Colorado Plateau Cooperative Ecosystem Studies Unit
(Cooperative Agreement # H1200-09-0005)

Final Report: October 1, 2009 – March 31, 2011

Park: Hovenweep National Monument

Project Title: ENVIRONMENTAL STUDIES AT THE GOODMAN POINT UNIT, HOVENWEEP NATIONAL MONUMENT

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CPCESU Partner Institution: Crow Canyon Archaeological Center

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ABSTRACT

The Goodman Point Unit of Hovenweep National Monument is a 142-acre parcel located on Goodman Point in Montezuma County, Colorado. The Unit contains 43 sites that, in 1889, were the first archeological resources to be set aside for protection by the federal government. As such, the Unit now contains one of the best-preserved clusters of sites in the Mesa Verde region.

For six years, between 2005 – 2010, Crow Canyon Archeological Center partnered with Hovenweep National Monument to conduct archeological survey and testing at the Goodman Point Unit. The research has focused on questions that are fundamental to understanding the occupational history of the unit, which formed the center of a large community between about A.D. 1000 and 1300.

This project analyzed environmental samples collected as part of the ongoing testing efforts at the Goodman Point Unit. Funding defrayed the costs of analysis of pollen samples, carbonized plant remains, faunal remains, soil samples and tree-ring samples from archeological and recent deposits to better characterize the long-term development of the environment at Goodman Point, and to investigate ways in which the present-day environment is a legacy of past human occupancy.

These data and results will further analyzed, interpreted, and incorporated into three chapters of the final report on the archeological research at the Goodman Point Unit. This final report will be produced in collaboration with NPS personnel and will contain discussions of research goals and strategies, human remains found, public involvement, American Indian involvement, video documentation, a listing of personnel who participated in the field portion of this project, site maps, many color photos of artifacts and exposed structures, and tree-ring dates, detailed descriptive field and analytic

information in a user-friendly database, numerous interpretive text chapters, AutoCAD maps, and more than 3200 color images. The report will be available through Crow Canyon's website at a future date.

Accomplishments to date, October 1, 2009 – March 31, 2011: To date we have identified subject matter experts (Dr. Karen Adams – archaeobotany, Kirk Anderson – geomorphology, and Dr. Steve Wolverton – fauna) and compiled lists of materials to be analyzed. Crow Canyon hired three interns; one to help with the faunal analysis, the other two to help with the archaeobotanical analyses. All analytical reports are complete and included with this report attached. Additionally all progress reports have been submitted as required.

What remains to be done: All analytical reports are complete and have been submitted as described below (Attachments).

Unexpected challenges: To date, the only unexpected challenge has been the delay in receiving the results of the pollen, soil, and radiocarbon analyses.

Attachments: Soil Characterization of General Field Testing Units: Goodman Point Unit of Hovenweep National Monument (including radiocarbon results and soil nutrient results), letter report from Dr. Karen Adams.

Raw data tables, including

- pollen analytical tables,
- tree-ring analytical tables,
- archaeobotanical tables,
- faunal analytical table

were provided to Chris Goetze, Cultural Resource Program Manager, Southeast Utah Group under separate cover.

Dr. Scott Ortman
Director of Research and Education
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July 28, 2010

Dear Scott,

This letter reports recent progress in analysis of Goodman Point Pueblo archaeobotanical samples. From May 16-July 23, 2010 (10 weeks) I was in residence at Crow Canyon supervising two interns in learning the common reproductive and wood types of our area, and then during their analysis of Goodman Point Pueblo flotation samples. After a two-week training period, these two interns (Sarah Oas and Maia Dedrick) analyzed 133 flotation samples over an eight week period. I supervised this process on a daily basis. They also entered all the resulting data into the Crow Canyon research database, and then data-checked this information. The methods and procedures they utilized during analysis have been fully reported on the Crow Canyon website: www.crowcanyon.org, Publications, Manuals and Guides, Archaeobotanical Analysis, Microfossils: Flotation Samples. The resulting raw data for the 133 flotation samples are attached as a separate Excel file (2010 Archaeobotanical Analysis Results for 5MT604.xls). This file is currently formatted to print out on 66 pages of legal size paper.

All best wishes,

Karen R. Adams
Archaeobotanist

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Soil Characterization of General Field Testing Units: Goodman Point Unit of Hovenweep National Monument

Report Prepared by

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February 10th, 2011

Soil Characterization of General Field Testing Units:
Goodman Point Unit of Hovenweep National Monument

Kirk C. Anderson

INTRODUCTION

The following section presents results of soil-geomorphic investigations conducted at the Goodman Point Unit of Hovenweep National Monument during June and October, 2010. The goal of the fieldwork was to (1) obtain soil and stratigraphic data to better understand the natural setting of areas between habitation sites that are not known to contain cultural features. Part of this project is to characterize the soils to better understand the agricultural setting, potential for buried materials, and estimate the ages of the sediments and soils; and (2) to evaluate the soils and sediments in the meadow area to provide some insights into the nature of linear features that might be related to water control features. To achieve these goals, soils exposed in six test units were described and sampled. The field testing was conducted as part of Phase II of the Goodman Point Project: Community Center and Cultural Landscape Study.

METHODS

One of the tasks identified for the Community Center and Cultural Landscape Study was to better understand the soils and agricultural potential of the landscape. As such, six locations were chosen for study that represented different landscape positions and different soil types as defined and mapped by the NRCS.

The Goodman Point Unit is in the headwaters of Goodman Canyon, along a small eastward draining tributary. This tributary nearly bisects the Goodman Point Unit in half, with a ridge on the north side and another on the south. The bedrock in the study area is sandstone which overlain by a relatively thin layer of wind deposited loess. The loess deposits cover most of the ridges and mesas in the area, providing good water holding capacity, slow drainage, and are relatively fertile. Vegetation is pinyon-juniper woodland. The mean annual precipitation is about 35 cm, and the mean annual temperature is about 9°C. There are approximately 100-120 frost-free days. The elevation of the project area is 2035 m.

The four soil types mapped by the NRCS are mostly differentiated on their slope and aspect. The four soil series are Cahona, Pulpit, Gladel, and Wetherill. Series complexes, that is properties that are similar to two series, include the Cahona-Pulpit and Gladel-Pulpit complexes. According to the NRCS, all of the soils are classified as Haplustalfs at the great group level. The term Hapl-ust-alf identifies the soil order as Alfisol ("alf"), with a dry soil moisture regime ("ust") and relatively simple soil horizonation ("hapl"). Alfisols are essentially well-developed forest soils with high base saturation (high concentrations of calcium, magnesium, sodium, and potassium). A summary of the soil series characteristics is included in Appendix A. (see: Missouri Cooperative Soil Survey: http://soils.missouri.edu/soilseries.asp?x=ALL&sort=Series&st=CO).

Six "general field testing" (GFT) units were excavated, described, and sampled. The six units are termed GFT 1 through GFT 6. GFT 1, 2, and 3 are located north of the main drainage, along the south-facing slopes and crest of the northern ridge. GFT 4 and 5 are located along the crest of the southern ridge, south of the main drainage.

The location for GFT 1 was chosen to sample a potential field area in soils designated as Wetherill loam (NRCS), with 3 to 6 percent slopes, and slight southern exposure at higher elevation. The location for GFT 2 was chosen to sample a potential field area in soils designated as Cahona-Pulpit complex (NRCS), with 3 to 9 percent slopes, and a slight southeast exposure at mid-range elevation. The location for GFT 3 was chosen to sample a potential field area in soils designated as Gladel-Pulpit complex (NRCS), with 3 to 9 percent slopes, a slight southern exposure at lower elevation. The locations for GFT 4 and GFT5 were chosen to sample a potential field area in soil designated as Wetherill loam (NRCS), with 3 to 6 percent slopes, a slight northern exposure at mid-range elevation. The location of GFT 6 was chosen for two reasons. The first is to sample a potential field location in soils designated as Cahona-Pulpit complex (NRCS), with 3 to 9 percent slopes, and a slight northeast exposure near a drainage bottom. The second reason was to investigate linear features that produced remote sensing anomalies and a different vegetative signature in the meadow area.

Soils were described and sampled according to guidelines set forth by the NRCS (Schoeneberger et al., 2002). A line level was set up and measured from the southwest datum at each unit. Drawings were conducted on graph paper at a scale of 1 inch = 20 cm

for GFT 1-5, and 1" = 50 cm for GFT6. Each soil horizon was sampled, labeled, and placed into either plastic or paper bags. Samples were also collected for radiocarbon, pollen, and ostracod analysis. The purpose of soil sampling is to obtain soil nutrient data for evaluating soil fertility and potential productivity. The purpose for sampling pollen is to obtain paleoenvironmental data as well as possible cultigens and/or economically important plants, such as cattail. In addition, ostracodes were sampled from the GFT6 profile so that the paleoenvironmental conditions of the soil in GFT6 could be evaluated, because it is thought that GFT 6 represents a wet meadow or marshy habitat. Results of theses analysis are pending. This section focuses on interpretations made from the physical properties of the soils and sediments. Soil descriptions are presented in Table 1.

RESULTS

Results of the soil descriptions indicate moderately well-developed A horizons with pale brown colors overlying red, well-developed clay and silt-rich B horizons. Bedrock was encountered between about 50 cm to 1.5 meters below the ground surface in the GFT 1 through 5 units. In the following discussion and in Table 1, lower case letters indicate the following subordinate soil horizons: (1) "w" refers to reddening of the soil horizon, indicating a weak to moderate degree of soil development, (2) "t" refers to the presence of translocated clays, indicating moderate to strong degree of soil development, (3) "k" refers to the concentration of calcium carbonate in the soil, making it white, (4) "ss" refers to the presence of slickensides, which are shiny striations on ped faces, indicating the presence of enough clays to cause shrinking and swelling, (5) "r" refers to weathered bedrock. Detailed descriptions for all horizons are found in Table 1.

GFT 1

GFT 1, located near the crest of the northern ridge, was excavated to a depth of 54 cm (Table 1). An auger hole reached an additional 72 cm below the bottom of the unit, for a total depth of 126 cm (Figure 1). Weathered bedrock was reached at the bottom of the auger hole.

Soil horizons described and sampled are A1/A2/2A3/2Bw/2Bt. A1 and A2 are manifestations of the surface A horizon, or topsoil. The A horizons are brown (7.5 YR)

sandy loams with a soft dry consistence. Below the topsoil is an older A horizon representing an older land surface, containing charcoal and ashy deposits (Figure 2). It is thought that the 2A3 horizon is related to the puebloan occupation of the area. Indeed, four sherds (three white ware and one corrugated) were found at the base of 2A3 horizon. Underlying the 2A3 are Bw and Bt soil horizons, representing an older, longer period of soil formation. The B horizons are red (5 YR) clay loams that have a very hard dry consistence. Soil horizons exposed in GFT 1 represent a very stable surface with a well-developed soil underlying the prehistoric ground surface.

The sherds found at the base of soil horizon 2A3 strongly suggest that this charcoal-rich and artifact bearing horizon dates to the puebloan period. This indicates that the upper 16 cm of material, consisting of eolian and sheetwash redistributed sand, and organic matter, accumulated over the puebloan surface.

GFT 2

GFT 2, located along the south-facing slopes of the northern ridge, was excavated to a depth of 68 cm (Table 1). An auger hole reached an additional 98 cm below the bottom of the unit, for a total depth of 166 cm. Weathered calcium carbonate-rich bedrock was reached at the bottom of the auger hole. Soil horizons described and sampled are A/Bw/Bt (Figure 1). The A horizon is a brown (7.5 YR) sandy loam with a soft consistence (Figure 3). The Bw horizon is a reddish brown (5 YR 4/4) loam, with a hard consistence. At the base of the Bw are ash and charcoal stained soil. The Bt horizon is a yellowish red (5YR 6/4) loam with a very hard consistence. GFT 2 represents a well-developed soil overlying bedrock.

The presence of ash and charcoal stained soil near the bottom of the Bw horizon could be from a natural fire or from cultural activity. The lack of artifacts does not preclude a cultural origin, and the occurrence at approximately the same depth (8-24 cm) as the ash, charcoal and artifacts in GFT1 (16-26cm) hints at correlation. However, the stain occurring at the bottom of the Bw suggests that it may have occurred earlier in the soil forming sequence than stains that are within a soil horizon higher up in the sequence, such as those in GFT 1.

GFT3

GFT 3 is located at a lower elevation near the bottom of the northern ridge. It was excavated to a depth of 54 cm when weathered bedrock was encountered (Table 1). The soil profile consists of A1/A2/Bw/Bt (Figure 1). The A horizons are brown (7.5YR) sandy loam with soft to hard dry consistence. Within the A2 horizon, at a depth of 11 cm, an ash and charcoal stained layer is present. At the contact between the A2 and Bw horizons, at a depth of 26 cm, is a sandstone slab measuring 40 cm x 3 cm thick. The Bw and Bt horizons are also brown (7.5 YR). The Bw is a sandy loam with a hard consistence, whereas the underlying Bt is a silt loam with a soft to slightly hard dry consistence. These properties differ from those of the other units because these horizons are intensely mixed with the underlying calcium carbonate-rich weathered bedrock. Mixing is most likely due to rodent, insect, and root turbation (Figure 4).

The presence of an ash and charcoal layer at 11 cm depth, and a sandstone slab at 26 cm depth, could be cultural or natural. However, this occurrence at approximately the same depth as the four sherds in GFT1, and the ash and charcoal lens in GFT2 also hints at correlation. The stain here is within the A2 horizon, and the sandstone slab is at the base.

GFT4

GFT 4, located on the southern ridge, was excavated to a depth of 32 cm. An auger hole reached to 116 cm where a Btk soil was encountered that was heavily bioturbated with insect burrows forming hardened carbonate casts (Figure 5). Although weathered bedrock was not encountered, the Btk horizon most likely lies directly over the weathered bedrock (Figure 6). Soil horizons described and sampled include A/Bw1/Bw2/Bt (Table 1). The A horizon is a brown (7.5 YR) sandy loam with a soft consistence. The B horizons are reddish brown to yellowish red (5YR) loam to clay loam with hard to very hard consistence.

Within the Bw2 horizon are charcoal flecks, and a concentration of charcoal, ash and burnt orange sandstone or adobe. These materials occur at a depth of 26 cm. No associated artifacts were found. These ash and charcoal concentrations occur at the same

depth as those in GFT1 (with sherds), GFT2, and GFT3, but were located within the Bw2 soil horizon.

GFT5

GFT 5, located on the southern ridge, was excavated to a depth of 60 cm, with an auger hole reaching an additional 60 cm for a total depth of 120 cm (Figure 5). Horizons described and sampled include A/Bw1/Bw2/Bt (Table 1). GFT 5 was an unusual unit in that much of the excavated portions consisted of mixed and mottled materials (Figure 6). The A horizon is a brown (7.5YR) sandy loam with a soft consistence. The Bw1 is a brown (7.5YR) silt loam with a slightly hard to hard consistence. The Bw2 exhibits mixing from above and below. The Bw2 is mostly brown (7.5YR) with reddish brown (5YR) mottles; silt loam with a slightly hard to hard consistence. Below this is a zone of mixing of the overlying dark brown Bw and underlying reddish brown Bt horizons. The materials contain ash and charcoal, with burned adobe and/or burnt sandstone. This zone extends below the bottom of the unit in the southern end of GFT5. In the northern end of GFT5, it appears that a vertical contact truncates the underlying Bt horizon, very much like a cultural pit feature excavated through the Bt soil layer. This zone of mixing is very similar to feature fill deposits of cultural origin. However, no artifacts were found in this unit.

Ash, charcoal, and burnt sandstone or adobe mottling starts at a depth of 32 cm and continues well below the depth of the excavation. No artifacts were found at this location. Again, however, the ash and charcoal materials occur at approximately the same depth as those in all of the other GFT units, between about 15 and 35 cm, but below the Bw horizon.

The question remains, are the ash and charcoal concentrations, lenses, and stains found in GFT 1 through 5 natural or cultural? Although they occur at about the same depth, they are within different soil horizons, suggesting multiple ages/occurrences.

GFT6

GFT 6, excavated in the main drainage, reached a depth of 80 cm. An auger hole reached an additional 45 cm, for a total depth of 125 cm (Table 1). GFT 6 is actually two

trenches, one running north-south and the other east-west (Figure 7). The west wall of the north-south trench was 4.0 meters long, and the south wall of the east-west trench was 3.0 meters long. The following discussion will focus on the north-south trench. Soil horizons encountered were A1/A2/2Ass1/2Ass2/2Ass3/2Btkss. All of the A horizons are dark brown to dark grayish brown (10 YR), with slightly hard to very hard consistence. A1 and 2Ass1 are loam, A2 is a sandy loam, and the 2Ass2 and 2Ass3 are loam to clay loam textures. The Btkss is a brown (7.5 YR) silty clay loam. The Btkss horizon exhibits very large soil structural features (large columnar peds) that are coated with the overlying sediments, suggesting that this horizon experiences shrink swell and desiccation over time. These lower horizons are also very heavily bioturbated with insect burrows and contain abundant calcium carbonate. The auger hole contained white calcium carbonate materials that are characterized as a marl or marl-like materials.

Where the north-south and east-west trenches come together, a slab-lined thermal feature was encountered. This is also in the area where the linear feature is cut by the north-south trench. Initially thought to be part of a water control feature, further excavation definitively identified it as a thermal feature with burnt adobe and/or sandstone, and abundant charcoal. No artifacts were found associated with this feature. The slab-lined feature is stratigraphically below the A1 and A2 soil horizons. Although it is difficult to tell, it seems that the feature truncates, or may be contemporaneous with the lower horizons, staring with 2Ass1.

CONCLUSIONS

The overall soil horizon sequence is nearly identical for GFT 1 through 5. There are one or more A horizons that are generally brown (7.5 YR), loose, sandy loams with a moderate amount of organic matter. These A horizons overlie moderately well-developed Bw horizons. In all of the GFT units, ash, charcoal, burnt adobe (or sandstone) are associated with either the A horizons or the Bw horizons. Sherds were also found in this zone in GFT 1. Underlying the Bw horizons are generally well to strongly developed, red (5 YR) Bt horizons with abundant clay, very hard consistence, and numerous vertical cracks along ped faces. This well-developed soil may be quite old, perhaps early

Holocene or late Pleistocene. These soils directly overlie bedrock, which generally was no more than 1.5 meters below the ground surface.

There are very few artifacts or other evidence of cultural activity in the GFT 1 through 5 profiles. However, in GFT 1, 2, 3, 4, and 5 the presence of lenses and concentrations of charcoal, ash, and small bits of burnt sandstone (adobe?) suggest cultural activity occurred and is preserved in these test units. It is interesting to note that the level of the possible cultural materials ranges from 15 to 35 cm below the modern ground surface in GFT 1 through 5. If these stains date to the puebloan period, there is between 15 and 35 cm of accumulation during the post-occupational period. This accumulation results from deposition (primarily eolian), redeposition (primarily sheetwash), and aggradation from soil formation processes such as addition of organic matter, trapping of eolian loess, and bioturbation.

The soils in GFT1 through 5, classified as Haplustalfs, represent the loess soils that cap much of the plateaus and mesas in the region. These soils are known to be quite productive due to the ability to retain water and for their relatively good nutrient status (see Appendix A). One potential problem for crops may be the degree of shrink swell illustrated by the numerous and extensive cracks in the soil. These can be damaging to roots during periods of high shrink and swell activity.

The Meadow profile (GFT6) clearly contains a "wet meadow" soil that is stratigraphically related to the cultural feature nearby. The A horizons have good soil structure and are very dark grayish brown (10 YR 3/2), most likely indicating abundant organic matter content. All layers are heavily mottled and bioturbated. The mottling in the lower A horizons (2Ass3) consists of yellowish brown to weak red (10YR 5/8 – 2.5 YR 4/2). All these properties are evidence of fluctuating water tables causing alternating oxidizing and reducing conditions. The soil term for the gray and red mottled coloration of masses, nodules, or coatings is redoximorphic. Redoximorphic features are diagnostic properties of alternating higher to lower water tables. The location of bedrock so close to the surface creates a perched water table during wet periods, perhaps seasonally during the monsoons, or perhaps as a result of longer term climatic cycles. At any rate, the soils here differ from those on the ridges in that they have very thick, dark A horizons that are distinct evidence of moist soil conditions that may have supported marshy habitats.

Pollen analysis from these deposits could be very interesting if they contain cattail or other marsh vegetation.

The origin and nature of the linear features that are transected by the GFT 6 profile is still not clear. Speculation suggests that this could have been a water control channel to direct water towards the meadow area; perhaps snowmelt during springtime. If this were the case, it is likely that the present drainage would not have been incised for these channels to function properly or efficiently because the surface and subsurface flow would inevitably move towards the lowest portion of the drainage, away from the artificial channels. If the wet meadow began drying out (the soils in the Meadow profile show evidence of desiccation) there may have been an attempt to direct water to keep the wet meadow (or marsh ?) moist to keep plant resources viable. However, to counter this hypothetical scenario, the stratigraphy exposed in the GFT 6 units showed no evidence of running or ponded water. There was no alluvial stratigraphy, no laminations, lenses, or sorting of water-transported sediment. Therefore, other possibilities should be explored. One possibility is that the channels are simply a part of the extensive puebloan trail system well documented at the site. A cursory examination of aerial images shows that the imprint of these linear features is very similar to other trails that trend towards the main pueblo. More trenching, pollen, and ostracod analysis are necessary to test the various hypotheses.

Authors note: As this report was being finalized, six radiocarbon assays were received. Three came from the charcoal concentration at the bottom of the Bw horizon in GFT 2, and three came from pieces of wood associated with the slab feature in GFT 6. With a 1 sigma degree of confidence, the three uncalibrated radiocarbon ages from GFT 2 are 7190 ± 20, 7185 ± 20 BP, and 7175 ± 20 BP. The three uncalibrated radiocarbon ages associated with the slab feature in GFT 6 are 7590 ± 20 BP, 7535 ± 25 BP, and 7550 ± 25 BP. The dated samples from GFT 2 were from approximately the same depth as the four sherds collected from GFT 1, and at the same approximate depth as the ash and charcoal concentrations in GFT 3, 4, and 5. However, the sherds in GFT 1 are located at the base of the 2A3 horizon but the dated charcoal samples are from the lower part of the Bw horizon. The Bw horizons are moderately well-developed, overlying a strongly developed Bt horizon that could easily be early Holocene to late Pleistocene in age. The charcoal stain in GFT 3 is also located in the A2 horizon, and the sandstone slab in GFT 3 is located at the base of the 2A horizon. These could be within the puebloan age range as they occur in the A horizon. The charcoal

stained areas in GFT 4 are in the Bw2 horizon and could therefore be associated with the dated layer in GFT 2. In short, assuming that the sherds were not translocated by bioturbation, there could be two different ages for the charcoal stains: one age associated with the early period of soil formation 7100 years ago, and the other, higher up in the soil sequence, dating to the puebloan period.

The ages on charcoal associated with the slab feature in GFT 6 suggests the feature is 7500 years old. This age range seems too old for this well-constructed, slab feature that stratigraphically appears to be related to the buried A horizons. The feature is located close to the ground surface and the large chunks of charcoal appeared relatively fresh looking. It is not out of the question that this is an early archaic hearth. Perhaps a field visit to each site may be necessary to assess the sample locations.

References Cited

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Table 1. Soil descriptions for GFT 1, 2, 3, 4, 5, and 6.

GFT 1 Horizon[1]	Depth (cm)	Color	Texture	Consistence			Structure	Roots	Pores
				dry	moist	wet			
A1 (GFT1-1)	0-10	strong brown (7.5YR 4/6)	sandy loam	soft	very friable	slightly sticky slightly plastic	moderate, fine, crumb	many, fine, tubular	many, fine intergranular
A2 (GFT1-2)	10-16	dark brown (7.5YR 4/4)	sandy loam	soft	very friable	slightly sticky slightly plastic	moderate, fine, crumb	many, fine to medium tubular	many, fine intergranular
2A3 (GFT1-3)	16-26	dark brown (7.5YR 4/4) to brown (7.5YR 4/2_	sandy loam	soft	very friable	slightly sticky slightly plastic	moderate, fine, crumb	na	na
2Bw (GFT1-4)	26-34	reddish brown (5YR 4/4)	silty clay loam	very hard	very firm	sticky plastic	strong, medium angular blocky	few, very fine, tubular	many, very fine, intergranular
2Bt (GFT1-5)	34-54+	yellowish red (5YR 4/6)	clay loam	very hard	very firm	sticky plastic	strong, medium angular blocky	few, very fine, tubular	many, very fine, intergranular

GFT 2 Horizon	Depth (cm)	Color	Texture	Consistence			Structure	Roots	Pores
				dry	moist	wet			
A (GFT2-1)	0-8	brown (7.5YR 5/4)	sandy loam	soft	very friable	slightly sticky slightly plastic	weak, medium, angular blocky	few, very fine, tubular	few, very fine intergranular
Bw (GFT2-2)	8-24	reddish brown (5YR 4/4)	loam	hard	friable	sticky plastic	strong, medium to coarse, blocky	few, very fine, tubular	common, fine intergranular
Bt (GFT2-3)	24-68+	yellowish red (5YR 4/6)	loam	very hard	friable	sticky plastic	strong, medium to coarse, blocky	few, very fine, tubular	common, fine intergranular

GFT 3 Horizon	Depth (cm)	Color	Texture	Consistence			Structure	Roots	Pores
				dry	moist	wet			
A1 (GFT3-1)	0-6	dark brown (7.5YR 4/4)	sandy loam	soft-slightly hard	friable	slightly sticky slightly plastic	massive	few, very fine, tubular	few, very fine intergranular
A2 (GFT3-2)	6-24	dark brown (7.5YR 4/4)	sandy loam	hard	friable	slightly sticky slightly plastic	strong, medium, angular blocky	few, fine to medium, tubular	few, fine intergranular
Bw (GFT3-3)	24-32	dark brown (7.5YR 4/4)	sandy loam	hard	friable	slightly sticky slightly plastic	strong, medium, angular blocky	few, fine to medium, tubular	few, fine intergranular
Bt (GFT3-4)	32-54+	brown (7.5YR 5/4)	silt loam	soft-slightly hard	friable to firm	sticky plastic	massive (brecciated)	few, fine to med., tubular	few, fine intergranular

Table 1. (cont'd)

GFT 4 Horizon	Depth (cm)	Color	Texture	Consistence			Structure	Roots	Pores
				dry	moist	wet			
A (GFT4-1)	0-10	brown to dark brown (7.5YR 5/4, 7.5YR 4/4)	sandy loam	soft	very friable	slightly sticky slightly plastic	weak, medium angular blocky	few, very fine, tubular	few, very fine intergranular
Bw1 (GFT4-2)	10-15	reddish brown to yellowish red (5YR 4/4, 5YR 4/6)	loam	hard	friable to firm	sticky plastic	moderate, medium, angular blocky	few, fine to medium, tubular	few, fine intergranular
Bw2 (GFT4-3)	15-32	reddish brown (5YR 4/4)	loam	hard to very hard	firm	sticky plastic	strong, medium to coarse blocky	few, fine to medium, tubular	few, fine intergranular
Bt (GFT4-4)	32-88+	yellowish red (5YR 4/6)	clay loam	hard to very hard	firm	sticky plastic	strong, medium to coarse blocky	few, fine to medium, tubular	few, fine intergranular

GFT 5 Horizon	Depth (cm)	Color	Texture	Consistence			Structure	Roots	Pores
				dry	moist	wet			
A (GFT5-1)	0-5	brown (7.5YR 5/4)	sandy loam	soft	very friable	none sticky none plastic	weak, medium angular blocky	few, very fine, tubular	few, very fine intergranular
Bw1 (GFT5-2)	5-10	dark brown (7.5YR 4/4)	silt loam	slightly hard to hard	firm	sticky plastic	moderate, medium, angular blocky	few, fine to medium, tubular	few, fine intergranular
Bw2 (GFT5-3)	10-28	dark brown (7.5YR 4/4); reddish brown mottles (5YR 4/4)	silt loam	slightly hard to hard	firm	sticky plastic	moderate, medium, angular blocky	few, fine to medium, tubular	few, fine intergranular
Bw/Bt (mixed and mottled)	28-60+	dark brown (7.5YR 4/4); reddish brown mottles (5YR 4/4)	silt loam	This is a zone of mixed and mottled soils and sediments; contains charcoal and burnt soil which may be burnt adobe. It is probably that this represents cultural activity and may indeed be cultural feature fill material. It is also possible that this is a zone of natural woodland fire.					
Bt (GFT5-4)	28-60+	brown (7.5YR 5/4)	silt loam	hard	friable to firm	sticky plastic	strong, medium to coarse blocky	few, fine to medium, tubular	few, fine intergranular

Table 1. (cont'd)

GFT 6 Horizon	Depth (cm)	Color	Texture	Consistence			Structure	Roots	Comments
				dry	moist	wet			
A1 (GFT6-1)	0-10	dark grayish brown (10YR 4/2)	loam	very hard	friable	sticky plastic	strong, medium, crumb	many, very fine, tubular	A1 and A2 are the surface soils, post-occupation.
A2 (GFT6-1a)	10-20	dark brown (10YR 4/3) very dark grayish brown (10YR 3/2) brown (7.5YR 5/4)	sandy loam	slightly hard to hard	very friable	sticky plastic	strong, medium, angular blocky	common, very fine, tubular	
2Ass1 (GFT6-1b)	20-30	very dark grayish brown (10YR 3/2)	loam	hard to very hard	friable	sticky plastic	strong, medium, angular blocky	few, very fine, tubular	2Ass1, 2Ass2, and 2Ass3 are soil A horizons that most likely date to the period of occupation and appear to be stratigraphically related to the cultural feature nearby.
2Ass2 (GFT6-2)	30-50	dark grayish brown (10YR 4/2) to very dark grayish brown (10YR 3/2)	loam – clay loam	very hard	firm	sticky plastic	strong, medium, angular blocky to prismatic	few, very fine, tubular	
2Ass3 (GFT6-3)	50-70	dark grayish brown (10YR 4/2) with mottles of yellowish brown (10YR 5/8) and weak red (2.5YR 4/2)	clay loam	very hard	very firm	sticky plastic	strong, fine to medium, angular blocky	-	
2Btkss (GFT6-4)	70-80	brown (7.5YR 5/4)	silty clay loam	very hard	very firm	sticky plastic	strong, fine to medium, angular blocky	-	

1 –alphanumeric values in parenthesis below soil horizon designations indicate sample numbers.

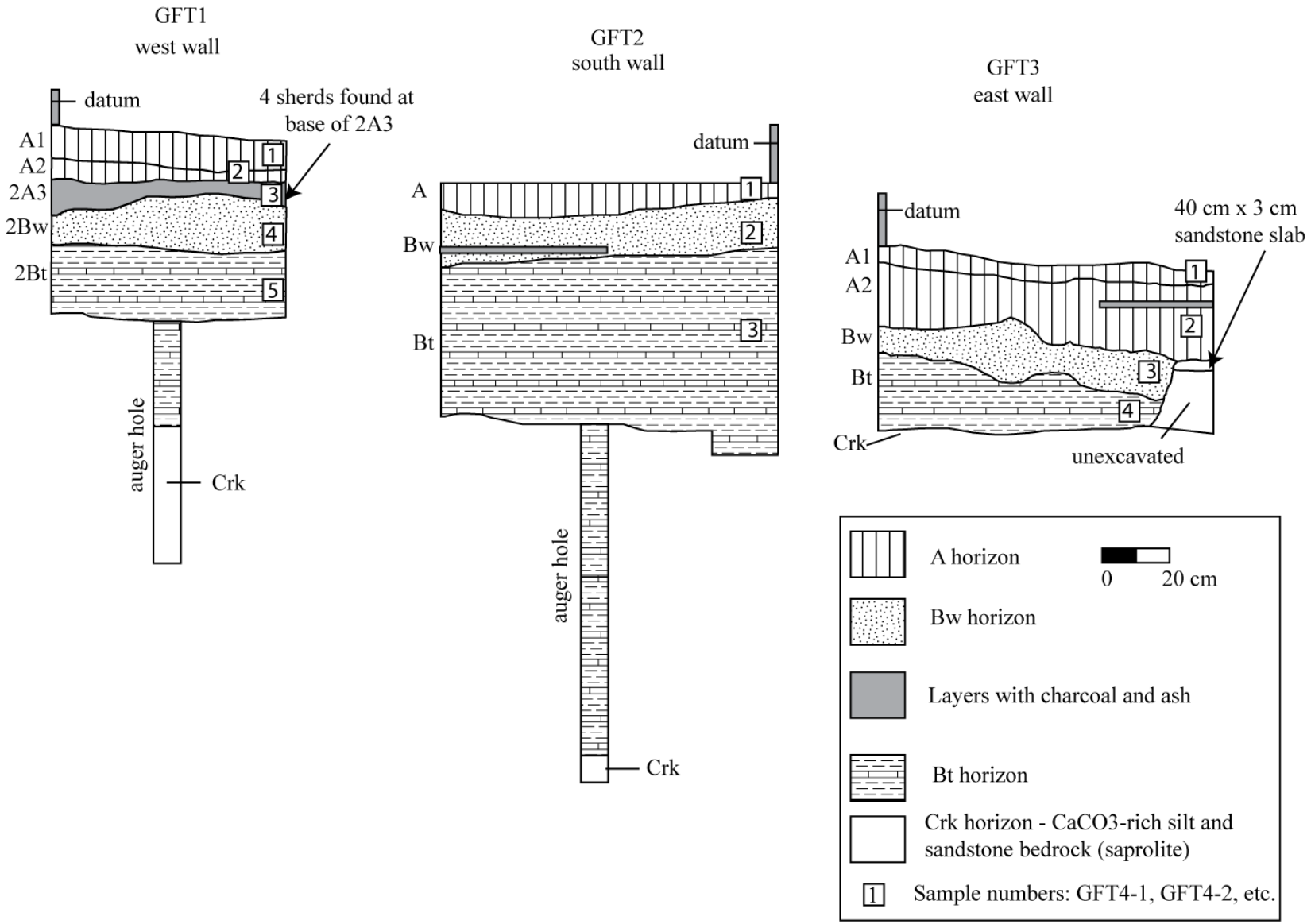


Figure 1. Profile drawings of GFT1, GFT2, and GFT3.

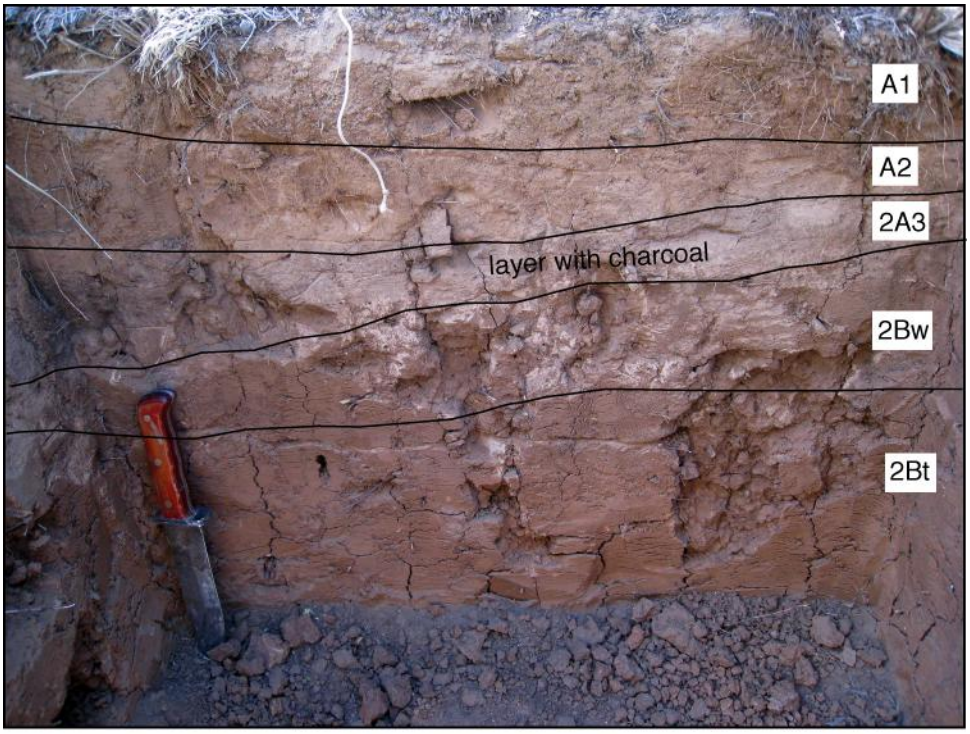


Figure 2. Photograph of GFT1.

Figure 3. Photograph of GFT2.

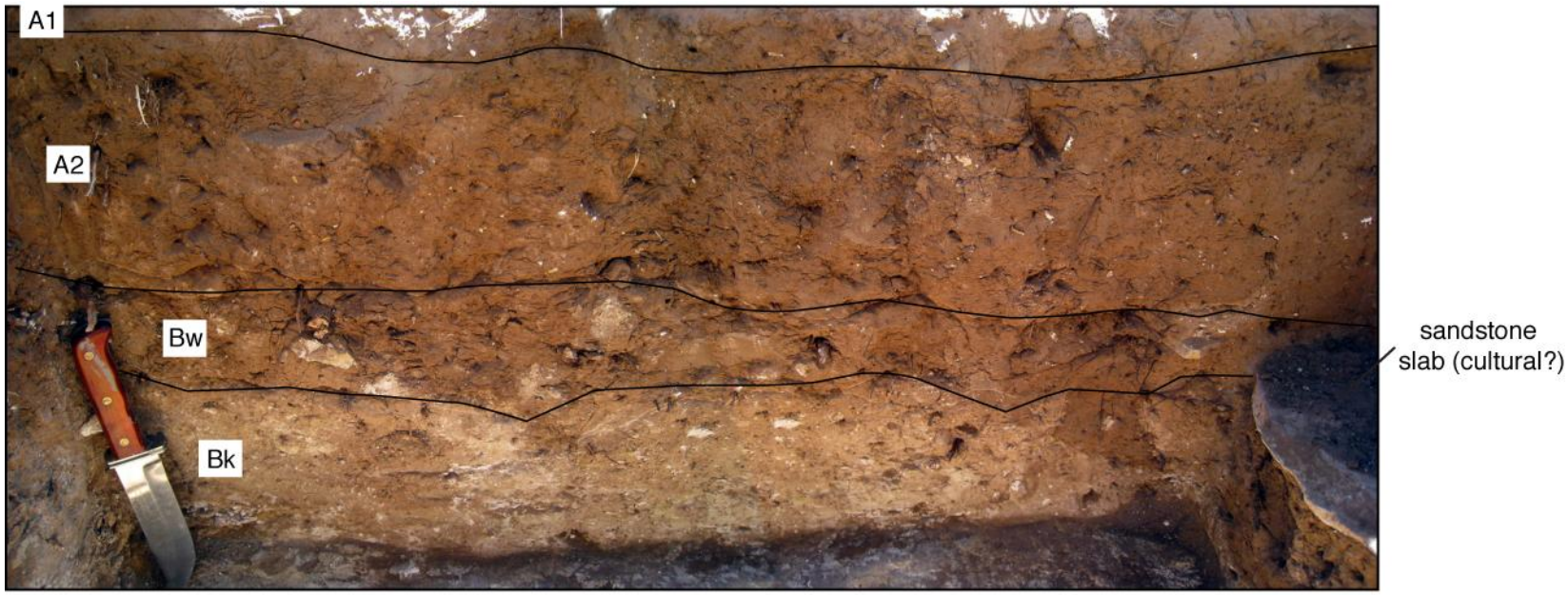


Figure 4. Photograph of GFT3.

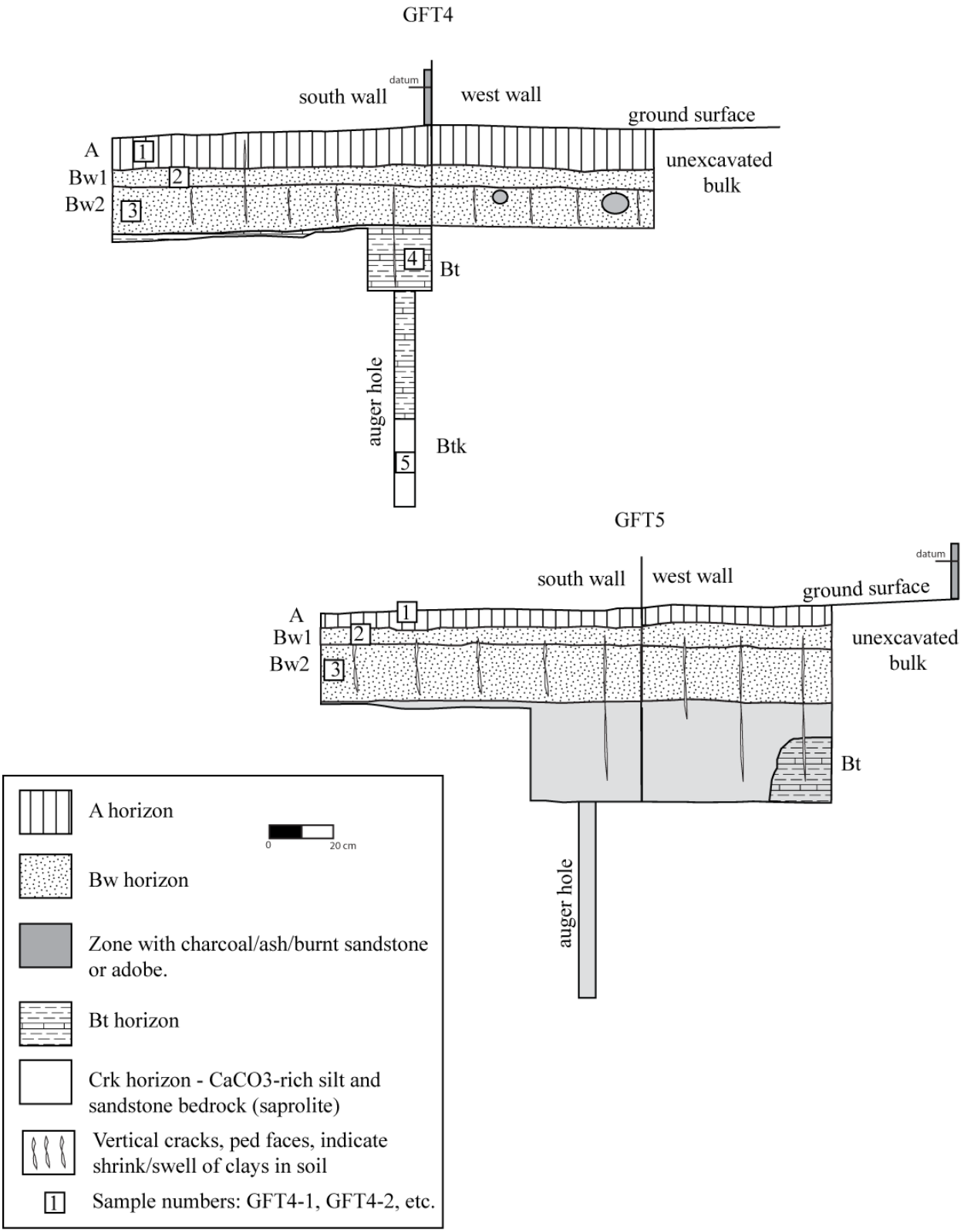
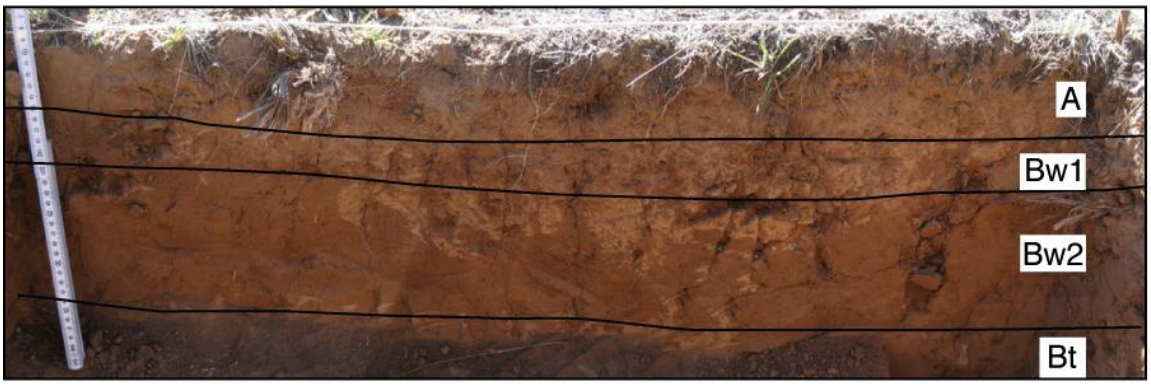


Figure 5. Profile drawings of GFT 4 and GFT5.

GFT4



GFT5

Figure 6. Photographs of GFT 4 and GFT5.

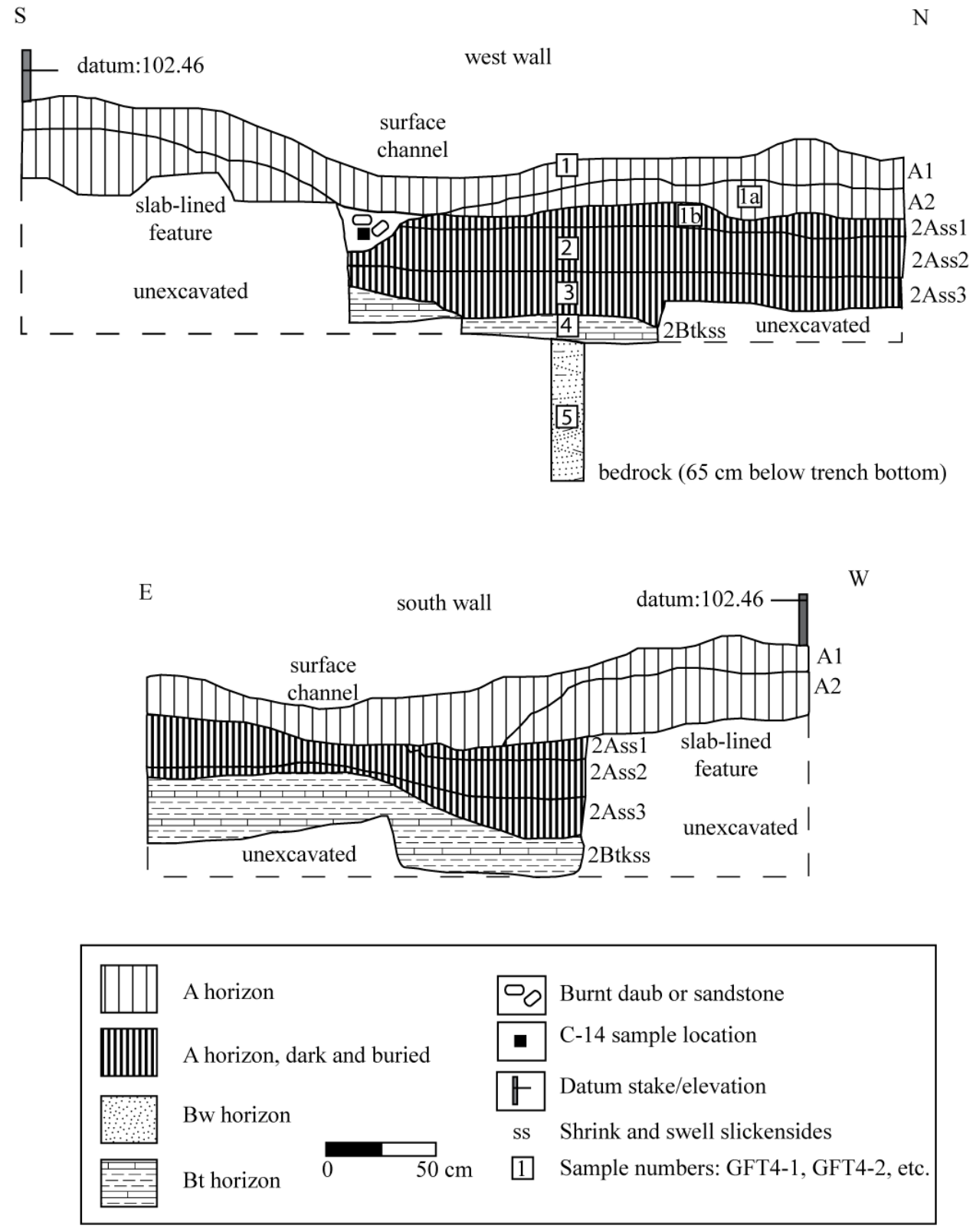


Figure 7. GFT 6 - the north-south, and east-west trenches excavated in the meadow area.

Appendix A
(from Missouri Cooperative Soil Survey:
http://soils.missouri.edu/soilseries.asp?x=ALL&sort=Series&st=CO)

Appendix A contains and brief summary of important characteristics of the soil series found in the project area. GFT 1, 4, and 5 represent the Wetherill soil series, GFT 2 and 6 represent the Cahona-Pulpit complex, and GFT 3 represents the Gladel-Pulpit complex.

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CAHONA SERIES

The Cahona series consists of very deep, well drained soils that formed in eolian material derived from sandstone. Cahona soils are on hills and mesas. Slopes range from 1 to 12 percent. Mean annual precipitation is about 14 inches and the mean annual temperature is about 48 degrees F.

TAXONOMIC CLASS: Fine-silty, mixed, superactive, mesic Calcidic Haplustalfs

Clay content: 18 to 35 percent

A horizon:
Hue: 5YR or 7.5YR
Value: 4 to 7 (3 to 6 moist)
Chroma: 2 to 6
Texture: fine sandy loam, loam or silt loam
Rock fragment content: 0 to 5 percent
Calcium carbonate equivalent: 0 to 1 percent
Reaction: neutral or slightly alkaline (pH 7.5)

Bt and Btk horizons:
Hue: 5YR or 7.5YR
Value: 4 to 7 dry (3 to 5 moist)
Chroma: 2 to 6
Texture: loam, clay loam or silty clay loam
Calcium carbonate equivalent: 0 to 10 percent
Rock fragment content: 0 to 5 percent
Reaction: slightly to strongly alkaline (pH 7.8 – 8.0)

Bk horizon:
Hue: 5YR to 7.5YR
Calcium carbonate equivalent: 15 to 50 percent
Reaction: slightly to strongly alkaline (pH 8.4-8.6)

Frost-free period: 100 to 120 days

DRAINAGE AND PERMEABILITY: well drained, medium to very high runoff, moderately slow or slow permeability

USE AND VEGETATION: These soils are used for dryland and irrigated cropland, and for grazing. The native vegetation is scattered two needle pinyon and Utah juniper, big sagebrush, Indian rice grass, mutton grass, and western wheatgrass.

GLADEL SERIES

The Gladel series consists of shallow, well drained soils that formed in residuum and eolian material derived from sandstone. Gladel soils are on mesas and hills. Slopes range from 1 to 50 percent. Mean annual precipitation is about 14 inches and the mean annual temperature is about 47 degrees F.

TAXONOMIC CLASS: Loamy, mixed, superactive, mesic Aridic Lithic Haplustepts

Clay content: 5 to 18 percent

A horizon
Hue: 5YR to 10YR
Value: 5 to 7 (3 to 6 moist)
Chroma: 1 to 6, dry or moist
Calcium carbonate equivalent: 0 to 5 percent
Reaction: slightly alkaline or moderately alkaline

B horizon
Hue: 5YR or 7.5YR
Value: 5 to 7 (3 to 6 moist)
Chroma: 2 to 6, dry or moist
Texture: fine sandy loam or sandy loam
Calcium carbonate equivalent: 1 to 15 percent
Sodium Adsorption Ratio (SAR): 0 to 13
Reaction: moderately alkaline

Frost-free period: 100 to 160 days

DRAINAGE AND PERMEABILITY: well drained, negligible to high runoff, moderately rapid permeability

USE AND VEGETATION: These soils are used principally as grazing land. Native vegetation is mainly pinyon, juniper, sage, western wheatgrass, cactus, and Indian rice grass.

PULPIT SERIES

The Pulpit series consists of moderately deep, well drained soils that formed in eolian material derived from sandstone. Pulpit soils are on hills and mesas. Slopes range from 2 to 12 percent. Mean annual precipitation is about 14 inches and the mean annual temperature is about 48 degrees F.

TAXONOMIC CLASS: Fine-silty, mixed, superactive, mesic Aridic Haplustalfs

Clay content: 18 to 35 percent

A horizon:
Hue: 2.5YR to 7.5YR
Value: 4 to 7 and (3 to 6 moist)
Chroma: 2 to 4
Texture: loam, fine sandy loam, silt loam, or sandy loam
Rock fragments: 0 to 10 percent gravel
Calcium carbonate equivalent: 0 to 1 percent
Reaction: neutral or moderately alkaline (pH 7.2)

Bt horizon:
Hue: 5YR to 10R
Value: 5 to 7 and 3 to 6 (moist)
Chroma: 3 to 6
Texture: clay loam, silty clay loam, loam, silt loam, or sandy clay loam
Rock fragments: 0 to 10 percent gravel
Calcium carbonate equivalent: 0 to 5 percent
Reaction: neutral to moderately alkaline (pH 7.4-7.6)

Bk horizon:
Hue: 5YR to 7.5YR
Value: 5 to 8 (4 to 7 moist)
Chroma: 2 to 4
Texture: loam, fine sandy loam, silt loam, or clay loam
Rock fragments: 0 to 10 percent gravel
Calcium carbonate equivalent: 5 to 10 percent
Reaction: slightly or moderately alkaline (ph 8.2)

Frost-free period: 100 to 120 days

DRAINAGE AND PERMEABILITY: well drained, low to high runoff, moderately slow permeability

USE AND VEGETATION: These soils are used for grazing and for dry or irrigated cropland. Native vegetation is predominantly sagebrush, pinyon, juniper, western wheatgrass, and Indian rice grass.

WETHERILL SERIES

The Wetherill series consists of deep and very deep, well drained soils that formed in eolian material derived from siltstone and sandstone. Wetherill soils are on plateaus, mesas, cuestas, hills, and terraces. Slopes range from 1 to 60 percent. Mean annual precipitation is about 14 inches and the mean annual temperature is about 49 degrees F.

TAXONOMIC CLASS: Fine-silty, mixed, superactive, mesic Aridic Haplustalfs

Clay content: 20 to 35 percent

A horizon:
Hue: 5YR or 7.5YR
Value: 4 or 5 dry, 3 or 4 moist
Chroma: 2 to 6
Texture: very fine sandy loam, loam, or silt loam
Rock fragments: 0 to 3 percent
Calcium carbonate equivalent: 0 to 1 percent
Reaction: neutral to moderately alkaline (pH 7.2)

Bt horizon:
Value: 4 to 6 dry, 3 to 5 moist
Chroma: 3 to 6
Texture: loam, sandy clay loam, or clay loam with a very fine sand content of 35 to 50 percent, or silt loam
Clay content: 18 to 35 percent
Rock fragments: 0 to 3 percent
Calcium carbonate equivalent: 0 to 3 percent
Reaction: neutral to moderately alkaline (pH 7.4)

Btk1, Btk2 horizon:
Hue: 5YR or 7.5YR
Value: 4 to 6 dry, 3 to 5 moist
Chroma: 4 to 6
Texture: clay loam, loam, or sandy clay loam with a very fine sand content of 35 to 60 percent
Clay content: 18 to 32 percent
Rock fragments: 0 to 3
Calcium carbonate equivalent: 5 to 10 percent
Reaction: slightly or moderately alkaline (pH 8.2)

lower Btk or Bk horizon:
Hue: 5YR or 7.5YR
Value: 5 to 8 dry, 4 to 7 moist
Chroma: 2 to 6
Texture: loam, fine sandy loam, or sandy clay loam with very fine sand content of 40 to 60 percent
Clay content: 12 to 32 percent
Calcium carbonate equivalent: 5 to 40 percent
Reaction: moderately or strongly alkaline (pH 8.2 - 8.4)

Frost-free period: 100 to 150 days

DRAINAGE AND PERMEABILITY: well drained, low to high runoff, moderate and moderately slow permeability

USE AND VEGETATION: Wetherill soils are used for livestock grazing and woodland. Present vegetation is Wyoming big sagebrush, Utah juniper, pinyon, bottlebrush squirreltail, green Mormon-tea, datil yucca, and muttongrass.