groundwater and the drip in a karstic environment and weathering soil environment. The karst water included seasonally saturated carbonate-charged waters from run-off on the bluff face and phreatic and/or vadose water that moved through the cave as the aquifer in the rear of the cave was recharged. When these carbonate enriched waters encountered the high CO_2 concentrations of the soil water and the high amount of organic matter in the talus, the carbonates quickly precipitated resulting in calcrete deposits. The result is a localized vertical and horizontal continuum of unique calcite crystal precipitation that peaks in Zone B2 just south of (away from) the drip line. The opposite ends of the continuum include decalcification at the base in Zone S2 and on the surface in A1. The talus provides a unique opportunity to study calcrete formation at a microenvironmental interface across several scales.

CHAPTER 10

THE DEPOSITIONAL HISTORY OF DUST CAVE

Introduction

In this final chapter I present a comprehensive depositional history of Dust Cave. This history addresses the relationship of Dust Cave to the regional geomorphology and builds a contextual framework based on the cave's microenvironment. This framework provides for reliable interpretation of artifact patterning within the context of the physical environment of the cave. Through time the microenvironment of Dust Cave changed influencing both where human activity occurred, and how, or if, residues of that activity were preserved. It is only by conceptualizing the archaeological record as a complex series of geogenic, biogenic, pedogenic and anthropogenic processes, enlisting geoarchaeological methods, that we can we begin to identify behavioral patterns with confidence.

Depositional History

In light of the regional concentration of Paleoindian projectile points, one of the original objectives of the University of Alabama's research program was to identify Pleistocene/Holocene transition period surfaces where sites might be preserved. In the case of the project area, the upper terraces were at least partially destroyed during the Late Pleistocene. Based on years of archaeological study in the area, it is clear that the only opportunities to identify altitudinally high (and presumably the oldest) terraces in this narrow inundated valley were through the analysis of cave sediments. The working hypothesis proposed by Collins and Goldberg (1995), is that the top of the micaceous sequence in Basket Cave represents a subaerial remnant of the highest reaches of local Pleistocene terrace development. Dust Cave, during this time, was completely filled with sediment. Between 15,000 and before 10,500 B.P. the river cut down through this restricted section of the valley, extensively eroding most of the upper portions of the valley floor. With this downcutting, the base level of the karstic water table dropped to approximately 134 m. With the lowering of the water table the caves in the valley wall, one of which was Dust Cave, became major spring conduits, flushing contents from their entrances onto their talus slopes below (Collins et al. 1994).

Nearly all of the ancient Pleistocene sediments that once filled Dust Cave were removed during this period. Zones X1 through X4, identified as rubified micaceous sediments in the deepest portion of the dark zone (Test Unit C), are interpreted as remnants of these ancient fluvial deposits. Relic cold climate features in Zone X1 - X5 (e.g., ice lensing) suggest their formation during the end of the last glacial (Table 10.1). The absence of these sediments in Test Unit B suggests that these ancient deposits were eroded. This eroded surface slopes towards the entrance and could be the erosional boundary formed during the Late Pleistocene/Early Holocene flushing of the cave.

The entrance chamber was a formidable shelter just prior to 10,500 years ago. The cave entrance measured approximately 12 m across and 4 m high. A gently sloping talus spread out from the entrance (Zone S2), composed of large limestone blocks, colluvium and reworked alluvial sediments. These deposits in part were associated with the increased moisture conditions occurring during the Pleistocene/Holocene transition, which encouraged weathering of the limestone bluff face. The deposits were also derived from mass wasting of slope sediments, and overbank deposition from the Tennessee River (Table 10.1).

Much of the bedrock floor within the entrance chamber was exposed, while some areas (depending on the micro-topography of the floor) retained localized remnants of alluvium. The bedrock floor sloped upward along the walls and gently downward from the rear of the entrance chamber to the entrance.

Two, perhaps three, passages continued into the dark zone from the entrance chamber. There were two passages to the west, one slightly north of the other. The first was initially 2 m wide, leading into nearly 30 m of narrow passages in the dark zone. The second one was barely 50 cm wide and joined the other, wider passage within approximately 8 m of the entrance chamber.

X7	□10,500	n/a	back passage	Reworked and saturated ancient Tennessee River alluvium, correlated with entrance chamber Zone Y2.
Y	□10,500	n/a	entrance chamber	Decalcified reworked Tennessee River alluvium mostly filling phreatic drainage channels in the bedrock floor. Fining upward suggests reduced energy. Variable wet and dry phases. Contains fragmented Pleistocene fauna fossils.
X8	?10,500 - 10,200	n/a	back passage	Mixed Unknown Silt source and Tennessee River alluvium post depositionally altered by decalcification (which lead to compaction) and possible cryoturbation suggests wet conditions. Correlated with entrance chamber Zone U.
U	10,500 - 10,200	Late Paleoindian	entrance chamber	Mixed Tennessee River alluvium and Unknown silt. Resurgence of the phreatic drainage channels periodic overbank deposition and slope wash resulting in periodic wet and dry conditions. First human habitation.
T4	~10,300	Late Paleoindian	entrance chamber	Transitional zone of decalcified Tennessee River alluvium and extensively weathered éboulis. Strong resurgence relating to phreatic drainages resulting in erosion. Early Side Notched projectile points may represent lag material.
T3	~10,300 - 10,000	Late Paleoindian	entrance chamber	Influx of well-sorted clayey silt (related to Unknown Silt) and reworked Tennessee River alluvium and with periodic slack water conditions, and slope wash follows. Post-depositional processes include burrowing, trampling and bioturbation. Eroded by influx of Zone T2. Anthropogenic deposits preserved in ephemeral localized lenses concentrating in the forward central portion of the chamber (just inside the drip line).

X9	~10,300 - 10,000	n/a	back passage	New influx of Tennessee River alluvium transporting materials (including microartifacts) from the entrance chamber into the back passage.
S2	>10,500 - 10,000	Late Paleoindian	talus	Mixed Tennessee River alluvium with colluvial debris and limestone éboulis from the retreat of the bluff face. Probably a product of reworked ancient Tennessee River Alluvium from the flushing of the cave and the Pleistocene/Holocene transition overbank deposition. Bioturbated soil material with subangular-blocky structure.
R	10,000 - ~9,700	Early Side Notched	entrance chamber	Intensive human activity on the T2 surface. Spatially, activity continuing to concentrate on the forward central portion of the entrance chamber. Intersecting pits and prepared surfaces. Colluvial drape forming along west side of entrance. Rear of the cave relatively dry but only limited human activity. Upper boundary erosional suggesting upper portion of Zone R removed or reworked which may account for the relative absence of a Kirk Side-notched component.
Q	?9,500 - 8,500	Early Side Notched and Kirk Stemmed (Mixed?)	entrance chamber	Erosional event initiating Zone Q with the source area from outside the cave but very little Tennessee River alluvium. Several massive slope wash events probable. Cave mostly abandoned except for few anthropogenic deposits toward the back half of the entrance chamber. 14C indicate decreased sediment rate result of reduction in human activity, however, could be due to sampling error. Evidence for vegetation suggesting stability. Chamber-wide burning event resulting in dense charcoal deposit covering the top of Zone Q.

P	<8,500 - 7,000	Kirk Stemmed	entrance chamber	Floodplain now stabilized. First intensive human occupation of the entire chamber. Activity focused on burning based on extensive ash deposits and prepared surfaces. Western limits of the chamber, towards the entrance of the back passage, used as a dumping area based on layered mixed ash deposits.
S1	~8,000 - 10,000	Seven Mile Island	talus	Sources include Tennessee River alluvium, unknown silt, and colluvium. Alluvium decreases with increased elevation, relating to the growing stability of the Tennessee river floodplain after ca. 8,500 B.P. Complex calcrete deposition related to the influx of calcium carbonate-charged runoff from the bluff and the drip line. Few anthropogenic sediments in the talus in general, the result of diagenesis and pedogenesis. Extensive bioturbation.
N	~7,000 - 6,500	Eva/Morrow Mountain	entrance chamber	Following deposition of Zone P and prior to formation of Zone N, cave used for burial based on the presence of numerous Eva/Morrow Mt. burials extending into Zone P. Large basin shaped pits (possible burials) also present. N composed of slope wash combined with colluvium and limited anthropogenic sediments. Slope from the entrance into the eastern portion of the chamber (suggested by initial excavation there) funneled in colluvial material. Few prepared surfaces associated with Zone N. Extensive localized bioturbation.
K	7,500 - 6,500	Eva/Morrow Mountain	entrance chamber	Primary sediment source is human activity including coalescing prepared surfaces, hearth deposits, and hearth rake-out. Activity concentrates at the front of the cave again with mixed dumping areas towards the chamber walls. Fire hardened surfaces later act as barriers to vadose carbonate rich waters resulting in localized saturation producing localized cementation. Intermittent slope wash (often transporting anthropogenic sediments from the exterior or entrance further into the cave) deposits suggest periodic (seasonal?) wet conditions. Possible prehistoric excavation along the eastern chamber to lower floor for additional "head room" (increase vertical

6,800 - 6,500	Eva/Morrow Mountain	entrance chamber	Primary source human activity, specifically burning. Concentrated ash may be a byproduct of Zone K activities. Reduced vertical space along the interior margins of the chamber with concentrated mixed ash indicates use as dumping areas. Large pits (function unknown) also placed along the back wall. Continued evidence for seasonal wetting and drying.
~6,500?	mixed	back passage	Slope wash entering the rear of the cave periodically transported fine sediments including mixed artifacts (bone needle, Benton projectile point, Big Sandy projectile point, etc.)
6,700 – 6,000	Eva/Morrow Mountain	entrance chamber	Human activity continues to concentrate toward the front of the entrance chamber. Areas of intensive use just inside drip line with numerous intersecting charcoal filled pits (some intrude into Zone J) and surfaces. Large pits or burrows (?) excavated into the front of the cave along the drip line. Localized saturation associated with seasonal ceiling drip.
<6,500	n/a	back passage	Conformable boundary between Zones X10 and X11 suggests slow shift to autochthonous sources as the cave fell into disuse and exterior alluvial environment stabilized.
5,900 – 5,200	Seven Mile Island	entrance chamber	Colluvial source sediments with periodic anthropogenic deposition from decreasing (relative to earlier zones) human activity. Both prepared and unprepared burning surfaces concentrate near the entrance. Zone continues beyond the drip line where it is designated Zone B.
<6,000	mixed	talus	Talus accumulation represents a slightly steeper slope outside the cave than the current slope. Extensive gravel and boulder size limestone attests to the continued reduction of the bluff. Extensive bioturbation and root structures.

As the passages continued deeper into the karst system the floor elevation rose. A third passage most likely existed to the rear of the cave along the northern wall. The floor of this passage appears to be at a higher elevation than that of the western passage, as the cave floor slopes up to the north ca. 50 cm. The location and size of a north passage is, at this point, little more than an educated guess based on erosion of the deepest sediments in the rear of the cave and the periodic activation of phreatic drainage in this area. This "passage" may consist of only a narrow joint opening.

After the Pleistocene sediments were eroded from the cave interior, phreatic drainage followed a northwest-southeast trending floor joint from the western chamber. Here, the Zone Y deposits are significantly deeper compared to other areas in the entrance chamber and are associated with a channel for the continuing (though dwindling) water flow along this terminal aquifer (Table 10.1). The deepest sediments within this channel consisted of reworked coarse alluvium combined with finer contemporary sediments derived from within the cave system. The structure of these sediments suggests wet and dry conditions in the entrance chamber during the Pleistocene/Holocene transition, prior to human habitation, with periods (perhaps seasons) of extreme cold. Partially fossilized Pleistocene and Holocene faunal remains were incorporated into these deposits, essentially as channel lag.

The first human habitation of the cave was initiated approximately 10,500 B.P. based on artifactual evidence in Zones U and T (Table 10.1). Just prior or during the initial habitation of the cave, winters were still extreme. Possible cryoturbation features are identified in the western limits of the entrance chamber in Zone U3. Although the data are limited, these features may relate to the Younger Dryas chronozone (see below).

Late Paleoindian hunters and gatherers first used the cave in the fall months while exploiting nearby resources, primarily water fowl from the adjacent floodplain and mast crops in the nearby uplands (Detwiler 2000; Walker et al. 2001). This seasonal interpretation is based on the fact that, for Dust Cave, the fall months were both the driest season in the cave and the period when most of these subsistence resources were most abundant.

Through brief seasonal occupations people generated sediments in the form of charcoal, ash, burned sediment, microartifacts, and sediment imported from the outside adhering to other materials. Activities took place on the cave's most horizontal surfaces immediately inside the entrance and on the talus outside (Zone S2). The prominent boulder-sized limestone blocks on the talus and at the entrance probably functioned as site furniture. During this time the cave was both dry enough for human occupation and hospitable to ensuing soil fauna, which subjected the deposits to localized bioturbation.

Considering the relatively large size of the cave during this time and the amount of sunlight that entered from the southern exposure, both endogenous and exogenous processes influenced the microenvironment of the entrance chamber. Exogenous processes included slope wash from the talus in front of the cave, plant growth during periods of human abandonment, influx of aeolian sediments blown off the floodplain, and occasional overbank deposition during flooding along Cypress Creek and the Tennessee River (Zones U and T, Table 10.1).

Shortly before 10,000 B.P., there was a resurgence of the phreatic aquifer in the cave, and the joint-controlled drainage channels within the cave became active again, eroding fine-grained sediment and leaving weathered limestone gravel (Zone U4). Post-depositional water movement resulted in partial decalcification of the sediments, producing subsidence of these deposits. This was quickly followed by the influx of well-sorted silt related to periodic slopewash, and possible aeolian and slackwater accumulations in the cave (Zone T3). This fine-grained sediment is observed in the back chamber of the cave as well. The source of this sediment is still unclear.

Periodic resurgence in the karstic aquifer accounts for the inverted dates and diagnostic artifacts derived from levels 22 and 23 in Test Unit A and the northernmost portion of the Test Trench. Driskell (1994) notes the presence of Early Side Notched points (regionally diagnostic Early Archaic tools) associated with pre 10,000 B.P. dates. In Unit N64W64, at the rear of the Test Trench, Early Side Notched forms were recovered from early strata. These excavation areas are each juxtaposed over the joint-controlled phreatic drainage associated with Zone Y, and in some cases, Zone U. The resurgence of the phreatic aquifer resulted in the winnowing of fine sediments along the top of Zone U into Zone T4, and consequently could have easily mixed charcoal from Zone U with coarse clasts (in this case projectile points) from upper Zone T.

By 10,000 B.P. the entrance chamber consisted of a relatively horizontal surface, with Zone T covering the northern slope of the floor. Tennessee River alluvium is associated with most of the zones within T (Table 10.1). A disconformity is evident between Zones T2 and T3, and T2 and R9, which suggests that alluvial events, subsequent small-scale erosional events, and slopewash were the primary sources and transport agents for sediment during the Late Paleoindian and Early Archaic Periods up to approximately 8,500 B.P. The alluvial events overtopped the talus, introducing contemporary alluvium as well as ancient alluvium, loess, and residual soils from the plateau above the entrance to the talus. These sediments are also found in the back chamber of the cave.

At the close of the Pleistocene, the narrow section of the Tennessee River floodplain near the cave probably consisted of braided river channels with limited point bar stability. Through the beginning of the Holocene, as precipitation decreased and the coarse sediment loads from the uplands subsided, the Valley became increasingly stable with the development of a single channelized flow meandering system. The current topography of the floodplain and site distributions indicates that in the early Holocene the meandering river began to migrate southward across the floodplain. Overbank deposition buried Early Archaic sites on the floodplain (Meeks 1997a, 1997b). Cypress Creek also abandoned its main channel against the base of the escarpment, and as it stabilized it intersected the Tennessee River perpendicular to the main river channel. At this point Cypress Creek settled into its current confluence with the Tennessee River where it exited the uplands along the eastern edge of the project area. The confluence of these two rivers continued southward as the main river channel migrated across the floodplain. Springs which once drained directly into Cypress Creek continued to feed the old Cypress Creek channel (now Coffee Slough), producing an intermittent flow with seasonal contributions from overbank flooding of the Tennessee River. These changes in the Cypress Creek channel also had a profound effect on the fish and shellfish species occupying the creek bed outside the cave.

In Dust Cave, burrowing, trampling and increasing human activity influenced Zones U and T. Variability in the effects of wet conditions suggests micro-relief in the entrance chamber resulting in lower, wetter areas that people avoided and higher, dryer areas where anthropogenic deposits concentrated.

These higher areas are concentrated in the central, front portion of the cave and include discrete anthropogenic deposits, including fireplaces and the first clearly defined prepared surface in the cave (Zone T9). After 10,000 B.P., during the Early Archaic, these prepared surfaces became more concentrated, with superimposed surfaces seen in Zone R. The base of the Early Side-Notched component (Zone R) marks the first intensive use of the entire entrance chamber. Prior to this time, activity was concentrated toward the front of the cave, probably because of periodic wetness in the rear of the cave.

By the time Zone R sediments began to accumulate, it is possible that the rear of the cave was dry. At the same time, however, micromorphological evidence associated with Zone R suggests that the western front portion of the cave was periodically wet. Evidence from further up the sequence suggests that a colluvial drape formed around the western edge of the entrance. Colluvium settled against the base of the escarpment and fanned around the edge of the entrance into the opening of the entrance chamber. The drape articulated with Zone S1 in the talus and resulted in a localized, steep slope extending into the western edge of the chamber. At this point it is unclear how the southwestern drainage channel and this drape articulated in the vicinity of the western wall. The sediment that accumulated in the channel probably deterred intermittent drainage, resulting in saturation. One thing is clear: the colluvial drape feature funneled fine sediment into the western edge of the entrance, in the form of small-scale slope wash associated with the drip line. Higher up in the profiles in this southwestern area there are relatively intact anthropogenic deposits, indicating that the area was at least intermittently dry. Nevertheless, post-depositional microfeatures suggest that these deposits were frequently saturated with calcium carbonate-rich waters associated with the drip line and the drape feature. It is likely that a similar feature, yet to be discovered, exists on the east side of the entrance.

The Early Side Notched component (Zone R) is only a remnant of what might have once been in the cave. A disconformity is interpreted between Zone R and the overlying Q, with a >1,000 years gap among the current radiocarbon dates. Erosion rather than non-deposition is supported by the sudden change in the character of the sediments, the sharp boundary, and the conspicuous absence of the Early Archaic Kirk Corner Notched point type. The sedimentation rate could have dropped significantly during this time with human abandonment of the cave, but the unconformable boundary and features related to such abandonment (burrowing, soil formation near the drip line, sedimentation deficient of anthropogenic sediments) are not present.

What produced this disconformity is not yet clear. Most of the evidence points towards a major fluvial event, occurring sometime between ca. 8,500 and 9,500 years ago, that originated within the karst system and flushed sediments out of the cave, resulting in the mixed, unsorted character of Zone Q and the unconformable boundary between the talus Zones S1 and S2. This event may also explain the unconformable boundary observed in the back passage in Test Unit B between Zones X9 and X10 (Figure 7.4). The shape and distribution of Zone Q (thickest at the front and thinning towards the back) might suggest the opposite direction for the source area. However, the absence of Tennessee River Alluvium does not support this source.

Zone Q is an extensive, tabular red zone with a mixture of Early Side-Notched and Kirk Stemmed materials, along with a few of the otherwise-absent Early Archaic Kirk Corner Notched projectile points. This mixture of components further supports an erosional event(s) that reworked material from the upper reaches of Zone R or brought artifacts in from outside the cave. So while Zone Q may be primarily the result of one major depositional event, the zone is also the product of a number of slopewash events as evidenced by the remnant fluvial microstructures and comparatively brief human deposition (based on the presence of a few possibly prepared anthropogenic surfaces). The low sedimentation rate is due to the reduced human activity in the cave during this time. Zone Q is extensively bioturbated and indicates widespread plant growth, further supporting the interpretation that this was a period of non-deposition and human abandonment. There is no other evidence for large scale burrowing or other disturbances during this time. The surface of Q is marked with a dense charcoal deposit (wood and nut) that occurs throughout the entrance chamber. The extent of the charcoal suggests one large-scale burning event.

After the period of relative inactivity represented by Zone Q, the overlying Zone P indicates intensive human activity. Conventional radiocarbon dates place Zone P at roughly 8,500 B.P. (possibly as early as 8,800 B.P.) to 7,500 B.P., with diagnostic Early Archaic Kirk Stemmed points supporting this temporal placement (Figure 8.4; Table 10.1). Anthropogenic sediments within the entrance chamber are concentrated from the center of the room to the back wall. Human activity is represented in complex localized intersecting deposits, including stacked prepared surfaces, small pits, and large-scale sediment accumulation generated from burning (charcoal, ash, burned aggregates and burned microartifacts). At the front of the cave the deposits are massive and include several large intrusive "pits". These features are probably burrows. It seems curious, however, that burrows would concentrate just within the drip line and not closer to the back wall. These disturbances, whatever their origin, skew our view of activity organization within the entrance chamber, since small-scale anthropogenic deposits which were most likely present at the front of the cave are no longer visible. The periphery of the room, at least that portion that has been investigated along the western margin, was used as a dumping area for a prodigious amount of fireplace rake-out.

Immediately following this phase of intensive burning in the entrance chamber, the function of the room may have shifted for a time from habitation to a place for human burial. While burials are found in other components in Dust Cave, the majority appear to intrude into Zone P with a tentative Eva/Morrow Mountain association at roughly 7,000 B.P. The intrusions are evident among the radiocarbon samples submitted from depths of around 380 cmbd, and assumed to relate to Zone P. Figure 8.4 shows that dating burial fill can be problematic and that these samples are intrusive with one from ca. 6,200 years ago and the others concentrating at 7,000 B.P. While very few of the burials contain diagnostic grave goods, the fact remains that there are a large number of sizeable pits intruding from the contact between Zone N and P into the Zone P sediments.

Following this period of human burial in the cave, the deposition of Zone N suggests an approximately 200 year time span of restricted human activity around 7,000 B.P. to 6,800 B.P. Human habitation was limited, and the majority of the Zone N sediment appears to be the result of slopewash events combined with colluvium and autochthonous sediments. The red color of the zone may be due to comparatively limited anthropogenic input and concentrated red papules from the cave interior. This deposit is similar to Zone Q in color and lithology but contains far fewer artifacts and is concentrated in the front portion of the entrance chamber.

The upper boundary of Zone N is sharp, and may be an erosional one associated with intentional lowering of the cave floor. Physical topographic alteration to cave and rockshelter living areas is observed ethnographically among hunters and gatherers (Galanidou 2000). Observed alteration includes hollows for a hearth, domestic space or separate sleeping depressions. I cannot speculate at this point on the purpose of such alterations in Dust Cave. However, based on the limited ceiling height, I suggest that the need to increase the vertical height through localized excavation is a plausible explanation.

Immediately above Zone N, Zone K represents the return of intensive anthropogenic deposition concentrated in the front of the entrance chamber. From ca. 7,000 to 6,000 B.P., anthropogenic sedimentation increases along with the presence of Middle Archaic Eva/Morrow Mt projectile points. Zones K, J, and E are also associated with this time period (Table 10.1). One portion of Zone K consists of coalescing surfaces, some prepared, and features associated with burning (including several rock-lined hearths). Zone J may be a byproduct of activities related to Zone K, with massive amounts of combusted sediments, particularly wood ash, often extensively bioturbated. Activity in the entrance chamber was concentrated in the southern half of the room, shifting away from the back half of the cave towards the entrance. This was due to decreasing vertical height in the chamber.

Microenvironmental conditions in the cave during this ca. 7,000 to 6,000 B.P. period indicate periodic wetness. Zone J in particular underwent extensive saturation, with limited effects on the deposits below, perhaps because of the localized "perched water table" effect of the Zone K2 burnt and/or prepared surfaces. However, based on concentrated human activity during this time, stable and relatively dry conditions probably dominated the microenvironment, with seasonal or periodic moist phases.

Zone E represents the top of the Eva/Morrow Mountain component. Human activity was intensive, with numerous prepared surfaces and intersecting small basin pits. This kind of repeated use of the same location within the cave for the same function suggests a high level of spatial organization that persisted through time. The overall spatial distribution of these activities shifted further to the front of the cave as headroom decreased to about 2 m.

The final occupation of Dust Cave is associated with Zone D and a Seven Mile Island Phase component dating to approximately 5,900 to 5,200 B.P. (Table 10.1). During this time the cave living space was significantly reduced vertically and horizontally due to sediment infilling. The primary geogenic sediment source was colluvium, contributing to both the interior sediments and the talus deposits composing Zone B2. Human activity continued intermittently, concentrating even closer to the mouth of the cave and shifting to the east. It is not clear why this lateral shift occurred. Perhaps there is a change in the floor or ceiling elevation to the east of the current excavation.

The upper zones, beginning with Zone D, become increasingly decalcified. Decreasing human activity resulted in less ash to buffer the sediments. Buffering conditions also produced periodic carbonate-enriched water moving through the cave sediments, either through vadose activity or as drip when the interior microenvironment was more moist. Whatever the processes, as the cave filled with sediment and became increasingly dryer, the sediments became decalcified, resulting in decreasing preservation of organic artifacts.

Zones A1, A2, and A3 were all deposited after human occupation of Dust Cave after 5,200 B.P. These zones contain little evidence of cultural activity and represent a dry, relatively static phase in the cave's depositional history. The zones all reflect limited chemical and mechanical weathering within the cave, with colluvial processes outside the cave contributing the majority of the sediments. This source material also continued to build the talus sequence where soil formation and plant growth homogenized the sediments and obscured distinct microstratigraphic subzones that may have continued beyond the drip line. Thus, while human activity clearly took place over a long period of time outside the cave entrance, it is not possible to directly associate potentially corresponding assemblages of artifacts or strata beyond the level of gross lithostratigraphic units. The difference between the depositional environments inside and outside the cave results in completely different sedimentary sequences.

Discussion

Cold Climate Features

The first point of discussion centers on the presence of relic cold climate features associated with Pleistocene sediments (perhaps as old as 25,000 B.P.) in the back passage of the cave (Zones X1, X2, X4) and with the ca. 10,500 B.P. Pleistocene/Holocene transition deposits deep in the entrance chamber (Zone U). The earlier deposits include a unique platy structure and are intensely rubified. This structure may relate to ice lensing, associated with freezing and thawing and the resulting cryoturbation common in regions with extreme cold (Texier et al. 1998; VanVleet et al. 1984). Freezing in the typically stable microclimate of a cave system could conceivably occur only in conditions of sustained and extreme cold, which may have been the case during the Late Wisconsin.

The relic cold features observed in Zone U, located in the western portion of the entrance chamber near the beginning of the back passage, include both localized ice lensing and aggregated cryoturbation microfabrics. These basal zones temporally correlate with the Younger Dryas chronozone (ca. 11,000 to 10,000 B.P.), a cold and dry interval (Anderson 1997; Mayewski and Bender

1995; Wright 1987). Though this interval was not a major climatic setback to the south, it may have initiated extreme winters. The identification of cold climate features is unusual but not unreasonable considering the extreme conditions during the Late Wisconsin. Perhaps the large size of the cave entrance at this time resulted in exposure of the back passage sediments to cold climate conditions.

The mild cryoturbation features deep in the entrance chamber sequence are more problematic. Based on pollen data, prior to 10,500 B.P. at 34° N, as the climate warmed Dust Cave would have been in the midst of a northward shift of the spruce and jack pine forests. By ca. 10,500 B.P. the local environment transitioned into a cool-temperate climate with deciduous forests (Delcourt and Delcourt 1979, 1983). This interpretation of the pollen data makes extreme cold conditions capable of creating cryoturbation seem unlikely.

The faunal data from the Midsouth infer the presence of boreal mammals around 13,000 B.P. with a shift to contemporary species well established by 10,000 B.P. (Graham and Mead 1987; Klippel and Parmalee 1982; Snyder and Parmalee 1991). This accepted view of faunal change in the Midsouth may be more complicated than previously thought. Investigations considering nonanalog mammal communities during the late Pleistocene suggest that conditions during this time were not uniform. Mammal communities varied geographically suggesting regional environmental differences that are difficult to model without documenting individualized species response to fluctuating climates (Stafford et al. 1999:906).

These insights regarding nonanalog mammals, combined with our ever increasing knowledge of fine-scale climatic changes (like the Younger Dryas), leave the door open for as yet poorly documented regional variability during the Pleistocene/Holocene transition. The post-depositional features observed in Zone U may indeed be relic cold features that attest to a brief extreme cold phase or seasonal cold extremes. Future investigations into oxygen isotope ratios from aquatic gastropods found in the Dust Cave sequence may provide insights into changing local water temperatures over time. Ultimately, these data should clarify the issue and enhance our understanding of the region's geomorphic and climatic history.

Stratigraphic Trends

The entrance chamber stratigraphy in Dust Cave reveals two striking patterns. The first is that although geogenic, biogenic and pedogenic processes are substantial contributors to the deposits, anthropogenic processes generate or modify the majority of the sediments. The second pattern is the similarity in the types of anthropogenic sediments over time, which is ultimately a reflection of the activities that generated them (Courty et al. 1989). For example, the coterminous construction and organization of the prepared surfaces suggest that the features share a similar function, and consequently indicate similar types of activities in the cave for 5,000 years. The primary differences in the deposits are related to the intensity of human activity, and the spatial organization within the cave, not to the kinds of activities taking place. The spatial organization appears to be directly linked to the microtopography within the cave and the condition of the substrate (e.g., wet or dry). The only deviation from this trend of similar activity occurs for a brief time soon after 7,000 B.P., when the cave may have functioned chiefly as a burial place and not a habitation or specialized activity site.

Prepared Surfaces

One of the most interesting results of the micromorphological analysis at Dust Cave is the isolation of prepared surfaces. These deposits are conspicuously similar throughout the Dust Cave sequence, typically composed of noncalcareous red clay or silty clay, 1.5 to 3.0 cm thick, with unconformable boundaries relative to the zones above and below. Thin ash deposits typically cover the top of these zones and are often closely associated vertically. The construction of these red deposits involves the transport of sediment, typically from an autochthonous source, to a selected ~1 m^2 area. The sediment is spread evenly over the surface, resulting in a fairly compact and smooth upper surface. The substrate may have been too wet or infirm for the task at hand or was deemed ineffective for fireplaces. Nearly all of these surfaces were burned at varying temperatures, which directly affected their hardness and preservation. The firm surface probably allowed air to freely circulate into the fire, effectively radiated heat, and possibly retained heat.

Similar prepared surface deposits were identified during the Tellico Project in the Little Tennessee River Valley at several deeply buried Early and Middle Archaic Sites, including Ice House Bottom (Chapman 1973), the Rose Island Site (Chapman 1975) and the Bacon Farm Site (Chapman 1978). These sites contained both prepared and unprepared burned surfaces. At Ice House Bottom alone over 200 "burning surfaces" were identified in the Early and Middle Archaic levels (Chapman 1975). Over half of these surfaces were reportedly constructed of clay transported from a nearby source, and include impressions of basketry and netting employed during their preparation (Chapman and Adovasio 1977: 624). A few instances of similar surface attributes have been recovered at Dust Cave. The unique preservation circumstances at the Tellico Sites and Dust Cave, and the abundance of these deposits, suggest that these features are not necessarily unusual in prehistory, only that they are rarely preserved or not recognized archaeologically. This ancient technology and the function it played in day-to-day life were probably not only important but also commonplace.

The ability to identify prepared surfaces and their use over short periods of time, perhaps even a single occupation or cooking event, provides a tool to tease apart palimpsests and gain new insights into the spatial organization of human activity in caves. Conceivably, prepared surfaces offer evidence for early cooking technology. The timing of these deposits and the impressions of early textiles in the surfaces at Tellico point to a precursor of ceramic technology. Future avenues of study regarding these prepared surfaces at Dust Cave should include detailed chemical analyses to identify source and perhaps criteria for sediment selection. In addition, residue analyses will lead to specific functional interpretations.

Future Directions and Conclusions

In using a geoarchaeological framework for the study of cave sites, I have emphasized the relevance of micromorphology in the examination of cave sediments and the subsequent need for ancillary analytical techniques to clarify observations and address specific questions raised by thin section data. Continued stratigraphic investigation at Dust Cave will target several of the remaining areas of uncertainty. For example, the depositional history of Zones Q and N remain vague, and the exact origin of their distinct red color is unclear. A combination of processes is most likely responsible, including neoformation of hematite, a low frequency of organic matter and carbonate diagenesis. Chemical and clay mineralogy data should elucidate the history of these deposits. Additional radiocarbon dates will also help refine the resolution of the chronostratigraphic sequence and the circumstances under which it formed. Regarding the chronostratigraphic sequence, additional samples relating to the

Zone Q and the disconformity between Zones Q and R will serve to determine if a sampling bias is responsible for the time gaps or if erosional processes were at work.

The source of the Unknown Silt signature, and the exact role of this sediment signature in the depositional history of the cave remain to be solved. Understanding the nature of local aeolian transport will contribute to a clearer understanding of Dust Cave as well as the environment beyond. In an effort to isolate the source of this material, additional micromorphological control sampling from different areas on the landscape, specifically along Coffee Slough and in the uplands, will be initiated. Detailed mineralogical analyses of this silt and neighboring potential source areas (top of the bluff, base of the bluff, etc.) could ultimately tie the source with known regional paleoenvironmental sequences involving loess deposition (e.g., Beavers 1975, Leigh 1994).

My relational database of thin section descriptions has yet to be used to its full potential. The exploration of future questions will use these data in the context of the larger site database. The success of this database and artifact analyses will depend on this contextual information in order to structure results within the framework of the site stratigraphy. Understanding the matrix supporting the artifacts goes beyond enriching and clarifying our traditional archaeological interpretations. Knowledge of the sediments permits the organization of the artifacts into behaviorally meaningful units and illuminates aspects of site formation not possible in the analysis of macroartifacts alone.

In conclusion, Dust Cave demonstrates clearly the key role that the dynamic landscape played in early prehistoric settlement. At the regional scale, the geomorphic transformations that occurred during the Late Pleistocene/Early Holocene directly affected the timing of the Dust Cave occupation and played a significant role in the cave's depositional history. At the site scale, microenvironmental conditions directly affected both the organization of human activity and its preservation. Understanding these unique environments requires a geoarchaeological approach to decipher the intricacies of the sediments preserved there. The geoarchaeological perspective used in this dissertation assembles a comprehensive data set that reveals humans as playing a significant role in the depositional history of Dust Cave.

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APPENDICES

APPENDIX A

DUST CAVE ZONE DATABASE
CD ROM

Introduction

The following discussion briefly presents the attributes used to describe Zones at Dust Cave. The table of zone data is available in Microsoft Excel format on the attached CD ROM. Chapter 5 defines the term Zone and explains the structure of the database. Many of these observations were not made in the initial descriptions and were only systematically implemented during the 1998 season. Both the excavation and the database remain in progress so there are gaps in the copy of the database that follows. Ultimately this database will serve as the framework for interpreting the artifacts recovered in the cave.

Color

Color, the most straightforward attribute used to distinguish and describe zones can often be related to specific chemical, physical and biological properties (Boul et al. 1997). Color, measured by hue, value and chroma, is recorded by matching moist sediment samples removed to the natural light at the entrance of the cave where they can be compared to color chips in the Munsell Color chart (Munsell Color 1994). Many of the zones, specifically those with primary designations consist of subzones with variable colors. In addition, even subzones contained more than one color, especially the red and gray zones. The policy in these situations is to describe the predominant color and note additional colors in the comment section.

Fine Texture

There are different nomenclatures used to define soil and sediment texture (Buol et al. 1980; Folk 1980). Generally texture is defined as the relative proportion of particle sizes represented in a deposit. As the terminology indicates, "Fine Texture" refers to the matrix or sediment surrounding the coarse material (see below) or clasts. This attribute is based on the textural classifications used in soil science where a triangular diagram divides the percentages of sand, silt and clay into standardized terms (e.g. clayey, silty clay, etc.).

The use of soil terminology for the description of cave sediments was based on several issues. The first was the experience of those recording the zones in the field and their ability to confidently identify texture using soil terminology. The second aspect took into consideration the talus deposits outside the drip line and their identification as soil material. The nomenclature had to be applied to both depositional environments. A major drawback to instituting soil terminology in the cave is the use of the term loam. In the soil diagram it is simply used to identify relatively equal amounts of sand, silt and clay. The term, however, has also been used to refer to mixed sand, silt and clay containing decayed vegetable matter. I ask that the reader remember that I use the term "loam" to merely represent the distribution of sediment size.

Consistence

This attribute consists of only three designations (soft, crumbly, hard) and is used to describe the field conditions of the zone. Consistency is an attribute that suggests several other characteristics of the deposit (e.g., hard may indicate cementation, soft may indicate high organic matter content). This attribute also aided in the correlation of zones from one field season to the next.

Shape

Shape refers to the three dimensional form of the deposit in its entirety. The dimensions of a deposit are suggestive of the composition, transport agent and the environment of deposition. This attribute is intended to assist the three dimensional zone interface data (see below). Terms used to identify shape are:

Pit - generally applied to features in the zone database

Tabular - horizontally extensive, generally flat, greater than 20 cm thick

Lenticular - horizontally limited, generally flat, less than 20 cm thick

Stringer - horizontally discontinuous, generally flat, less than 5 cm thick

Elliptical - oval shape with variable thickness, generally thickest at the center

Mounded - oval to round shape with a horizontal base and a top surface or boundary at a higher elevation (at least >20 cm)

Internal Organization

The internal organization is a rough field estimate of the distribution of the overall texture or matrix within the zone. The existence of clusters of larger materials and their patterning may imply the presence of subzones. Patterns such as linear banding may suggest, depending on the texture, fluvial transport or possibly a prepared surface. Again, the terms used to distinguish this attribute are not part of a standardized taxonomy but are designed to give a general sense of the characteristics of the zone. The internal organization is described using the following terms.

Heterogeneous – materials distributed throughout the matrix

Massive – no internal structures are visible accompanied by a general absence of coarse materials within the matrix

Laminated – thin, flat lying concentrations of well-sorted fine grains suggesting fluvial transport or slopewash

Bedded – flat lying sequence of layers each containing like sediments, typically distinguished based on textural difference between the layers. Thicker than laminated.

Cross-Bedded – sequence of layers that intersect the top of the underlying bed at an angle

Post-depositional Features

Post-depositional features are recorded as present or absent. These features are deemed present only if they can be observed in the field at the macro-scale. The features are identified as follows:

Clay coatings – fine clay skins visible on the ped surfaces and/or void surfaces.

Cementation – sediment with a hard aspect. The degree of cementation varied from a few single clasts joined together to the entire hardened deposit. In the latter cases the sediment could not be troweled and had to be removed in large pieces.

Burrows – cross-cutting, typically granular, isolated deposits, composed of loose, often organic-rich sediment

Wormcasts – round aggregates approximately sand-sized.

Waterdrip – concentrated areas of wet, saturated sediment associated with ceiling drip. These areas often include concentrated residual coarse materials where the finer matrix has been removed.

Cracks – open vertical fractures in the zone caused by roots and/or dry conditions.

Pits – basin shaped deposits within the zone (typically produced by human activity.

Other Attributes

As in any multi-year project, our data recording has improved over the years. An important attribute not recorded in the database is the nature of the boundary. The nature of the contact between strata is instrumental for interpreting processes actively creating and affecting the deposits as well as gaps in time. Unconformities are frequent in cave strata and may be crucial in the correlation of zones across the cave, in reconstructing the local depositional environment, distinguishing artifact palimpsests, and in the construction of chronosequences. This attribute was excluded from the database due to the variability that can exist in a zone but is noted on profiles and in field notes.

Spatial properties of zones are not included in the version of the database presented here but are recorded in the cave in two ways. First, the location and extent of the zone is recorded within the excavation system when zones are recorded by elevation and 5 cm level within the 1 m units of the site grid. The spatial properties of zones are also archived as on-site interfaces between zones with the notation of the zones located above, below, and those adjacent. Once an area is exposed, zones originally given two different designations (in the interest of accuracy) may be found to be the same zone. When this occurs the interface recording system also allows for the correlation of these zones.

The Zone Database

The excavation, processing, and analysis at Dust Cave are carried out within the context of the lithostratigraphic context. As each new zone or zone derivative is encountered it is described and recorded in the field directly into the relational database. Entry in the zone database operates as follows. Once the designation and description have been generated in the field the zone designation is entered using a graphic user interface. The description is recorded with the standardized nomenclature (described above) using drop-down menus. These menus are derived from tables that are populated with information such as Munsell colors and texture designations. These tables act as "watch dogs" providing referential integrity to assure specific attributes contain only predefined values. As new values are encountered in the field, they can be easily added to the dictionary table. No database is ever complete without a comment section. The Zone Database contains a such a section where we record specific provenience information or unique attributes (e.g., artifacts, inclusions, etc.). In order to conserve space we use an abbreviation system listed in the table below.

One of the many goals of the research team is to create a graphic representation of these data, something along the lines of the Harris Matrix (Harris 1989; Stein et al. 1992). In the meantime the data allow chronological queries to place zones (that are not directly dated) in time using the law of superposition (based on existing dates from neighboring zones) and diagnostic artifacts (Sherwood and Riley 1998). This portion of the database is still in significant stages of development and therefore not presented here. The following systematic field descriptions are generated using the database.

breviations used in the "Comment" sections of the Zone and Thin section Databases and the 14C Tables (Table 1.1 and Appendix B)

Abbreviation	Term
//	separates comments
~	approximately
abund	abundant
adj	adjacent
ang	angular
ang bk	angular blocky
B	burial
b4	before
bdry	boundary
betw	between
bio	biological
brn	brown
c	clay
c l	clay loam
c/si	clayey silt
carb	carbonate
cc	charcoal
cem	cemented
corrl.	correlated
CR	ceiling rain
cs	coarse
depo	depositional
dia	diameter
diff	difficult
dis	dispersed
distb	disturbance
dk	dark
evid	evident
f	fine
Fea	feature
fract	fraction
frag	fragment(s)
gr	gravel
gry	gray
hvy	heavy
incl	inclusions

Abbreviation	Term
lg	large
ls	limestone
lt	light
mica	micaceous
mot	mottles/mottled
paps	papules
poss	possible
postdepo	post depositional
predom	predominantly
prep	prepared
prob	probably
rd	red
rnd	rounded
rx	rocks
2ndary	secondary
s	sand
sed	sediment
sev	several
si	silt
si l	silt loam
si/c or si c	silty clay
sm	small
sq	square
stratg	stratigraphy
there4	therefore
thr/out	throughout
tr	trench
TT	Test Trench
TU	Test Unit
v	very
w/	with
WC	witness column
wea	weathered
wh	white

APPENDIX B

DUST CAVE RADIOCARBON DATES: CALIBRATED

DUST CAVE RADIOCARBON DATES: CALIBRATED

Conventional radiocarbon ages calibrated using the OxCal Program v3.5 (Ramsey 2000).

Zone	Beta No.	Convent. 14C Age (BP)	+/-	Calibrated Date (BP) 95.4%*	Calibrated Date (BP) 68.2%*	TU	N	W	Lev	Depth (top)	Depth (bot)	Fea.	Context Comment
D4	65168	**5,280**	**130**	**6,400-5,750**	**6,320-5,970**		60.00	64.00	6	160	178	42	basin shaped, intersecting feature complex Fea.47, 136 (hearths)
D4	100508	**5,000**	**80**	**5,960-5,650**	**5,940-5,700**		60.00	65.00	11	173		136a	intersecting basin shaped features, 136a originates at the base of D4, intrudes into E1, Fea.47 adjacent and same temporal placement
D4	58895	**5,590**	**50**	**6,530-6,330**	**6,460-6,360**		62.00	64.00	6	175	185	15	base of D4, intersecting shallow basin pits
D4/E1	48753	**5,380**	**90**	**6,360-5,980**	**6,340-6,040**	H	60.20	60.10	7	150	160		
E1*	100509	**5,400**	**80**	**6,370-5,990**	**6,340-6,050**		59.20	64.60	15	196		150b	series of intersecting shallow basins of ash and cc with variable amount of burned gastropods, intrusive into E5. *could be intrusive into E1
E1	48752	**6,700**	**100**	**7,790-7,470**	**7,720-7,530**	H	60.00	59.60	12	200	210		Benton and Morrow Mt projectile points immediately above
E1	58898	**5,670**	**120**	**6,800-6,250**	**6,670-6,360**		58.00	64.00	11	200	208	56	small pit intruding into E8, (E8d zones).
E4	65169	**5,910**	**70**	**6,950-6590**	**6,910-6,690**		62.60	62.90	11	215	220	69	small basin shaped sparse rock lined pit, originated in E1/E4, intrudes into J1/J3
X10	48751	**6,560**	**140**	**7,750-7,200**	**7,630-7,370**	B			2	327	347		back passage level w/ bone needles, Benton and Big Sandy base
J/K	58899	**6,660**	**100**	**7,740-7,380**	**7,660-7,480**		58.00	64.00	14	240			base of J/top of K (spit D), prior to zone designations
J1a	100510	**6,480**	**90**	**7,620-9,290**	**7,520-7,320**		62.00	64.50	23	245		177	shallow elongated rock feature (cc and ash beneath rock) originates in J1a intrudes into J3
J3	65171	**6,280**	**90**	**7,470-6,990**	**7,360-7,070**		63.50	63.50	11	222	225		Upper J3, material intruded by Fea.69, excav from'92-'93, possible contamination
J3	58897	**6,790**	**120**	**7,900-7,480**	**7,800-7,560**	H	60.00	59.60	16	240	250	38	Top of Fea.38 in Zone J1/J3 (fea. above or intruding into zone containing Kirk Serrated and Eva projectile points), at cave entrance
J3d	65174	**6,350**	**90**	**7,480-7,060**	**7,470-7,210**		62.70	62.80	16	245	251	88	small cc and ash filled basin with red clay base, Fea.88 originates in J3d, intrudes into K2
K3	65173	**7,040**	**80**	**8,030-7,730**	**7,990-7,810**		60.00	64.00	18	259			base of K3, transition to N, complex zones with intruding features
K3	65170	**7,480**	**120**	**8,600-**	**8,440-**		58.00	64.00	18	270	275	71	base of K, outside entrance

Zone	Beta No.	Convent. 14C Age (BP)	+/-	Calibrated Date (BP) 95.4%*	Calibrated Date (BP) 68.2%*	TU	N	W	Lev	Depth (top)	Depth (bot)	Fea.	Context Comment
K3-K5/N2	65175	**6,570**	**190**	**7,850-7,050**	**7,670-7,320**		60.00	64.00	21	270	275		assoc. w/ 93-13, exact Zone not clear (prior to consistent use of zone designations)
L1	65178	**7,040**	**110**	**8,160-7,710**	**8,010-7,790**		59.10	62.50	24	283	293	98	rock lined shallow elongated pit w/ ashy silt and cc and red clay inclusions, intrudes into P1, just inside drip line at the N/L1 transition
L4	65183	**9,190**	**130**	**10,800-9,950**	**10,560-10,260**		58.00	64.00	35	385	390		transition entrance to talus, under R (L3), adjacent to R and R3/S2
N	65182	**6,840**	**90**	**7,970-7,550**	**7,800-7,630**		63.50	63.20	22	275	280		top of N2, cc concentration in NE quad of unit, associated with possible reworked Kirk projectile point into scraper (#73)
P1	48755	**6,050**	**100**	**7,300-6,700**	**7,200-6,800**		61.00	63.00	13	280	286	34	burial fill, intrusive into P3, part of zone P1, top depth ~246
P1	48756	**7,680**	**170**	**9,050-8,200**	**8,750-8,250**		60.20	62.20	17	285	295		
P2	65180	**7,010**	**90**	**8,030-7,710**	**7,990-7,790**		60.00	64.00	25	290			compact ash and cc zone, intrusive, may be part of a feature complex associated with Fea. 98
P3/ ~P14	65184	**8,330**	**170**	**9,750-8,800**	**9,580-9,140**		60.00	64.00	36	345			red silty clay, (bioturbated), just above Q1
Q1	81608	**8,470**	**50**	**9,600-9,370**	**9,580-9,485**		64.00	64.00	38	359			top of Q, below P5b
R1*	81606	**9,720**	**70**	**11,290-10,800**	**11,260-10,920**		63.00	63.00	43	380	385		cc concentration in silty clay *possible intrusive pit
R3f	16273	**10,140**	**40**	**12,350-11,400**	**11,990-11,620**		60.00	65.00		405	410		Early Side Notched component
R9	81602	**10,050**	**60**	**12,150-11,300**	**11,800-11,350**		59.00	64.00	46	400			soft red zone, associated with Big Sandy (material from top of 98058)
S1a	65176	**8,720**	**90**	**10,200-9,550**	**9,940-9,600**		58.00	64.00	25	306	313	94	cave entrance S1a or P3, basin shape shallow pit with artifacts
S2	81600	**10,450**	**50**	**12,900-12,00**	**12,850-12,200**		56.00	64.00	29	437			related to drip line just outside entrance, same material as 93020, above bedrock
T	81610	**10,070**	**70**	**12,200-11,300**	**11,950-11,350**		64.00	63.00	48	409			rock concentration, Beaver Lake projectile point in zone T, 50 cm to the south of sample
U3?	100506	**10,370**	**180**	**13,000**	**11,400**		60.00	64.00	57	451	453		cc concentration excavated as T associated with uniface scrapers
T1/T2?	65177	**9,990**	**140**	**12,400-**	**11,800-**		60.40	63.60	33	430	435		Zone T1 associated with uniface and Big Sandy projectile point

Zone	Beta No.	Convent. 14C Age (BP)	+/-	Calibrated Date (BP) 95.4%*	Calibrated Date (BP) 68.2%*	TU	N	W	Lev	Depth (top)	Depth (bot)	Fea.	Context Comment
T2/T3?	40681	**10,490**	**360**	**13,200-11,200**	**13,00-11,700**	A	60.85	66.60	22	381	391	33	problematic date?, Fea.33 intrusive into zone containing Big Sandy projectile point (98014)
T2	133788	**9,950**	**50**	**11,620-11,250**	**11,600-11,280**		61.95	65.63	55	384			cc concentration reddish brown, silty "loam" w/ éboulis, >15 cm above large bird humeri concentration
T2? T3?*	41063	**10,330**	**120**	**12,900-11,600**	**12,700-11,800**	A	60.50	67.00	23	391	401		*problematic sample, Big Sandy projectile point found above (SE, SW corner TU A)
T2c	16274	**10,020**	**40**	**12,000-11,300**	**11,680-11,350**		60.00	66.00		410	415		Late Paleoindian component
T8(T2)	81611	**9,890**	**70**	**11,620-11,210**	**11,600-11,240**		64.00	64.00	47	403			cc ash concentration in red micaceous clay
T8	133791	**10,100**	**50**	**12,200-11,300**	**11,950-11,400**		63.00	65.00	61	420			micaceous clay with cc and éboulis<10 cm above U3
U1a	65179	**10,390**	**80**	**12,900-11,800**	**12,700-12,000**		62.00	64.00	36	450	455		concentration of cc beneath a rock identified as lens U1a, originates in U2 just above bedrock, assoc. w/ unifacial tools, ~98041 (E. wall Test Trench)
U1a	65181	**10,310**	**230**	**12,900-11,300**	**12,700-11,650**		60.25	62.16	39	461	463		silty clay w/ cc, directly below #1000, intrudes or overlies basal U2, ~98074 (E. wall Test Trench)
U2	81599	**10,480**	**60**	**12,900-12,000**	**12,850-12,370**		60.24	62.20	40	476			micaceous silty clay on bedrock, w/ cc flecks, still contains bone and lithics underlying #1000 and 1037, (E. wall Test Trench)
U3	133790	**10,290**	**60**	**12,750-11,700**	**12,400-11,800**		61.00	66.00	59	428			brown silty clay with éboulis, associated w/ flot column #5678
U3	40680	**10,345**	**80**	**12,900-11,800**	**12,700-12,00**	A	60.20	66.20	27	431	441		silty clay (uniface tools, bone, flakes, etc.) ~10 cm above bedrock
U3	81613	**10,470**	**60**	**12,900-12,000**	**12,850-12,200**		64.00	64.00	55	445			excavated as T (west wall Test Trench), micaceous silty clay among weathering bedrock and éboulis
Y1	81603	**10,570**	**60**	**13,000-12,200**	**12,890-12,400**		55.00	63.36	35	460			silty clay at base of cave over bedrock

APPENDIX C

DUST CAVE MICROMORPHOLOGY SAMPLE
FIELD LOCATIONS AND DESCRIPTIONS

APPENDIX C: DUST CAVE MICROMORPHOLOGY SAMPLE FIELD LOCATIONS AND DESCRIPTIONS

Table Heading Explanations

Column Heading	Explanation
Zone	zone: lithostratigraphic unit recognized in the field
Sample #	sample number (last two digits of the year followed by sampling sequence)
TS	thin section designation (used for large samples, producing several thin section, typically from top to bottom – a, b, c)
Test Unit	sample derived from Test Unit during testing phase
Square N W	excavation units designated by the northwest corner of the excavation unit
N	point provenience - north
W	point provenience - west
Lev	excavation level
cmbd (top)	centimeters below datum, top of sample
cmbd (bot)	centimeters below datum, bottom of sample
Comment	Descriptive notes recorded in the field

Zone	Sample #	TS	MS Sample	Testunit	Square N	Square W	N	W	Lev	cmbd (top)	cmbd (bot)	Comments
A1	92001	a	92001		56	64	54.2	62		200		
A1	92006	a	92-006a		56	62	55.9	62		86		si c w/ eboulis, roots and room casts, near surface
A2	91008	a	91-008a	H			59.2	59.8		35		homogeneous red brown si/c w/ some (modern?) roots, cherty ls pebbles (1-3 cm) and dispersed cc. Soft, moist and fine crumbly structure w/ worm casts, no apparent dip. PG
A3a	90004	a	90PG004	F	62	64		64		10		Equivalent to top zone in E profile light tan silt, locally aggregated, with roots. PG
A3a	96052	a	96DC052		61	62	60.4	61		90		just below A2, red si/c w/ weathered ls gravel
A3a	96053	a	96DC053		61	62	60.4	61		110		A3a/A3b contact, increase in c in si/c w/ slightly fewer gravel
A3b	92012	a	92-012a	F	62	64	60.05	62		116		reddish brn 2.5YR4/4, moist si/c w/ some ang. flint chunks, siltier than c outside [non-calc.in TS] Unit continues from back wall toward cave entrance until it hits Zone A2 in N59W64, then grades into clayier, stonier unit. PG
A3b	96054	a	96DC054		61	62	60.4	61		140		base A3b, above top of D3, si/c few gravel over F155
A3b/D4	96018	a	96DC018		62	65	61.57	65		136		red si/c over D4:red cl/si w/ hard red inclusions
A4	92001	a	92-001		56	64	54	62		200		talus, SE corn of sq, crumbly si/c w/ abund ang flat rx frags (spall?), laterally becomes stonier, w/ diffuse area impreg w/ CaCO3, abund worms and bur. ~20 cmbs, f and cs roots, differs frm 2.5YR of cave c. PG / .5-1 m S of interface, sev b. SS
B1	92007	a	92-007a		56	62	55.75	62		137		red brn soil material, generally homogen, at drip line
B2	92002	a	92002		56	64	54.2	62		225		
B2	92002	a	92-002a		56	64				220		talus, 5YR3/3, dk reddish brn, below 92-1 but less granular, lower 1/2 could be lighter and mot w/ more reddish si/c and grades into "cave facies", snail frags, similar amount of roots
B2	92008	a	92-008a		56	62	55.75	62		180		Zone B2, just S of Be/D interface, c/si w/ abund carb veins and impredgnations, especially in circular area, ~80 cm in dia between d=120 to 200, possibly represents an old root system.
D4	91009	c	91-009c	H			60.2	60.8		80		Moister and softer than 91-8, w/ diffused pieces of cc up to 1-2 cm, some red silt granules probably representing fire reddened hearth substrates. Darker color probably due to finely dissem cc. PG
D4	98061	a	98DC061		63	62	63	61.75		190	200	cc concent in D4, v lg frags (gravel & larger) of cc (wood?)
D4/D4d	96056	a	96DC056		61	62	60.55	61		170		D4d: brn over broken up orange cemented frags, another orange lense over blackened, burned (?) contact over D4:brn w/ charc. (see dia. In field notes, SCS 8/10/96)
D4/D4f	96057	a	96DC057		61	62	60.65	61		180		D4: brn sed over D4f: mixed grey w/red micro lenses (soft), these "orange" lenses are sloping to the s and prob. W from the cave entrance
D4/E1	98062	a	98DC062		63	62	63	61.75		206	212	transition D4 to E1, more silty, less cc
D4b	96020	a	96DC020		62	65	61.45	65		154		lens of red brn cl/l w/ gravel size clasts in ashy cc rich sed of D4
D4e	93016	a	93PG016		60	64	59.8	62		167		reddish c/si. These probably represent preserved surfaces of some sort. Excavated as lev 6b

Zone	Sample #	TS	MS Sample	Testunit	Square N	Square W	N	W	Lev	cmbd (top)	cmbd (bot)	Comments
E	92009	a	92-009a		56	62	55.85	62		214		exterior end of Zone E adjacent to Zone C (interface at drip line), E grades into B2
E1	91010	a	91-010a	H			60.2	60.8		170		immediately above J3, ~ to 91-9 w/ grayish diffuse band ~1-3 cm thick, probably ash remains or area of decomposed. Ls seems to dip W laterally to E is ~10 cm band of dispersed ash. PG
E1	91010	b	91-010b	H			60.2	60.8		170		immediately above J3, ~ to 91-9 w/ grayish diffuse band ~1-3 cm thick, probably ash remains or area of decomposed. Ls seems to dip W laterally to E is ~10 cm band of dispersed ash. PG
E1	91010	c	91-010c	H			60.2	60.8		170		immediately above J3, ~ to 91-9 w/ grayish diffuse band ~1-3 cm thick, probably ash remains or area of decomposed. Ls seems to dip W laterally to E is ~10 cm band of dispersed ash. PG
E1	92013	b	92-013b	F	62	64	60.25	62		187		Reddish brn 2.5YR4/4, moist soft homogeneous ashy c w/ disp cc, laterally grades into reddish c (burnt?) to s, and to pit filling w/ cc to N. Seems bioturbated. PG
E1	96021	a	96DC021		62	65	61.45	65		162		si/l w/ cc.
E1	98017	a	98DC017a		63	61	62.06	60.4		200		E1: si lt brn over E1g: mixed red ash hard lens w/ variable s, appears splotchy, above E1g lenses of variable ash. Overlying E1 (again) brn si loose sed (photo, pedistaled sample).
E1a/E1o/E1p	93014	a	93PG014		62	64	60.75	62		211		Interbedded grey ash and red c (~ to sample 93-PG9). Some thin white strings, disappear laterally. Hard and prob calcite cemented.
E1g	93012	a	93-PG012		64	64	62.4	62		218		interbedded lighter and greyer ash below lg (~1 m) rockfall. Calc w/ calcareous tubules, shell frags and dispersed cc. Localized clast of reworked red c/si, appears pressed into Zone J
E1g	97006	a	97DC006		62	61	61.55	60.85		205		desc. for zone E1g, see lev form
E1g	98017	b	98DC017b		63	61	62.06	60.4		200		E1: si lt brn over E1g: mixed red ash hard lens w/ variable s, appears splotchy, above E1g lenses of variable ash. Overlying E1 (again) brn si loose sed (photo, pedistaled sample).
E1g	98068	a	98DC068		62	61	61.7	60		212		red zones w/ ash on top, here differ in that these are broken apart yet remain isolated. Not solid like N zones. Because near top of cave where preservation is poor (see dia. SCS 98 notes)
E7/E7b	96038	a	96DC038		59	65	58	64.7		194		lg red clasts in a matrix of calc ash
J3	93018	a	93PG018		60	64	58.8	62		194		hard packed possibly intact? surface but in greyer seds. Close to drip line
J3	96028	a	96DC028		62	65	61.45	65		224		J3: grey brn w/ cc flecks, may have some ash lenses at base (J3b?)
J3	98063	a	98DC063		63	62	63	61.75		223		designated J3 but difficult to distinguish from E1, less cc, more ash, the distinction is not clear along back wall. This corner unclear
J3b	92014	a	92014a	F	62	64	60.25	62		238		Interbedded ash and reddened si/c, looks intact. Reddish brn 5YR5/5 ash dk red 2.5YR3/2 burnt si/c

Zone	Sample #	TS	MS Sample	Testunit	Square N	Square W	N	W	Lev	cmbd (top)	cmbd (bot)	Comments
J3b	92014	b	92-014b	F	62	64	60.25	62		238		Interbedded ash and reddened si/c, looks intact but laterally to N disturbed (?). Reddish brn 5YR5/5 ash dk red 2.5YR3/2 burnt si/c.
J3d	98005	a	98DC005		61	62			2	~225		grey and red interbedded lenses w/ platy struct, 10R4/6 red c w/ s and gr size incl of "burnt" red c, cc & burnt shell over 2.5YR5/1 reddish gray c (ash) w/ s size wea ls, burned shell and red clasts
K1/K2g	96043	a	96DC043		59	65	58	64.65		243		K1 on top (brown/grey), over K2 on bot (red). Possibly some J3a on top
K10b	98009	a	98DC009		63	62	63	61.5		255		Under ls in cemented red w/dark brn red patches and organics(?) over ash with dark red stringer. A sm patch at base of J3 in K10s. The cemented reds and ash represent the back part of the K zones. Much thinner along the E edge, sloping west. SS
K2	93013	b	93PG013b		62	64	60.1	62		260		see SS notes 7-6-98 p.15. Top of Zone K, homogeneous red c/si, ~10 cm thick, w/ grey ash on top. Could be surface covered by ash. Truncated to right and left.
K2	93026	a	93-Dust10		64	64	62.22	62.25		259		sm fmt TS, same as Dust 93-9, base of sample, ash layered (very compact, fragile), represents variability in K2. SS
K2	93028	a	93-Dust12a		60	64	59.73	62.45		253		cemented K2 "floor", popped out during excavation, bits of K3 (ashy mixed layer) on the bottom of sample
K2	93028	b	93-Dust12b		60	64	59.73	62.45		253		cemented K2 "floor", popped out during excavation, bits of K3 (ashy mixed layer) on the bottom of sample
K2	93032	a	93-Dust19		60	64	59.2	62.45		249		copy of #s17&18, still attempting to get a sample w/ the red and tie it in w/ the F79 edge, also the ash (K3) between the 2 features.
K2	93033	a	93-Dust20a		60	64	60	62.9		248		edge of profile, red "oxidized, burned?" c, completely cemented (mistaken for a rock in the field)
K2	93033	b	93-Dust20b		60	64	60	62.9		248		edge of profile, red "oxidized, burned?" c, completely cemented (mistaken for a rock). SS.
K2/K3	93030	a	93-Dust17		60	64	59.2	62.45		249		Red sed between F. 78,79. These F. intrude through the red "floor" K2, overlying ashy K3
K2b	93023	a	93-Dust03		60	64	60	62.7		238		red oxidized c over ash stringer over orange w/ sm gr, over ash stringer (see diagram). S.S
K3/N	93011	b	93PG011	F	64	64	62.25	62		232		~93-10 but seems to have some v. fine white laminae which could be water-lain. Sediments below this zone P on N interface are fine bedded and could also be water lain or modified.
K3a	93024	a	93-Dust05		60	64	60	62.85		230		Red oxidized c w/ ash stringer on top and below clay
N2	93010	a	93-PG010	F	62	64	61.6	62		273		~20 cm thick unit of red brn c/si. Upper part of sample is redder and darker than lower part. Some fine (mm size) cc dispersed throughout. Overlies some burnt stones.
N2	98069	a	98DC069		60	61	60.3	60.1		260	270	N2, sample to tie into seq in TU H, samp is ~45 cm below Dust 91010 evid on the N wall of TU H behind shoring

Zone	Sample #	TS	MS Sample	Testunit	Square N	Square W	N	W	Lev	cmbd (top)	cmbd (bot)	Comments
N2	98073	a	98DC073		60	62	59	62.6		260		contact K10/N2, could be mostly N2 difficult to ID boundary, because sloping deposits down to W, what is the nature of these deposits?
N4d/N4e	98095	a	98DC095		62	66	61.85	65.85		280		red clay mapped as N4 but upper part hard w/ darker sharp upper boundary, dvided by brn mixed sed w/ cc, lower softer red, lighter orange.
P14/Q4	98039	a	98DC039		62	64	61.6	64.23		351		P14/Q4 bound betw lower half of P (beds of grey si/c w/ varying percentages of cc (size & freq), ash and arts. Top of Q w/ abrupt bound, bioturb channels evident.
P2	98057	a	98DC057		59	65	58.75	64		362	370	herogen brn w/ cc, red clasts & occas ls eboul, may be part of lg burrow or series of feas just S of lg angular rock fea, B?? (not in prof.)
P3	92016	a	92-016	F	62	64	60.25	62		321		Massive, reddish brn 2.5YR3/4, greyish ashy si/c to c/si, infilled pit?
P3	93008	a	93-PG008	F	62	64	61.1	62		337		Massive brnish grey, homogeneous c ashy si w/ dispersed cc clasts of burned si. Probably ____, laterally grades into hearth remnant. PG
P3	98047	a	98DC047		61	65	60.69	64.03		304	312	upper portion of P3, mixed "ashy" brn w/ cc, occasional red "clasts" & shell, some fine bedding, possible burrow fill or pit fill.
P3	98051	a	98DC051		60	65	59.3	64		298	306	convoluted area of red cemented zones & v f bedding of red, pink, & tan si/c's & ash (ash clasts). This may be part of a sm pit w/ the ang ls visible in profile adj to the sample
P30	98033	a	98DC033		63	65	62.1	64.1		287		red cemented lens, very hard, overlying microbedded soft grey ash (poor sample,diff to collect)
P3e/P4/P4a	98036	a	98DC036		62	64	61.8	64.1		330		P4 (originally P3f), red cl w/ ash and cc over ash (pink) and cc, "soft red" Boundaries v clean and abrupt (why?). SS
P3e/P4/P4a	98038	a	98DC038		62	65	61.85	64.23		328	335	immed below 37, intersects testing P4(=P3f), this zone also sampled in 98DC36, med. Brn si/l s size particles of (?), red cemented P4, no inclu evid, over med brn zone w/ lg charc. frag. (see notes SS), connects w/SS6 as does 98036
P3g/P3q	98035	a	98DC035		62	64	61.45	64.22		310		Next cemented grey/grey series down from 98DC34, red here is soft more brn over ash w/ lg cc frags, micro bone and shell.
P3m	98023	a	98DC023		64	64	62.3	62		300	310	This sm lense of P not Ided seperately during TT excav., solid white/grey ash over friable red clay over mixed brn w/ cc, red lense slopes down towards S (entrance) - same lense as in 93PG9, sim to 98DC34 (N7)
P3n/P29/P3	98034	a	98DC034		62	65	61.95	64.22		290	300	ash, thin <1 cm red lens, soft (considered N7) in ash mixed w/ cc and more brn of P3, should be sim to 98023 (P3m)
P3q/P3g	98037	a	98DC037		62	64	61.55	64.23		320		Dk red/brn soft red zone over dk tan ash w/ wh incl & tiny "tubes" coated in wh (cemented carb?) same as lithics? Lower portion finer, no microart, slightly pink (over another ash zone), adj to 98DC35
P5	98088	a	98DC088		60	67	59.61	66		315		similar to 98DC78, banded ashy cc sed generally slopes very slightly NW though, to the west - sloping downward
P6c	98089	a	98DC089		60	67	59.54	66		329		si banded ashy cc sed w/ faint red band, what is this band?, 2ndary color change (see dia.)

Zone	Sample #	TS	MS Sample	Testunit	Square N	Square W	N	W	Lev	cmbd (top)	cmbd (bot)	Comments
P7/Q3	98081	a	98DC081		60	68	59.28	68		370	379	P7 ashy w/ cc and shell sharp contact w/ Q3, reddish w/ limited rx and cc, begins to thin to the S
P7/Q3	98090	a	98DC090		60	67	59.54	66		356		P7/Q3 boundary: still abrupt here but not as sharp as along test trench, interesting stringers at contact(?)
P7b/P7/Q3	98098	a	98DC098		63	67	62.06	66		359		P7 over Q3 which both become very thin here, less pronounded toward the N wall but it is still distinct (see dia.)
Q	92017	a	92-017	F	62	64	60.25	62		360		Massive ashy c to clayey ash, laterally becomes streaky, interbedded reddish and greyish ash and si w/ some rx and flints. Traces of mica, seds look slightly redder from here down.
Q	92017	b	92-017a	F	62	64	60.25	62		360		Massive ashy c w/ clayey ash, laterally becomes streaky interbedded reddish and grey…
Q	92017	b	92-017b	F	62	64	60.25	62		360		Massive ashy c w/ clayey ash, laterally becomes streaky interbedded reddish and grey
Q	93007	a	93-PG007	F	62	64	61.5	62		357		Similar to 93-6 but slightly browner, quite homogeneous massive gritty c/si. Some dispersed cc flecks, widespread over much of T.U. F
Q	98027	a	98DC027		64	64	62.3	62		348	356	variability in Q, uncemented over a cemented zone (in base of 98028); red w/ shell and wea ls over browner lense, little charc
Q/Q1a	98028	a	98DC028		64	64	62.5	62		350	360	variability in Q, ephemeral "surfaces" changes in the relativley consistent red, top is same brown lense w/ little cc, over ephem red hard surf (Q1a) over red friable, broken up cem material
Q3	98011	a	98DC011		62	68	60.78	67.8		375		~124 cm from the S. wall, very top is P7 & remainder Q3. Q quite extensive in the entran. Tr. Is this Q the same? SS
Q3	98018	a	98DC018		60	68	67.65	59.5		368		S wall of TUA, top of Q3 just beneath, Contact of P7 (w/ cc). Q: red clay w/ gravel size eboulis, bone and lithics. SS
Q3/R6	98091	a	98DC091		60	67	59.53	66		368		Q3: 10R4/5 red c zone over, R6: med brn w/ eboulis
R1	93005	a	93-PG005	F	62	64	61.7	62		395		Similar to 93-4 but higher up in Unit R. PG
R1	98030	a	98DC030		64	64	62.35	62		383	390	greyish brown c/si w/ s size red aggs in gen appears mixed w/ sections of subzones, faint pits, etc., subzones & boundaries are clearer to the south, intruded by pit just to the North of sample
R1 (abce)	98041	a	98DC041		62	65	61.94	64.1		375	383	samples isolated red stringers in the upper part of R1, detailed desc and diag in field notes
R1/Q4	98040	a	98DC040		62	64	64.7	64.1		362		Q/R bound. Base of Q is abrupt, si/c over brn homogen zone, top of testing phase R1.
R1f	93006	a	93-PG006	F	62	64	61.75	62		374		homogeneous reddish, slightly gritty c/si, massive, ~10 cm thick, top part of the sample slightly greyer and looks like upper part of burned zone. Truncated to S., only a trace of mica.
R6/R6b/T2	98102	a	98DC102		61	66	60.65	66.08		380	388	R6a, base of R6, odd boundary w/ base of R6 very fine grained (burned?) over T2, only about 30 cm worth before truncated on S side, observed similar bound in TT

Zone	Sample #	TS	MS Sample	Testunit	Square N	Square W	N	W	Lev	cmbd (top)	cmbd (bot)	Comments
R6/R9	98052	a	98DC052		60	65	59.31	64		378	387	R6: bioturbated mixed zone looks like part of more massave mixed intrusion/fea. R9: soft red fairly consistent moving down profile, interupted by biot, fea, etc. v unique boundary (wavy, sharp)
R9	98058	a	98DC058		59	65	58.69	64		396	404	red soft c over string of bedded cc & ash, over hetero soft red c w/ eboulis & cc - represents "R9", overlies fea of rx and cc, part of T2
S1	92010	a	92-010a		56	62	55.7	62		238		Same material as samples 92-11(1m below), 93-PG19. PG Top of S1. SS
S1	92011	a	92-011a		56	62	55.6	62		330		Same material as sample 93-PG19 (1m below)
S2	93020	a	93-PG020		56	64	55.3	64		415		Similar to sample 93-PG19. Dk red 2.5YR3/6 si/c but w/ markedly more mica. Some lg ang pieces of roof fall. PG
T	93004	a	93-PG004	F	62	64	61.4	62		411		Homogeneous, reddish brn, moist micaceous si/c, widespread in sq over entire area, somewhat gritty, non-sticky but slightly plastic
T2/T3	98092	a	98DC092		60	67	59.53	66		390		contact s/ rocky brn T2 w/ red T3 which disappears quickly to the S, how are T3 and Q3 different?
T2/T3	98101	a	98DC101		62	66	62.18	66.08		392	400	T2/T3 bound, mostly T3 (red) si/c including the bound w/ T2, (more coarse, cc, etc.) similar to 98DC98 but further "down slope"
T2/T4	98014	a	98DC014		61	69	60.43	57.82		410	420	si/c, transition from T2 to T4 seems to be the influx of ls gravel in T4, matrix probably the same or similar material
T2/U3	98100	a	98DC100		63	67	62.06	66		397		rocky transition from T2 to the top of finer micaceous si of U3, ~10cm above sloping bedrock (see dia.)
T3	98093	a	98DC093		60	67	59.53	66		406	414	intersects contact of T3 w/ U3, different to ID here, more clear to the west, T3 red si/c, may include some of dispersed T3a (at N end).
T3	98043	a	98DC043		62	65	61.94	64.03		410	419	si/c w/ mica, drk brn gr size ls eboulis, lower half red micaceous c (top of U?), just above 98044
T8	98042	a	98DC042		62	65	61.88	64.05		375	383	boundary between R1&T not completely clear here, T typically contains more rx, top R1 lt reddish brn si/c over redder brn w/ ls g eboulis
T9a/T9	98059	a	98DC059		60	62	59.4	61.95		401	409	R (mapped as R3 in TT) mixed ash over soft red si/c, 20+ cm above similar to R3d on the W wall but it lacks the ash zone.
U1	93003	a	93-PG003	F	62	64	61.4	62		438		Soft, moist micaceous c/si w/ blk zones/spots (Mn)
U2	98032	a	98DC032		64	64	62	62		438	449	on bedrock, just S and below 31, lots of roots (may be due to shoring) reddish brn silty clay w/ ls gr frags
U2	98075	a	98DC075		60	62	59.45	61.95		482	488	generally a micaceous tan clay on bedrock, top is more soft and reddish, this material sampled in 98074
U2a/U2	98074	a	98DC074		60	62	59.45	61.92		453	463	similar lenses sampled 2 m to W across TT, brown, si/c w/ cc over reddish sed, similar texture but more clay
U3	98044	a	98DC044		62	64	64.55	64.08		423		U: 5cm above bedrock, micacous si/c to c. Similar to U along the W w/ very rounded wea ls and sm cc fleck, upper part of sample intersects soft red represented the base of 98DC43, T above.

Zone	Sample #	TS	MS Sample	Testunit	Square N	Square W	N	W	Lev	cmbd (top)	cmbd (bot)	Comments
U3	98050	a	98DC050		61	65	60.77	64		433	442	rest on bedrock in micaceous si/c, may include some cc observed resting on bedrock
U3	98054	a	98DC054		60	64	59.16	64		420		brn w/ wea ls gr and cc. Over yellow lt brn ashy zone (not an abrupt bound). Intersect incipient surface in U3 contiguous to F.118
U3	98055	a	98DC055		60	64	59.26	64		440		intersecting subzones of the yellow lt brn sampled at the base of 54 over a thin dk brn stringer, may divide T & U, mica yel lit brn, same as top zone in 56.
U3	98083	a	98DC083		60	68	59.28	68		412	420	micaceous si/c w/ ls gr size (none in TS)
U3	98094	a	98DC094		60	67	59.53	66		437		base of U3: micaceous clay, ~8 cm above bedrock. Thin dark stringer w/ cc (cultural?), only along this 1 m section of profile
U4	98084	a	98DC084		60	68	59.2	68		433	442	U3: (zone desc.), U4: generally redder sed among the rx, gr chert and few very wea. Ls eboulis
U4/Y2	98084	b	98DC084		60	68	59.3	68		433	442	U3: micaceous si/c over U4 g chert and few v wea ls eboulis, generally redder sed among the rx
X10	91004	b	91-004b	B			0			339		grey, bedded, OM rich clay, abundant cc, wet bone, porous w/ root holes, stringers of red clay as in 91-2, some snails being decalcified. Flaky fabric as if OM has decayed. PG
X10a	91004	a	91-004a	B			0			335		grey, bedded, OM rich clay, abundant cc, wet bone, porous w/ root holes, stringers of red clay as in 91-2, some snails being decalcified. Flaky fabric as if OM has decayed. PG
X2	91006	c	91-006c	C			0			385		3 lithologies: tan si on red c grading down to tan si. Red c has aggregated appearance as red layer in B (earthworms?) Tan si is more massive but also flaky structure/fabric. PG
X3	91006	a	91-006a	C			0			375		3 lithologies: tan silt on red clay grading down to tan silt. Red clay has aggregated appearance as red layer in B (earthworms?) Tan silt is more massive but also flaky structure/fabric. PG.
X3	91006	b	91-006b	C			0			380		3 lithologies: tan silt on red clay grading down to tan silt. Red clay has aggregated appearance as red layer in B (earthworms?) Tan silt is more massive but also flaky structure/fabric. PG.
X3	91007	a	91-007a	C			0			364		just above 91-6. Finely laminated (water lain?) si & c in clay curls. Below dome, some ls ghosts. PG
X3	91007	c	91-007c	C			0			375		just above 91-6. Finely laminated (water lain?) silts and clays in clay curls. Below dome, some ls ghosts. PG
X5	93001	a	93PG001	C			0			300		soft, crumbly micaceous c/si between eboulis which is matrix supported. PG 10R4/6 SS
X5	93002	a	93PG002	C			0			270		c/si between eboulis at top of the eboulis layer near the surface. PG 2.5YR4/4 SS
X6	98104	a	98DC104	C			0			340		red silty clay, eboulis

Zone	Sample #	TS	MS Sample	Testunit	Square N	Square W	N	W	Lev	cmbd (top)	cmbd (bot)	Comments
X7	91001	a	91-001a	B			0			435		"tan silty clay w/ red mottling" BD. Just above basal unit. Massive silts with vert and horiz red c laminae as in Beta horizon. Some Mn spots, probably decalcified, c coatings are clear. 5YR5/4. PG
X7	91001	b	91-001b	B			0			440		tan silty clay w/ red mottling BD. Just above basal unit. Massive silts with vert and horiz red c laminae as in Beta horizon. Some Mn spots, probably decalcified, c coatings are clear. 5YR5/4. PG
X7	91001	c	91-001c	B			0			445		tan silty clay w/ red mottling BD. Just above basal unit. Massive silts with vert and horiz red c laminae as in Beta horizon. Some Mn spots, probably decalcified, c coatings are clear. 5YR5/4. PG
X8	91013	a	91-013-1	B			0			390		"red c". Red crumbly si/c w/ abund c coatings and prob…
X8	91013	b	91-013-2	B			0			395		"red c". Red crumbly si/c w/ abund c coatings
X8	91013	c	91-013-3	B			0			400		"red clay". Red crumbly si/c w/ abundant c coatings and probably worm casts, some stones to S. Porous and many aggs. Dips toward entrance (NNE). Some calcite xls in voids (worms?), looks partly decalc, no snails. PG
X9	91003	a	91-003a	B			0			365		tan, stony silt w/ bone. soft, moist, cc. Cultural material in midden, lowest cultural layer. Bat (?) bones, looks turbated and decalc. PG
X9	91003	b	91-003b	B			0			369		tan, stony silt w/ bone. Soft, moist, cc. Cultural material in midden, lowest cultural layer. Bat (?) bones, looks turbated and decalc. PG
Y1	98056	a	98DC056		60	64	59.26	64		455		yellow lt brn, over red micaceous clay w/ ls eboulis sitting on bedrock
Y2	98085	b	98DC085		60	68	59.05	68		450		rocky micaceous c topof U5=Y2, rock increases w/ depth

APPENDIX D

THIN SECTION DESCRIPTIONS
CD ROM

THIN SECTION DESCRIPTIONS

An image of each thin section combined with the thin section description is presented in Appendix D on the CD Rom. These can be accessed using any web browser such as Internet Explorer or Netscape. In order to few the full format your screen resolution should be set at 1024 x 768 high color, 16 bit.

APPENDIX E

PLATES
(IMAGES ON CD ROM)

PLATES

The color plates cited in Chapters 7, 8 and 9 are on the accompanying CD Rom. These images are in a jpg format and can be viewed using any general graphic program. The captions are listed below with brief descriptions followed by the sample number in parentheses.