Many Mountains Moving: Tales of Mass-wasting and Archaeology in the Absaroka Range, Greater Yellowstone Ecosystem

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Abstract

Landslides occur in great frequency in northwestern Wyoming. More than half of the archaeological sites in the upper Greybull River region of the Central Absaroka Range are associated with a mass-wasting feature. This study includes a detailed examination of one site impacted by depositional sequences associated with a slump/debris flow feature. The landscape activity at site 48PA2811 is currently destroying parts of the site, but past activity has helped in preserving an environmental history of the site over the last 2500 years. Results from soil analyses, geomorphic mapping, and radiocarbon dating show a cyclic change of landscape disturbance and recovery through time. The results of this investigation are compared to regional data to offer insight into landscape change and archaeological patterning in northwestern Wyoming.

Keywords: Mass-wasting, archaeology, Greater Yellowstone Ecosystem

Introduction

Geomorphic processes and the archaeological record are intertwined. Geomorphic settings are often investigated to understand relationships between climate, paleoenvironment, and human occupations. Landscape change in mountain regions of the northwestern Great Plains has received some attention (Benedict 1992; Breckenridge 1974; Albanese and Frison 1995; Reider et al. 1988), but there is little data on mass-wasting processes in archaeological contexts and the information that can be provided by their study. Wyoming experiences some of the highest frequencies of landslides in the United States (Wyoming State Geological Survey and the Water Resources Data System 2001). These processes are difficult to ignore when addressing the archaeological record in the upper Greybull River in the Absaroka Range of northwestern Wyoming. The majority of sites found in this region are located on a landslide feature. To understand the complexity of the landslide/archaeology relationship, this study focuses on one particular site, 48PA2811, and its depositional environment. Soil science, geomorphology, and radiocarbon dating are used in this study to investigate physical changes occurring on this particular landscape through the late Holocene. Paleoenvironmental data are extrapolated from pedogenic layers in the landslide feature and the frequency of landscape change at the site locale is predicted.

THE UPPER GREYBULL RIVER LANDSCAPE

The upper Greybull River study area is defined by the tributaries and surrounding drainage divides that make up the headwaters of the Greybull River (Figure 1). Topography in the study area is defined by steep slopes, narrow drainages, and broad uplands. Multiple Eocene volcanic formations make up the Absaroka Range. These formations lay unconformably on older sedimentary deposits resulting is a mixture of textures prone to mass-wasting (Smedes and Prostka 1972).

Due to the frequent surface activity in the Absarokas, terrace features are not often preserved (Merrill 1974) and many streams do not contain floodplains where buried archaeological deposits often occur. Alternative surfaces conducive to site preservation include ancient mass-wasting deposits that form broad upland expanses. Many of these deposits contain a high density of surface archaeological sites (Ollie et al. 2006). Landslides also provide alternative surfaces on otherwise narrow floodplains.

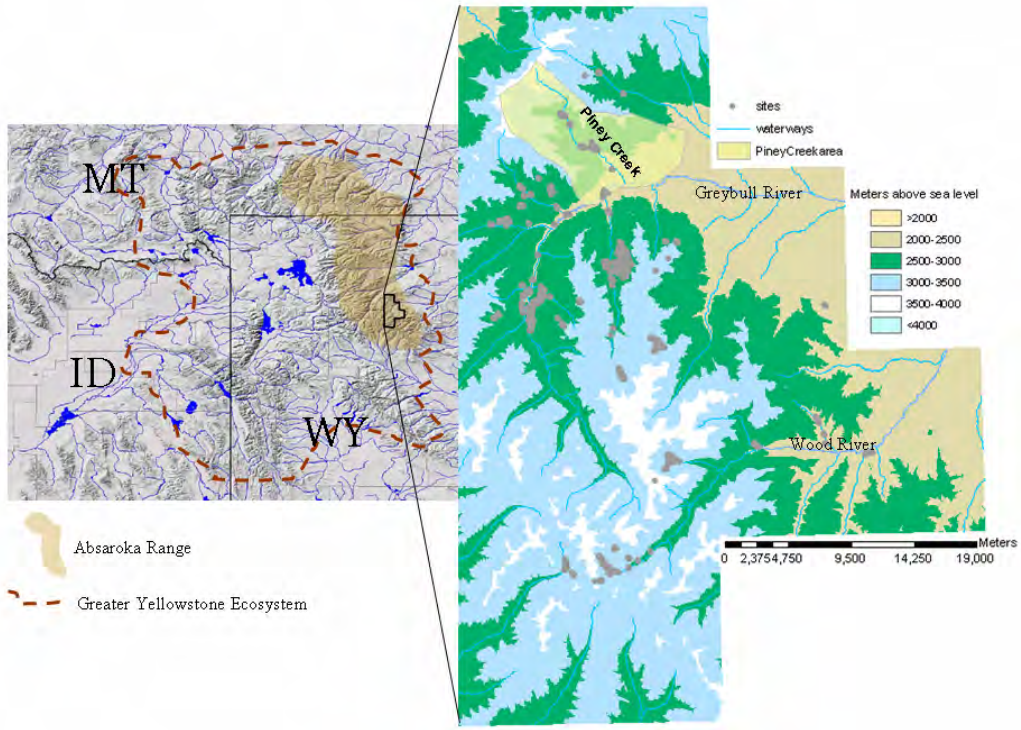


Figure 1. Location of Upper Greybull study area. (Base map from http://seamless.usgs.gov/website/seamless/viewer.php). Elevations presented in 500m intervals based on a digital elevation model from U.S. Geological Survey EROS Data Center (1999).

Archaeological Site 48PA2811

Piney Creek is a south-facing drainage originating from the peaks of Carter Mountain (see Figure 1). Archaeological surveys undertaken by the Colorado State University Archaeological Field School have identified multiple sites along the Piney Creek Drainage. Occupations older than the archaic time period has not been discovered on this drainage and projectile points diagnostic of a period earlier than the Late Archaic have not been positively identified. Paleoindian occupations have been documented along north-facing drainages in the upper Greybull (Bechberger et al. 2005; Burnett 2005). A reason for the lack of older occupations along Piney Creek may due to its active history.

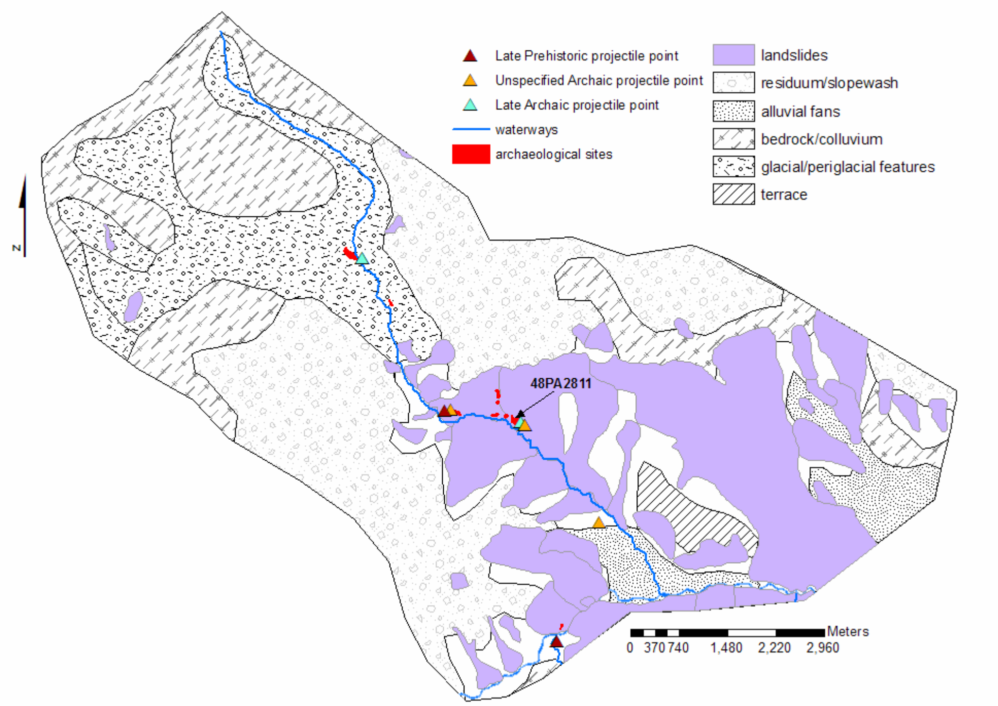


Figure 2. Piney Creek Basin surface geology (surface geology data from Chase et al. 1998; landslide data from Wyoming State Geological Survey and the Water Resources Data System 2001).

Figure 2 is the surface geology of the Piney Creek drainage. The middle and lower portions of the drainage basin are dominated by large slump/flow features. Bedrock outcrops, colluvium, and periglacial features occur on the upper reaches of the drainage. Alluvial fans are present at the creek's confluence with the Greybull River. A terrace section is also preserved at the lower reaches of the drainage. Site 48PA2811 is located on the eastern side of Piney Creek within the slump/flow feature.

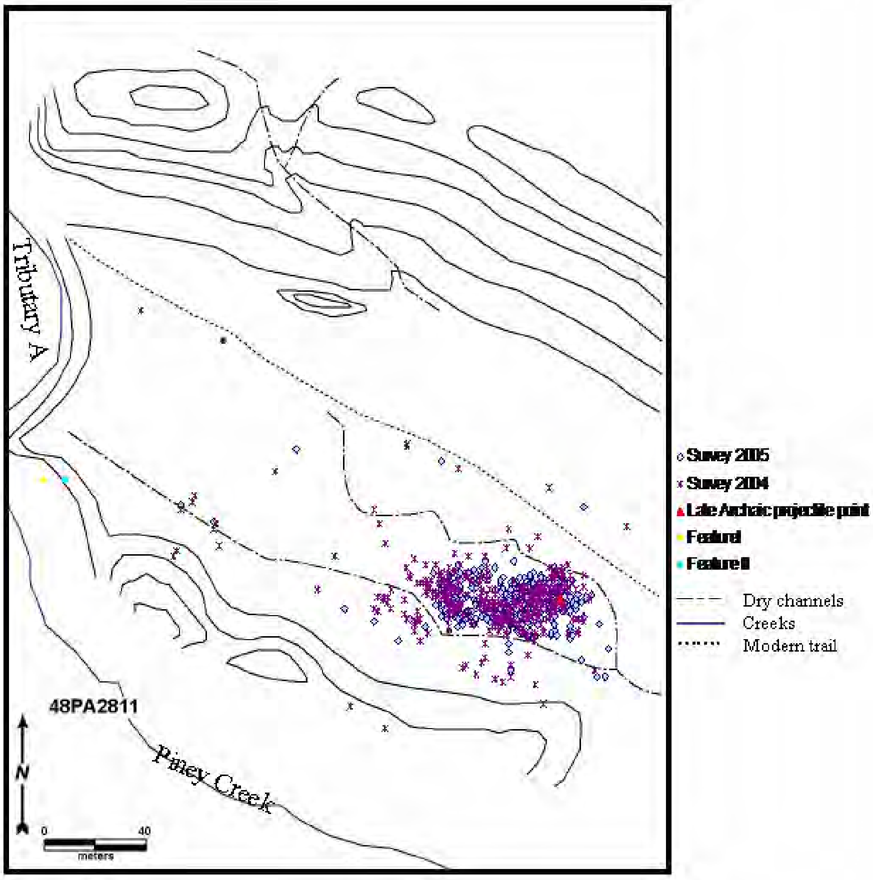


Figure 3. Site map

Site 48PA2811 was originally documented in 2004 and again in 2005 (Figure 3). The site consists of a surface lithic concentration, located on the eastern portion of a small basin. This concentration contains a Late Archaic projectile point. Two subsurface features were identified in an eroding creek bank west of the surface concentration. A hearth (feature 1) located nearly one meter below the present ground surface contained preserved wood. Dates obtained from the charred wood are listed in Table 1. Outer growth rings produced the most reliable dates and suggest that the hearth feature pre-dates the surface occupation.

Table 1. Radiocarbon dates from feature 1 at site 48PA2811

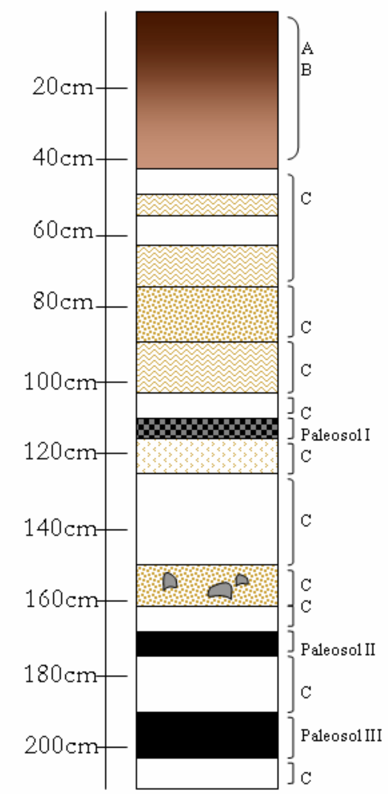
Sample number	Sample location	^{14}C age yr BP	2σ cal age ranges	Relative area
2811-1i	heart wood on log segment from hearth	1550 +/-90 BP	1687-1295	0.988
2811-1o	outer growth layers of same log	1100 +/-60 BP	1171-925	1
2811-2	outer growth layers of different log	1040 +/-60BP	1067-794	1

Figure 4. View of Piney Creek and the eroding creekbank of 48PA2811.

To explain the differences in deposition within the boundaries of site 48PA2811, soil layers exposed in the creekbank above and below feature 1 were mapped and sampled in 2005 and 2006 and analyzed in 2006. Soils were mapped to a depth averaging 2.5 meters below surface over 18 horizontal meters of the creekbank. The photograph in figure 4 shows a portion of the creekbank that was mapped. Due to the erosive nature of the creekbank, soils could not be sampled at even intervals but a representative sample for the profile was obtained by selecting areas of the profile with the best preservation. Soil samples for radiocarbon dating were selected from two different profile sections of the creekbank to test for accuracy of dating.

SOIL PHYSICAL PROPERTIES AT SITE 48PA2811

Field observations of soil physical properties are displayed in Figure 5 next to a composite of the profile. Soil texture is variable throughout the profile and indicates at least three separate periods of landscape instability. High-energy deposition was identified at 80, 120, and 150 centimeters below surface (cmbs). These layers are nearly devoid of any fines and are structureless. The deposit at 80 cmbs consists of over 90% coarse sand and small rounded gravels. The deposit at 150 cmbs contains large clasts and coarse sand. In contrast to these deposits, platy, layered sands and fines are present at 46-76 cmbs and again at 89-104 cmbs. These layers are typically more clay rich and range in texture from sandy loam to loam. The deposition of these finer-grained particles is expected from a low energy environment and probably occurred when the basin was an active pond.



Depth cmbs[a]	Color Dry	Moist	Texture[b]	Structure[c]
0-13	10YR4/2	10YR2/2	sl	1cogr
13-42	10YR4/2	10YR2/2	sl	2copr
42-50	10YR5/2	10YR4/2	sl	3vcpr
50-54	10YR5/2	10YR4/2	sl	2vkpl
54-66	10YR5/2	10YR4/2	sl	3vcpr
66-76	10YR5/2	10YR4/2	l	2tkpl
76-89	10YR5/2	10YR4/2	s	sg
89-104	10YR5/2	10YR3/2	l	2vkpl
104-111	10YR4/1	10YR2/1	sl	1vkpl
111-116	10YR4/1	10YR3/1	cl	2cosbk
116-124	10YR5/2	10YR4/2	ls	sg
124-150	10YR5/2	10YR4/2	sl	2copr
150-161	10YR5/2	10YR3/2	s	sg
161-169	10YR5/2	10YR3/2	sl	2tkpl
169-176	10YR4/1	10YR3/1	scl	2copr
176-190	10YR4/2	10YR3/2	sl	2copr
190-202	10YR3/1	10YR2/1	scl	3copr
292+	10YR4/2	10YR3/2	sl	2vcsbk

Figure 5. Composite of Piney Creek stratigraphy and soil physical properties
[a] cmbs-centimeters below present ground surface
[b] sl, sandy loam; l, loam; s, sand; cl, clay loam; ls, loamy sand, scl; sandy clay loam
[c] grade: 0-structureless, 1-weak, 2-moderate, 3-strong; size: co-coarse, vc-very coarse, vk-very thick, tk-thick; structure: gr-granular, pr-prismatic, pl-platy, sg-single grain, sbk-subangular blocky
Soil color determined by Munsell Color 1975, texture, soil grade, size and structure based on field observations.

Four different soil-forming periods are indicated in Figure 5. Dark colors, which usually imply organic material, correspond with three buried A-horizons; paleosol I (PI), paleosol II (PII), and paleosol III (PIII). The dark color does not fade with depth implying that even older soils like PIII are well-preserved. All soils are weakly developed. There is no evidence of the formation of a B-horizon in any of the three buried soils. The modern soil contains a B-horizon, but it is defined only by a change in structure from granular to prismatic. All buried A-horizons contain concentrations of charcoal. PI is especially charcoal rich.

Radiocarbon Dates for Paleosols

To provide temporal control for the stratigraphic sequence, radiocarbon samples were taken from PI and PIII. The results are presented in Table 2. Results are based on charcoal fractions in the soil and provide a minimum date for soil formation and a maximum date for the sediments that overlie these soils. PIII provides dates of roughly 2500 years BP. This relatively young age is unexpected based on the amount of sediment accumulation in this sub-alpine environment. PI produced dates close to 900 years BP. PI is directly above the hearth feature in the stratigraphic profile and these dates correlate well with the stratigraphic relationships.

Table 2. Radiocarbon dates from paleosols at site 48PA2811

Sample number	Sample location	^{14}C age yr BP	2σ cal age ranges	Relative area
2811RC3	Paleosol I, profile 1	907+/-40	917-739	1
2811RC6	Paleosol I, profile 2	880+/-40	915-699	0.991
2811RC1	Paleosol III, profile 1	2620+/-50	2852-2510	0.88
2811RC4	Paleosol III, profile 2	2480+/-40	2719-2365	0.918

SOIL LABORATORY METHODS

Additional analyses of the soils in 48PA2811 were conducted to examine the potential of biological change associated with physical changes on the landscape. Soil analyses were preformed for all soil horizons, including C horizons. Analyses included measurements of total carbon/nitrogen to quantify the presence of organic material in the soils. Total carbon/nitrogen percentages were determined using a LECO 1000 CHN elemental analyzer in the National

Resources Ecology Laboratory, Colorado State University. Soils for these analyses were pulverized and oven-dried before analyzed.

Percentages of sand, silt and clay in the soils were found using the hydrometor method adapted from Bouyoucos (1936). Texture is expressed as a clay-free index (silt+sand/sand) where the number 1 indicates 100% sand and higher values typify an increase in finer particles.

Carbon isotope values were also found for all soils in the study. The stable carbon isotopic composition in soil organic matter is largely controlled by plant type (Kelly et al. 1998:61). Two large plant groups, C_3 and C_4, differ in their $^{13}C/^{12}C$ ratios, due to differences in photosynthetic pathways (Farquhar et al. 1989) and these values, expressed as $\delta^{13}C$ are often used to look for transitions between forest and grassland communities. Values for $\delta^{13}C$ in this study were measured using CARLOGRBA NA1500 elemental analyzer (C.E. Elantech, Milan, Italy), coupled to a VG isochrom isotope ratio mass spectrometer (GV Instruments, Manchester, UK) located in the Natural Resource Ecology Laboratory, Colorado State University. Soils were pulverized for this analysis and each sample was measured according to percentage carbon due to the high range of total carbon in the soils.

Soil pH is a factor of biota, climate, parent material, and time (Jenny). Soil pH can hinder or promote organic preservation, which is important for archaeological preservation. A pH meter was used to record soil pH (Janitzky 1986). Inorganic carbon was found using a pressure transducer and voltage meter (Sherrod et al. 2002). Percentage of inorganic carbon is necessary to distinguish organic carbon and is also used to find $CaCO^3$ in soils (12% of $CaCO^3$ is inorganic carbon). While, $CaCO^3$ is expected to be low in the study area due to the absence of limestone and other carbonate-containing parent materials, inorganic carbon can influence pH values.

SOIL CHEMICAL ANALYSES RESULTS AND DISCUSSION

Chemical properties indicate that buried soils are well-preserved at 48PA2811. Amounts of organic carbon and nitrogen do not decrease with depth and high values of organic carbon and nitrogen typify all A-horizons. PI and PIII contain the highest percentages of organic carbon and nitrogen. There are slight pulses in organic carbon and nitrogen in depositional layers between 40 and 75 cmbs. These pulses correspond with the platy clay/sand layers that are believed to be pond deposits. Very low values in carbon and nitrogen reflect coarser-grained depositional layers in the profile.

A higher clay-free index should correspond with higher organic carbon and nitrogen percentages. Based on the results from Figure 6 there is no significant correlation between organic carbon and nitrogen and the clay-free index. This is in part due to the lack of a large pulse in organics from the more clay-rich layers between 40 and 75 cmbs. Higher values for fine-grained material do not necessarily mean high organics and these layered deposits seem to be more indicative of low-energy deposition instead of soil-forming layers.

The ratio of carbon to nitrogen is a comparison of production versus decomposition of plant material in soils. PI has the highest C:N ratio of the soil-forming layers—just above 19. This is typical for forest A-horizons which have

C:N ratios in the order of 20:1, while a grassland A-horizon ranges from 8:1 to 15:1 (Brady and Weil 2002: 506-507). High C:N ratios in buried soils can also result from the cessation of microbial activity brought on by rapid burial. There is an overwhelming presence of charcoal in PI and rapid burial of this soil surface helped to preserve this organic litter. A depositional layer 80 cm below the present ground surface also produces a C:N ratio of over 19. The percentage values of organic carbon and nitrogen are extremely low in this deposit, unlike the buried soils, and the C:N ratio for this depositional layer is indicative of trace organics that were carried with these sediments and deposited. Both PII and PIII have a C:N ratio similar to the present day soil-forming layer, with a slightly higher C:N ratio for PII.

The $\delta^{13}C$ signal indicates that the ratio of C_3 to C_4 plants was fairly consistent through time with a dominance of C_3 plants. Values vary but typically, C_4-dominated communities, such as prairie or steppe, have a $\delta^{13}C$ value of -12.0‰ while C_3-dominated communities, like forests and shrublands, have a value of around -26.0‰ (Bender 1968). There is some variability in these values among the buried soils. In general, the $\delta^{13}C$ value of soil organic matter should increase with depth in soil that has remained under the same plant community during a long period (O'Brien and Stout 1978). Both the modern soil forming layer and PI represent the lowest $\delta^{13}C$ values and PIII shows higher values, but $\delta^{13}C$ values for PII are highest. PII may have supported vegetation with a higher proportion of C_4 plants (Nordt et al. 1994). Alternatively, the higher $\delta^{13}C$ value for PII may indicate a time of drought stress (Stevenson et al. 2005). PII has less nitrogen, indicated by a slightly higher C:N ratio. A higher C:N ratio does not correspond with an increase in grasses. Paleosol II is suggestive of a period of more dry conditions in the basin.

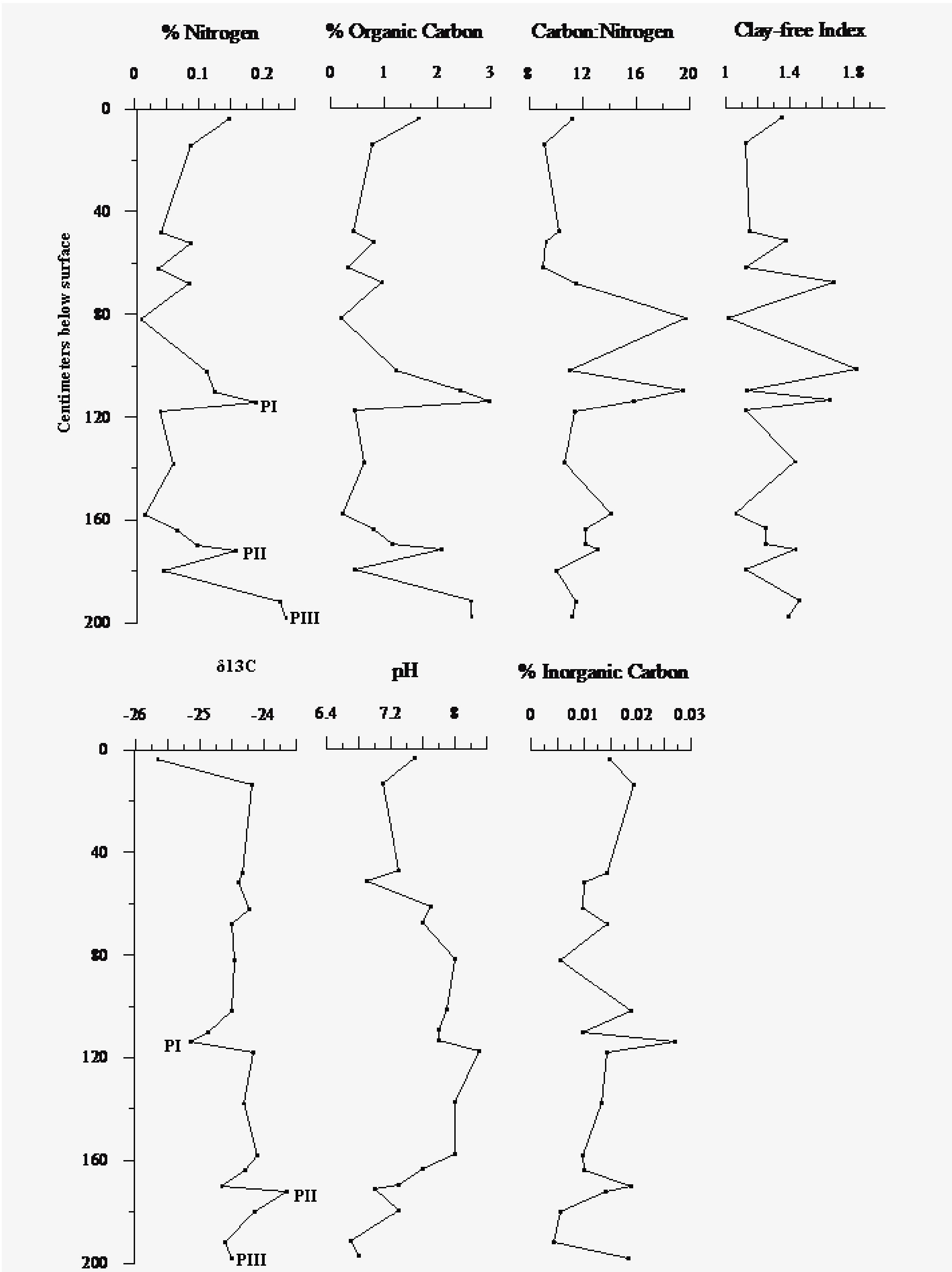


Figure 6.

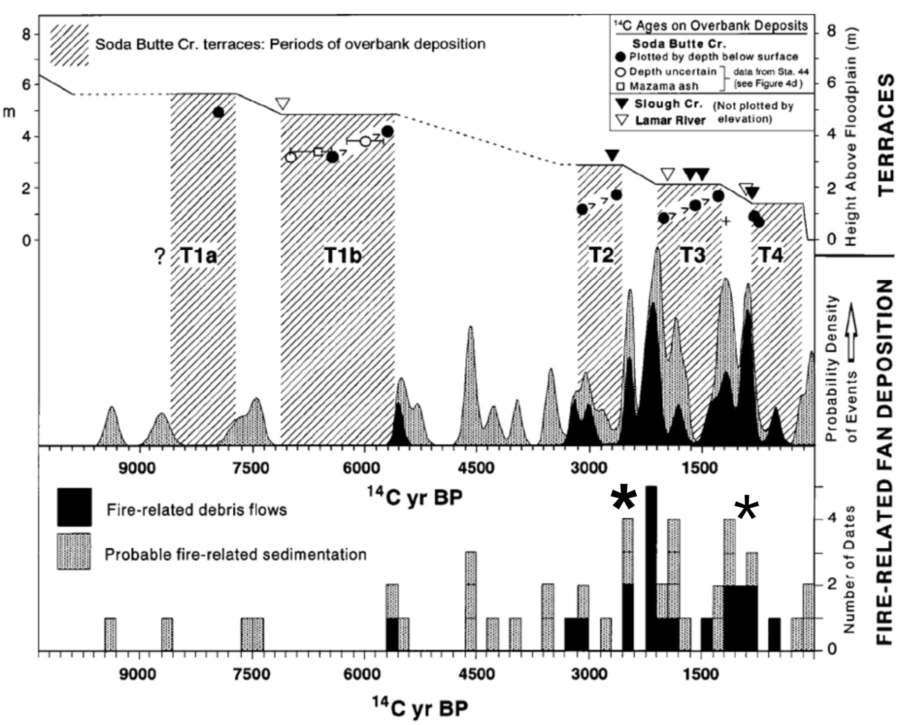
Soil pH lingers around neutral to slightly alkaline through profile. Often high pH is related to $CaCO_3$ accumulations, but there is no significant correlation between inorganic carbon and pH. Based on inorganic carbon values there is only a slight trace of inorganic carbon through the profile. The higher values of pH can be the result of many other factors. In an investigation of soils in the Sunlight Basin, to the north of the Upper Greybull study area in the GYE, Huckleberry (1985) hypothesizes that neutral pH and a decrease in pH with depth reflects pedogenic immaturity. This corresponds when comparing results from PIII and PI. PIII has the lowest pH values in the profile and has the thickest A-horizon while PI has the highest values and is a very thin horizon in the profile.

INTERPRETATIONS OF LANDSCAPE CHANGE

By combining results from archaeological, laboratory, and field data analyses, a phase by phase story of landscape change can be developed. Landscape change at site 48PA2811 is cyclic, characterized by stages of soil formation, disturbance, and rejuvenation. The landscape has repeated this cycle at least four times. While each cycle is not necessarily the same, the landscape tends to recycle itself.

Deposition rates at 48PA2811 are fairly rapid with 1 meter of sediment accumulation in less than 1000 years, while other surfaces within the site basin have been stable since the Late Archaic. Cyclic change in the form of fire disturbance and reorganization of vegetation communities occurs less than every 1,000 years. Four fires and four soils (PIII, PII, PI and the modern soil) are recorded in the last 2500 years. The modern surface burned in 2006. This constant disturbance and recovery regime means that plant and animal communities reorganize and proliferate often. More radiocarbon dates sampled from PII and an additional cultural deposit in the profile will contribute to a finer-grained understanding the timing of landscape change.

The dates acquired from 48PA2811 show a synchronicity with similar environmental change in the region during the Late Holocene. Fires that burned past surfaces at 48PA2811 correspond with periods of fire-induced debris flows in Yellowstone National Park (Meyer et al. 1995). Figure 7 lists the chronologies developed by Meyer et al. (1995). Radiocarbon dates from 48PA2811 are added to this figure. While site 48PA2811 is one study, the results suggests that these systems might be responding to similar catalysts including the Medieval Climatic Anomaly.



* Dates from paleosols at archaeological site 48PA2811

Figure 7. Calibrated calendar year chronology of alluvial activity in northeastern Yellowstone National Park. (from Meyer et al. 1995).

Comparisons between data from 48PA2811 and data in the Greater Yellowstone Ecosystem need to be expanded upon and this is only the beginning. Current development of landscape histories for the upper Greybull is underway for other sites in the area. Recent archaeological test excavations at 48PA2874 indicate sub-surface archaeological preservation in a sag pond of an older flow surface. These data will provide a further understanding of landscape processes in the region. As shown in this research, the relationship between archaeological sites and landslide deposits is far from a destructive one. Environmental archaeological data can be produced from these relationships and future investigations of landscape histories in the region will lead to a better understanding of the factors influencing these changes.

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