After the flood: Investigations of impacts to archaeological resources from the 2013 flood in southern Alberta

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The naked landscape: Science and the secrets of the FM Ranch Campsite (EfPk-1)

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ABSTRACT

The FM Ranch Campsite (EfPk-1), one of the province's most highly valued archaeological sites, was damaged by the 2013 catastrophic floods along the Bow River in southern Alberta. Our study, conducted under the Province's 2015 flood impact assessment program, recovered archaeological data that was exposed along eroded riverbanks and at risk of further loss. Our primary goal was to correlate the riverbank exposures with intact recoveries from the terrace interior. To do so, we employed geoarchaeological methods, including stratigraphy, magnetometry, luminescence profiling, magnetic susceptibility, and Accelerator Mass Spectrometry radiocarbon dating, in addition to soil micromorphological and palaeoenvironmental analysis of six hearth-type features. Our results indicate that at least seven occupations took place on different parts of the landform during the past 1,300 years. The north and central portions of the landform are oldest, predating occupations in the southern portion by approximately 400 years. The hearth-type features demonstrate variations in their use history, with some representing intact single or multiple uses, while others have been culturally redeposited. Occupations of the southern portion of EfPk-1 appear to be closely related to use of the adjacent FM Buffalo Jump (EfPk-2). However, occupations in the northern part of the landform likely occurred before the southern part was stable enough for occupation, and before EfPk-2 was in regular use.

KEYWORDS

Avonlea, Protohistoric, Late Precontact, geoarchaeology, stratigraphy, luminescence, soil micromorphology, palaeoenvironment, combustion, fluvial, hearth

1. Introduction

The FM Ranch Campsite (EfPk-1) is one of the better-known archaeological sites damaged by catastrophic flooding that took place in southern Alberta in 2013. Officially recorded in 1958 (Glenbow Foundation 1959), portions of the site have since been designated as a Provincial Historic Resource (PHR), which makes EfPk-1 one of the province's most highly valued archaeological resources.

The 2013 floods caused considerable riverbank erosion along the southern, eastern, and northern edges of the terrace on which the site is located, resulting in partial loss of the resource. The erosion also resulted in abundant sediment exposures adjacent to the river channel, which revealed multiple buried artifact-bearing layers and cultural features, almost all of which were at risk of further loss due to continued slumping and erosion (Vivian and Amundsen-Meyer 2015). These exposures provided a unique opportunity to address some long-standing uncertainties about the site, including: 1) the number of occupations, 2) occupation age, and 3) the nature of potential relationships of cultural materials in different portions of the terrace (e.g., a continuous deposit of human activity across the landform vs. discrete clusters of activity areas).

To mitigate the flood damage and capitalize on the opportunity to address these long-standing questions about EfPk-1, Alberta Culture and Tourism (ACT) issued a Request for Proposals (RFP) that focused specifically on the correlation of sediments exposed along the riverbank with those exposed during archaeological excavations, to be conducted in the northern and central portions of the landform. We undertook the requested 2015 FM Ranch Campsite excavations, the objectives of which required effective expertise in soils, sediments, and their intimate association with archaeological remains and with the wider landscape. This expertise is one of the domains of geoarchaeology, which is a subfield of archaeology that draws on approaches from the earth sciences, ecology, and palaeoenvironmental studies (among others) to address archaeological questions.

This paper presents an overview of our archaeological work at the FM Ranch Campsite (see Gilliland et al. 2016) and includes a discussion of the environmental setting and history of research at the FM Ranch Campsite, followed by some of the long-standing archaeological questions about the site, the geoarchaeological approach taken to address these questions, and the results of our study. I begin with a review of one of the most fundamental aspects of effective archaeological investigation—the stratigraphic profile and the interpretation of site formation processes.

2. The bare necessities: stratigraphy and site formation processes

From an archaeological perspective, one of the most useful definitions of a landscape is that it represents a tangible artifact resulting from the interaction between people and the environment (Crumley 1994). From this holistic perspective, the physical landscape can be studied along with the other artifacts (e.g., projectile points, bones, and ceramics) that are recovered from archaeological sites. By incorporating various earth science methods in these studies, landscape analysis can provide a wide range of cultural, environmental, and chronological information that can be interpreted to address key questions, such as, “What happened before people first lived here?”, “When did people first come here?”, and “How did the site change over time?”

One of the critical stages in studying an archaeological site from a landscape-based perspective is to establish a stratigraphic framework for the site. Key to establishing this framework is the stratigraphic profile, which is a vertical exposure of the layers of soils and sediments that exist below the modern land surface. The layers of soils and sediments recorded in an exposure and stratigraphic profile contain information about how these materials came to be present at that particular location, what types of cultural or natural events occurred on the landscape after they arrived, and when those events took place (Figure 1). By systematically documenting characteristics of each layer of a stratigraphic profile, archaeologists can detect and interpret changes that occurred at the site over time and space. This is possible because soils and sediments tend to build up over time like a layer cake (with the lower layers being older than the upper layers), and because of what we know about sediments and soils based on scientific observations of the natural world.

Sediments are mineral or organic materials eroded, transported, and redeposited in a location that is some distance from the initial source (Canarache et al. 2006). For example, in the case of archaeological sites documented along the Bow River, many are located on sediments that have been deposited by the river (“fluvial” deposits). Other depositional forces include wind (“aeolian” sediments), glaciers (“till”), hillslope (“colluvial”) processes, settling of fine materials within a lake (“lacustrine” sediments), or even people (e.g., compost spread over the garden, gravel pits).

Soils differ from sediments in that they form as a result of a combination of the incorporation of organic material and weathering processes (Soil Classification Working Group 1998). Unlike sediments, soils represent stable land surfaces on which vegetation, animals, and people depend, thrive, and interact. Depending on the environmental conditions at a particular location (such as length of time the land surface is stable, temperature, moisture, or degree of slope), weathering at the surface can result in the development of vertical sequences of soil layers (called horizons).

A soil becomes buried when a depositional event (such as a flood or a landslide) results in an accumulation of sediment on top of it. This new sediment protects the soil (and any associated artifacts or cultural features) from erosion and from the influence of weathering taking place at the newly formed land surface. If a soil becomes buried before it has time to develop horizons, only one horizon may be observed in a stratigraphic profile. This horizon represents the former surface and is usually darker in colour than the sediments that bury it. Regardless of whether or not horizons form, from an archaeological perspective, buried soils tend to be important indicators of intact former occupation surfaces, particularly if they contain artifacts.

Soils and sediments are not only important from a cultural perspective. Their visual, physical, and chemical characteristics also provide a variety of information regarding depositional and post-depositional processes that acted on them over time. For example, the particle size of the sed-

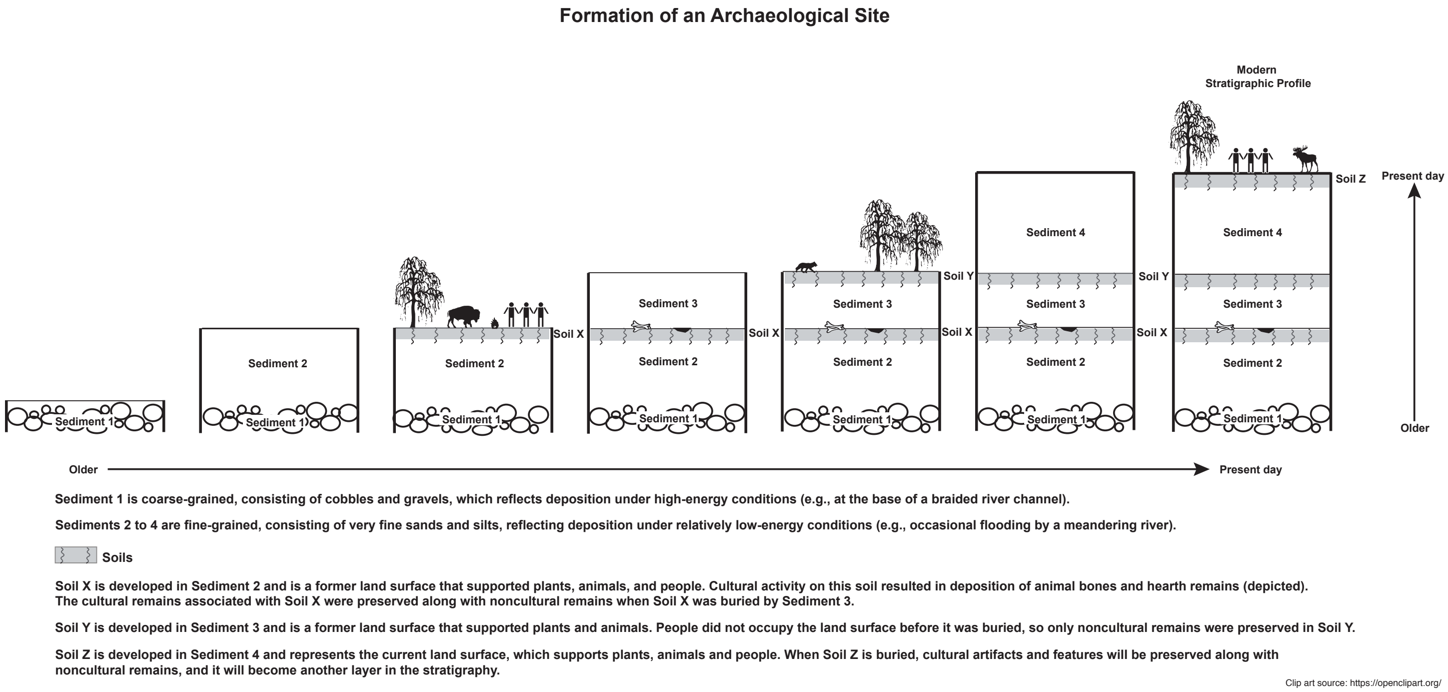

Figure 1. Simplified diagram of site formation processes.

iment generally reflects the depositional energy; therefore, cobbles and gravels will require high-energy transportation conditions (such as within a braided river), compared with very fine silts or clays, which typically accumulate in slow-moving creeks or in ponds or lakes.

The diversity of information that can be obtained from sediments and soils means that they can be studied by different types of specialists, resulting in interdisciplinary interpretations of archaeological sites that include both people and the environment in which they lived and helped to create. This integrative approach is becoming increasingly common in modern issues, such as responsible management of renewable and nonrenewable resources, including historic resources. As such, the geoarchaeological approach taken in this study was considered to be key in addressing the goals of Western Heritage's 2015 historic resources impact mitigation of EfPk-1.

3. The FM Ranch Campsite (EfPk-1)

3.1 Introduction and environmental setting

The FM Ranch Campsite (EfPk-1) is located on a large T2 terrace on the Bow River, about 10 kilometres southeast of the southern edge of the city of Calgary and 4 kilometres upstream from the confluence of the Bow and Highwood Rivers in southern Alberta (Figure 2). The T2 terrace is one of four terrace levels documented along the Bow River in the Calgary area (Wilson 1983). Based on stratigraphy, the absence of the distinctive Mazama Ash horizon, and recent archaeological studies (e.g., Vivian 2014), the T2 terrace level is estimated to have formed between about 2,500 and 2,000 years ago. The site boundaries extend across the entire terrace landform, which measures approximately 1.2 kilometres northwest–southeast and 0.45 kilometres west–east.

The landform is currently open, cultivated, and flat to gently undulating. Bolton's (2017) field observations of the non-cultivated, modern vegetation at the site noted many taxa common to riverine/wetland and transitional prairie/forest habitats, including cottonwood, white spruce, chokecherry, willow, wolf willow, trembling aspen, black currant, creeping juniper, buffalo berry, and golden bean. Many of these plants could have been used for food, medicinal, fuel, or construction purposes. Further, Bolton notes that it is likely that many of the modern plants observed at the site were also available to its past inhabitants, in addition to other plants not currently observed at the site.

EfPk-1 is located within the Grassland Natural Region, Foothills Fescue Natural Subregion. The underlying bedrock consists of the Scollard Formation, which is of Upper Cretaceous and Palaeocene age and is composed, predominantly, of sandstones and mudstones. The overlying surficial geology is comprised of fluvial (river-deposited) gravels and sands. The dominant soil type in the region is Orthic Black Chernozem (Moran 1986; Natural Regions Committee 2006; Prior et al. 2013).

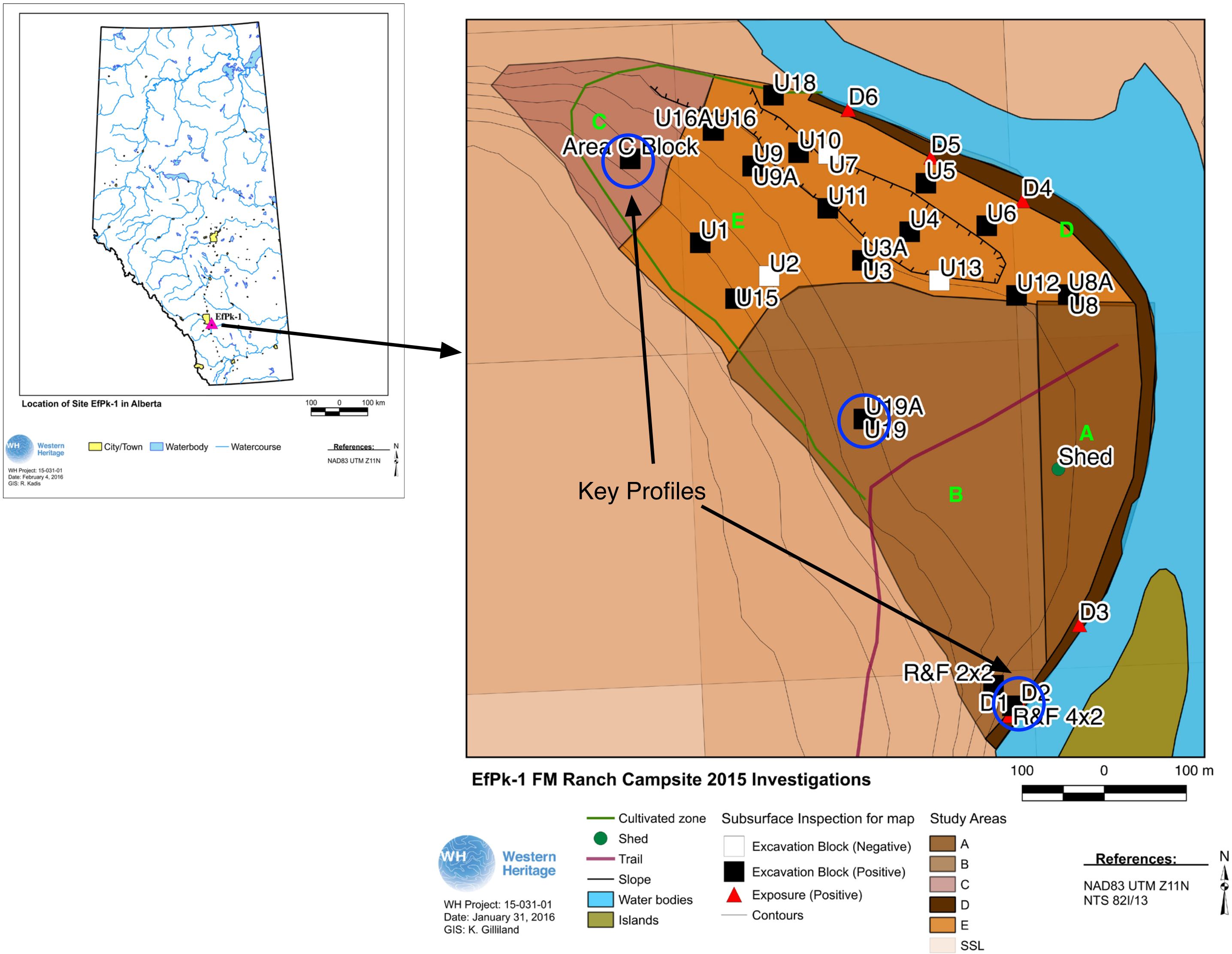

Figure 2. Location of EfPk-1 in Alberta and of key profiles at the site, discussed in this chapter. Blue circles indicate locations from which samples for radiocarbon dating were collected. Contour interval is 10 metres.

3.2 Formation processes

Fluvial activity predominates at EfPk-1; however, field observations in 2015 suggested that slope erosional processes and gravity-induced sediment transport ("colluviation") has also occurred along the escarpment on the western boundary of the site (Figure 3). Additionally, fine sediment deposition and erosion through wind activity ("aeolian" processes) have likely been active. Apart from fluvial erosion, widespread mole activity is a major disturbance at the site, resulting in displacement and localized redistribution of sediments and buried artifacts. Human activity, including cultivation and trail use, have also contributed to devegetation, destabilization, and homogenization of the upper 20–30 centimetres of the land surface, and have left sediments vulnerable to wind erosion.

3.3 Nearby archaeological sites

The Bow River valley was and continues to be a popular locale for people to use for hunting, fishing, camping, and travel. This lengthy history of human use is reflected in the number and variety of previously recorded archaeological sites along the river (Table 1). Of these, EfPk-2 (the FM Buffalo Jump) is of particular relevance (Figure 3). Situated at the south end of the EfPk-1 terrace, EfPk-2 has long been intimately associated with EfPk-1, and the two sites are assumed to form a killsite/campsite complex (Glenbow Foundation 1959; Rogers and Fromhold 1975; Vivian and Amundsen-Meyer 2015). Another killsite, EfPk-5, is located at the northwestern end of the EfPk-1 landform (Figure 3). Recorded in the 1970s (Wickham 2014), considerably less is known about the nature of EfPk-5 and its relationship to EfPk-1.

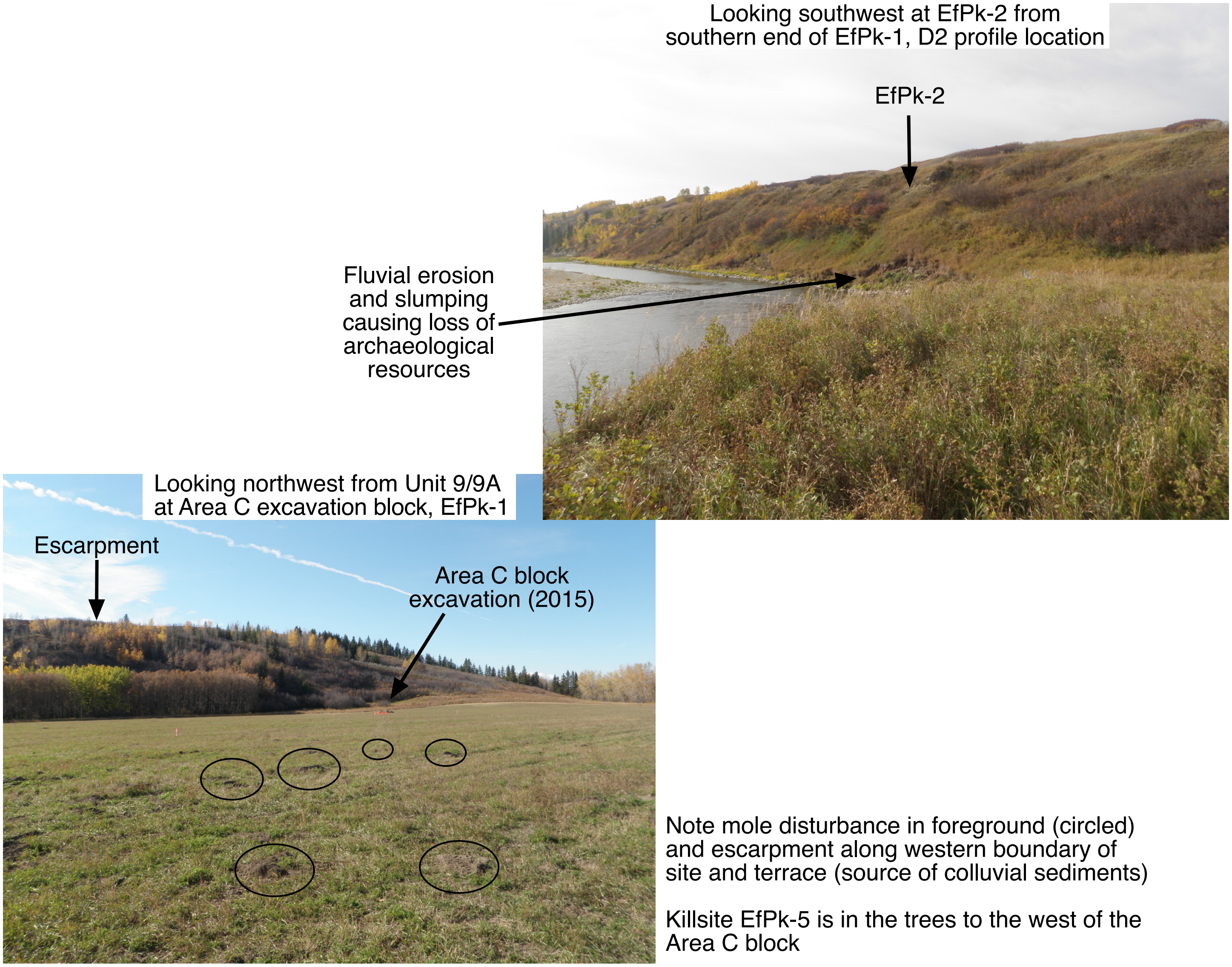

Figure 3. Landscape features and some formation processes at EfPk-1 and EfPk-2.

3.4 Background to EfPk-1

Beginning when it was first recorded in 1958, the FM Ranch Campsite (EfPk-1) has been considered to be an extensive and exceptionally well-preserved example of a campsite associated with a buffalo jump (EfPk-2). Largely due to its preservation and association with EfPk-2, EfPk-1 is considered to be one of Alberta's most valuable archaeological sites.

Early archaeological excavations at the site produced large quantities of artifacts and revealed numerous cultural features (Glenbow Foundation 1959). Since then, research at EfPk-1 has continued on a periodic but somewhat limited basis (Rogers and Fromhold 1975; Vickers 1982), with the most recent archaeological work at the site consisting of Historic Resources Impact Assessments (HRIAs; Wickham 2014; Vivian and Amundsen-Meyer 2015).

Until now, no formal radiocarbon ages have been reported for EfPk-1 or EfPk-2. However, age estimates based on artifact recoveries suggest that the two sites were initially inhabited or in use during the Avonlea Phase of Alberta Plains Prehistory (about 1,350–1,150 years ago [Peck 2011]), and that they have since been revisited numerous times. Previous archaeological work at EfPk-1 (referred to above) has generally concluded that the site was most intensively occupied during the Old Women's Phase (about 1,100 to 250 years ago [Peck 2011]) and into the Protohistoric Period (about 250 to 200 years ago [Peck 2011]).

3.5 Secrets remain

The previous archaeological work conducted at EfPk-1 contributed to general understandings about the types of cultural materials that remain buried at the site, and where these

Table 1. Previously recorded archaeological sites in the vicinity of the FM Ranch Campsite (EfPk-1). From Gilliland et al. 2016:12.

Site	Historic Resources Value	Site Type	Site Affiliation
EfPk-2	3	campsite, killsite (bison jump)	Late Prehistoric; Pekisko; Nanton Side Notched; Irvine; Protohistoric; Blackfoot?
EfPk-3	4	campsite, killsite	Late Prehistoric?
EfPk-4	0	campsite, killsite	Early Prehistoric; Cody; Scottbluff
EfPk-5	4	killsite	Undetermined
EfPk-6	0	campsite	Middle Prehistoric; Besant
EfPk-7	0	campsite	Undetermined
EfPk-8	0	campsite	Undetermined
EfPk-9	0	campsite	Undetermined
EfPk-10	0	campsite	Undetermined
EfPk-11	0	campsite	Undetermined
EfPk-12	0	campsite	Undetermined
EfPk-13	0	campsite	Undetermined
EfPk-14	0	campsite	Undetermined
EfPk-15	0	campsite	Undetermined
EfPk-16	0	campsite	Undetermined
EfPk-24	0	scatter, campsite, stone feature, kill site, settlement (ranch)	Prehistoric; Historic
EfPk-25	0	scatter, campsite, stone feature	Late Prehistoric; Pelican Lake, Besant, Avonlea; Historic
EfPk-26	0	campsite	Undetermined
EfPk-27	0	scatter, campsite, stone feature	Undetermined
EfPk-32	4	stone circle	Unknown Precontact
EePk-13	0	campsite, killsite	Undetermined Prehistoric
EePk-14	0	campsite, killsite	Undetermined Prehistoric
EfPl-62	4	campsite, stone feature, kill site	Middle Prehistoric; Duncan; McKean, Pelican Lake, Late Prehistoric; Protohistoric
EfPl-173	4	scatter >10, campsite, structure; hearth, killsite, ranch	Middle Prehistoric; Late Prehistoric Plains Side-notched; Prairie Side-notched; Historic

remains are concentrated. However, many questions persist regarding the history of occupation of this site, such as:

1. When did people first occupy EfPk-1?
2. How many occupations have there been?
3. What is the extent of the site? Does it include the entire landform or just the southern portion next to EfPk-2 (the FM Buffalo Jump)?
4. What were people doing there? Did they primarily process bison kills, or were there other important activities?
5. In order to address these questions, Western Heritage undertook science-based archaeological investigations at the FM Ranch Campsite through: 1) recording stratigraphies and cultural layers observed in riverbank exposures along the terrace; and 2) excavating a limited number of square metres within the terrace landform, with the focus on making the connection between the stratigraphies observed along the riverbank and those exposed in archaeological excavations within the landform.

Our 2015 work was conducted in the northern and central portions of the landform, which are relatively poorly understood, as they have been studied less intensively than the southern portion of the site. In addition, Western Heritage's 2015 archaeological work at EfPk-1 is distinguished from previous work in that it focuses primarily on establishing key stratigraphic and chronological frameworks for the site. By establishing these key frameworks, we address one of the primary objectives of the 2015 flood mitigation program: to provide evidence-based interpretations of the history of human activity and environmental events at EfPk-1 in order to ensure that future decisions regarding site management and protection are well-informed, meaningful, and appropriate.

Recent technological advances allow the incorporation of multiple scientific methods into our stratigraphic approach at EfPk-1. In the following sections, I provide a brief overview of each of the methods applied in addressing project goals, followed by a discussion of results of our 2015 work at EfPk-1 and how they have helped to reveal some of the long-standing secrets of the FM Ranch Campsite. For detailed discussions of the archaeological and geoarchaeological work conducted at EfPk-1, see Gilliland et al. (2016), Bolton (2017), and Gilliland and Bolton (2017).

4. The science: methods

In establishing reliable stratigraphic and chronological frameworks for EfPk-1, Western Heritage took an holistic approach that incorporated routine methods (such as stratigraphic description and radiocarbon dating) with lesser-known techniques (including magnetic susceptibility and portable optically-stimulated luminescence). The results from each method were integrated to provide a robust interpretation of the history of cultural activity. Although 18 stratigraphic profiles were analyzed in detail during our 2015 work, the rest of this chapter will focus on two key stratigraphic profiles; the first is the D2 riverbank profile (Figure 4) and the second is the Area C profile, exposed in the block excavations at the northern portion of the terrace (Figure 5).

4.1 Stratigraphy and relative age

Stratigraphic profiles were drawn, photographed, and described according to standard methods (Day 1983), including descriptions of texture, colour, and abundances of stones, roots, and mottles. Almost the entire southern, eastern, and northern edges of the terrace were exposed, revealing numerous buried soils, many of which contained artifacts and combustion features that resembled hearths. Hearths are of particular interest in archaeology, because in the past (as they are now), hearths tended to be the focus of cultural activities (cooking, tool manufacture, socializing). Buried hearths are therefore likely to contain a variety of artifacts that can indicate the types of activities taking place at the site. However, after burial, hearths are often only encountered by chance during traditional archaeological excavations (but see 4.3 Magnetometry, below, and Gibson 2017). The riverbank exposures thus provided a rare opportunity to examine several hearth features from the same site, and several of these were sampled for more detailed analyses (see 4.7 and 4.8, below).

Older deposits are usually at the bottom of a stratigraphic profile, and sediments typically get progressively younger the closer they are to the modern surface. Generally, this principle also applies to any associated artifacts or features, and to samples collected for formal dating or other analyses (e.g., radiocarbon dating, see 4.6, below). By anchoring certain stratigraphic layers with radiocarbon ages or with age estimates from diagnostic artifacts (such as projectile point styles), archaeologists can infer the relative age of adjacent or intervening layers that do not have an associated age (see Figure 6). Based on the principles of relative age, the numerous hearth features exposed in the riverbank profiles were clearly from different time periods, which made the opportunity for comparison even more intriguing (Figure 7).

4.2 Bulk sediment analyses

Bulk sediment analyses involve measurement of a number of different characteristics chosen based on specific research questions. As mentioned above, the characteristics of a sediment or soil can provide insights into how that material was deposited or formed. For example, garden composting is a cultural modification that increases the organic and phosphorus content of soil, changes that may be detectable hundreds of years after that soil has been buried. At archaeological sites, among the most common analyses for soils are pH, phosphorus, organic content, and particle size distribution (e.g., Eidt 1977; Dormaar and Beaudoin 1991; Crowther 1997; Simpson 1997; Parnell et al. 2001); these analyses were applied to selected samples collected from the two key stratigraphies at EfPk-1. Figure 8 is an example of the graphic depiction of the results from these analyses, used to interpret the site.

4.3 Magnetometry

Magnetometry is a well-known, non-destructive, and affordable method of investigating whether or not buried features are present in an area, before excavation (see also Gibson 2017). Magnetometry survey measures the Earth's magnetic field, which varies in part due to physical or chemical events taking place at or near a land surface before it becomes buried. For example, certain sediments or rocks that are heated to a specific temperature reset their magnetic orientation. As they cool, the sediments/rocks acquire new magnetic orientations that produce variations in intensity that can be measured using magnetometry. Also, the use of magnetometry can allow archaeologists to detect a soil that has been repeatedly heated to relatively high temperatures, because the iron-rich compounds within it convert and produce secondary magnetic fields through a process related to "paramagnetism". Archaeologists use magnetometry to look for buried, heated materials such as fire-broken rock, combustion features such as hearths (Gibson 1986, 2007; Tite and Mullins 1971), brick foundations, cobble floors, and metallic objects composed of iron, cobalt, or nickel-based alloys. To increase the likelihood that the excavations would result in abundant artifact recoveries, magnetometry has been used to locate possible buried hearths before determining where the excavation block should be placed.

4.4 Magnetic susceptibility

Magnetic susceptibility is related to magnetometry, in that it measures a material's response when it is exposed to a magnetic field. Among other things, magnetic susceptibility can detect signatures resulting from soil formation or

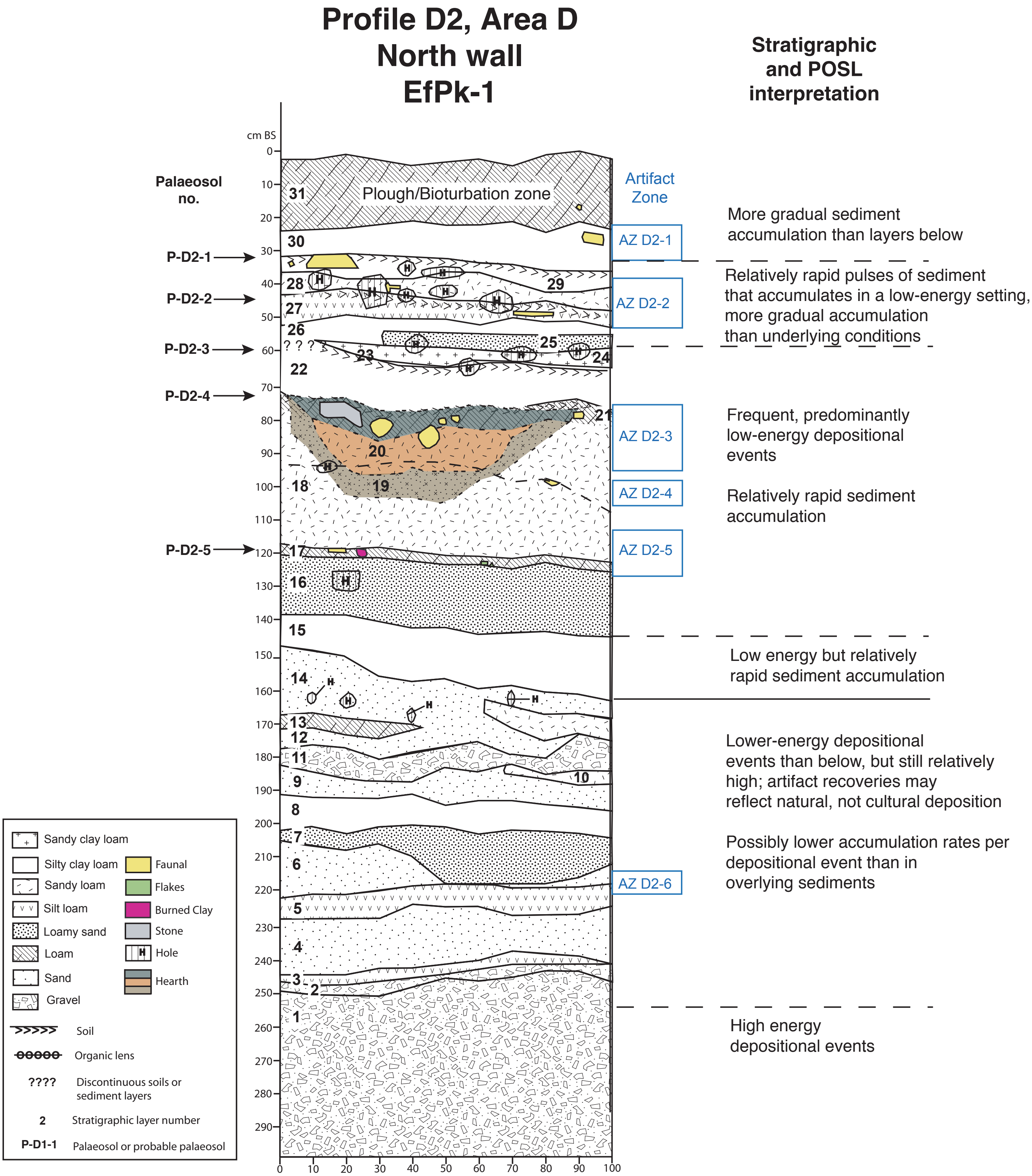

Figure 4. Schematic of stratigraphy, D2 profile, EfPk-1. From Gilliland et al. 2016:116.

Figure 5. Stratigraphy and sampling hearth-type feature for soil micromorphology, Area C profile, EfPk-1.

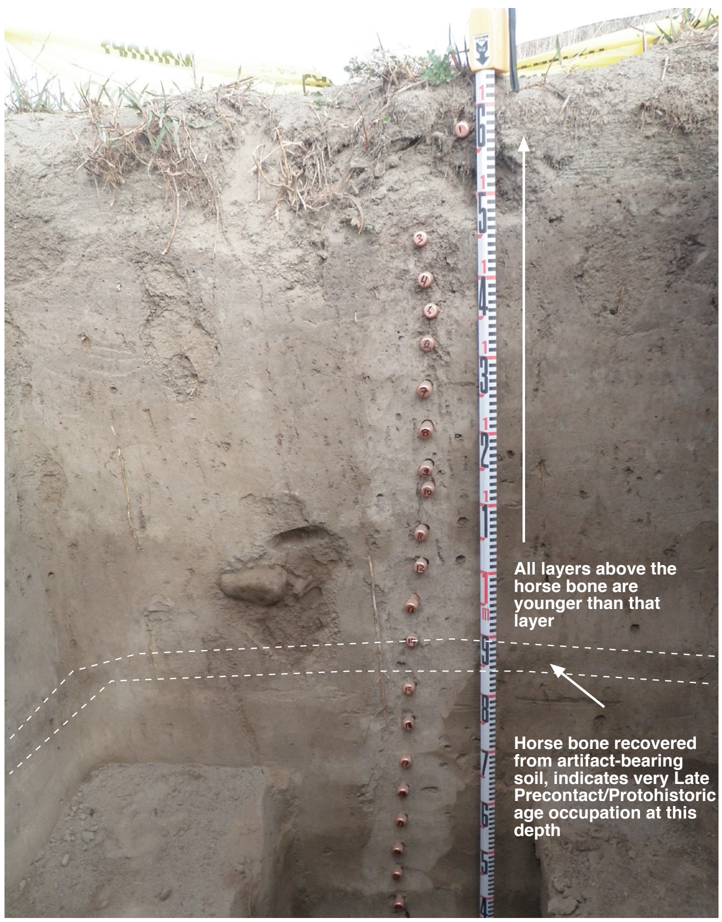

Figure 6. Stratigraphy and relative age, Unit 8/8A profile, EfPk-1. Dotted lines indicate a faint, artifact-bearing, buried soil from which a horse bone was recovered. Using the principles of relative age and stratigraphy, the bone indicates that the layer from which it was collected and all layers above it are of very Late Precontact or Protohistoric Period age and younger. The copper tubes in the wall of the stratigraphy are light-tight samples collected for portable optically-stimulated luminescence (POSL).

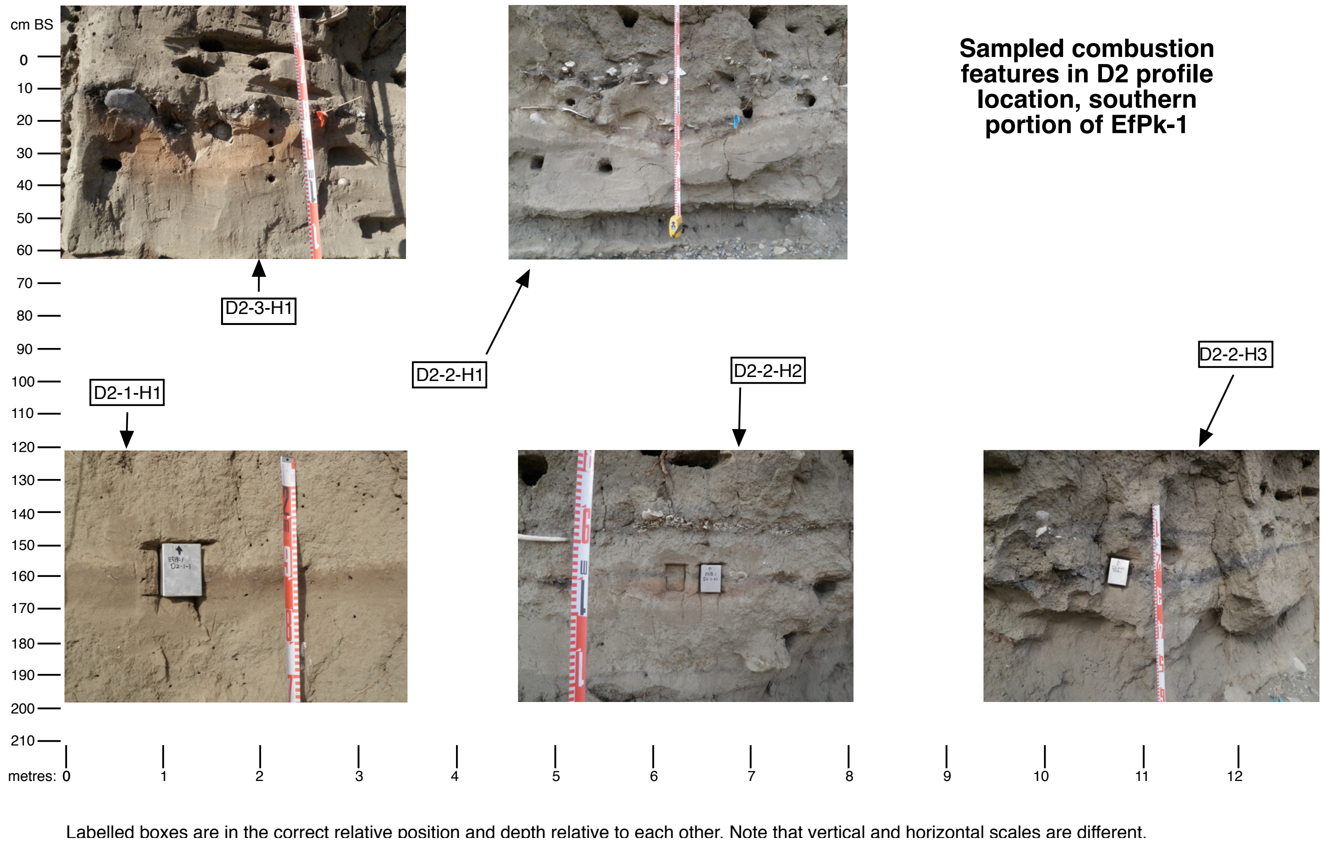

Figure 7. Hearth-type features within 12 m of the D2 profile, EfPk-1. All were sampled for soil micromorphology, bulk chemistry, and palaeoenvironmental analysis. From Gilliland and Bolton 2017:11.

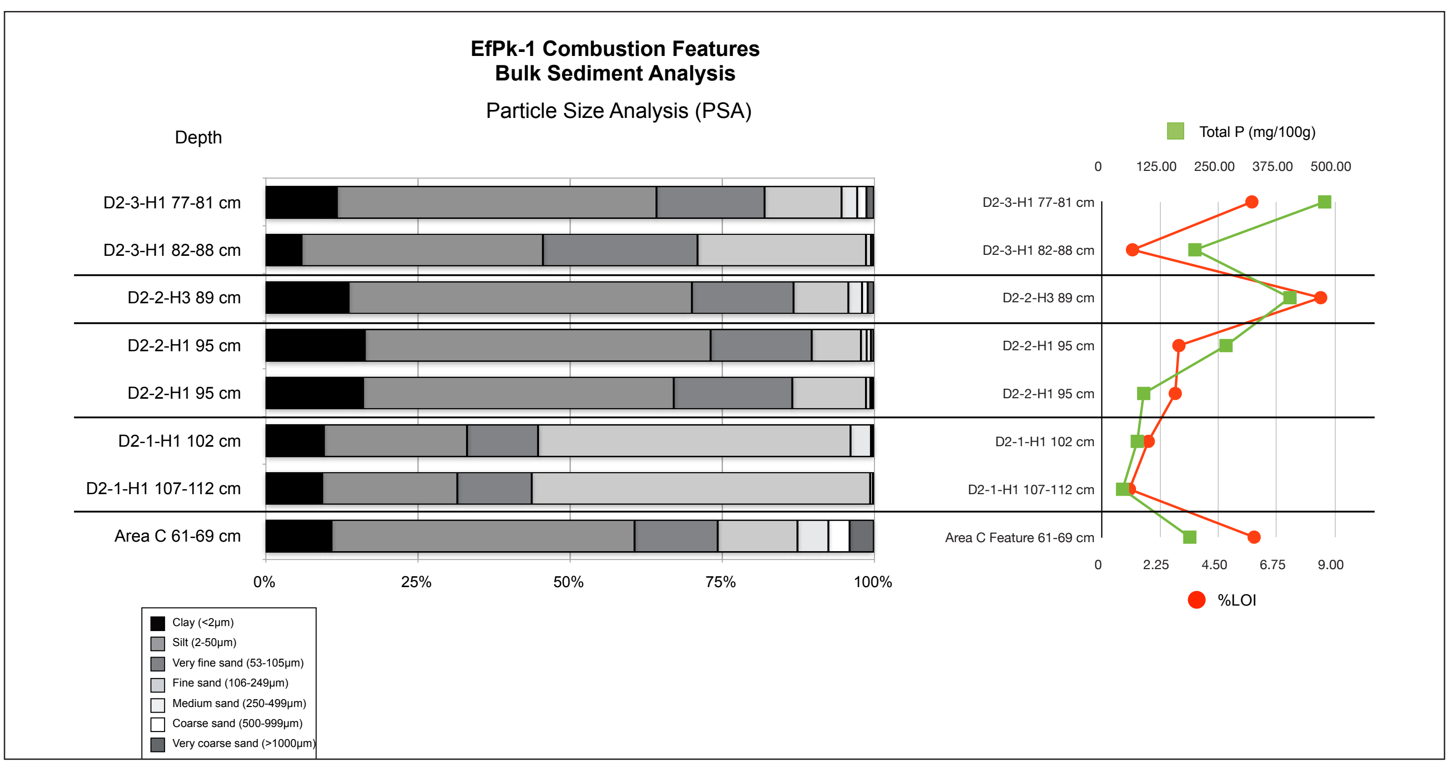

Figure 8. Particle size, total phosphorus (P), and loss-on-ignition (LOI, to estimate organic content) of five hearth-type features sampled at EfPk-1. The upper portion of Feature D2-3-H1 has the highest concentration of Total P, which suggests it may have undergone the highest intensity of cultural inputs/use. From Gilliland and Bolton 2017:28.

burning. This method is therefore useful to archaeologists who want to confirm whether or not a stratigraphic layer represents a former occupation surface associated with a hearth (Thompson and Oldfield 1986; Dearing 1999; Ketterings et al. 2000). Increased values can indicate high-intensity fires or multiple burning events. Recent developments allow rapid field measurements of magnetic susceptibility, using a hand-held instrument, such as the Terraplus handheld KT-10 meter that was used during the 2015 excavations at EfPk-1 (Figure 9).

4.5 Portable optically-stimulated luminescence

Portable optically-stimulated luminescence (POSL) is a rapid, inexpensive, field-based technique adapted from formal optically-stimulated luminescence (OSL) measurements. Formal OSL is based on the principle that, when buried, minerals such as quartz or feldspar steadily accumulate an optical signal due to natural radioactive decay taking place in the burial environment. If these buried minerals subsequently become exposed to sunlight (e.g., due to a disturbance such as a flood or wind erosion), the mineral's stored signal is released and reset to zero. Upon reburial, the signal once again begins to accumulate. Based on this principle, scientists can determine the date that sediments were last exposed to sunlight (Aitken 1998). Formal OSL measurements can be a useful method for dating archaeological sites, especially in cases where radiocarbon dating is difficult or impossible.

Portable optically-stimulated luminescence (POSL) is based on the principles of formal OSL, but it does not provide "absolute" (chronological) ages. Rather, POSL is used to obtain a wide variety of information about cultural and environmental processes operating at an archaeological site or within the wider landscape through time (Bishop et al. 2004; Sanderson and Murphy 2010). POSL can also be used to estimate "relative" age and to correlate artifact-bearing layers across a site or study area (e.g., Bateman et al. 2014). Because the method is light sensitive, special collection methods are used (see Figure 6), and samples are processed under safe light conditions. Figure 10 provides a graphic depiction of a sample of POSL data used to interpret and correlate stratigraphies at the FM Ranch Campsite.

Figure 9. Collecting in-field handheld magnetic susceptibility measurements using the KT-10. From Gilliland et al. 2016:33.

4.6 Radiocarbon measurements

Radiocarbon dating is a well-known method for obtaining ages of organic materials (e.g., bone or charcoal) at archaeological sites that are about 50,000 years old or younger. It was first invented in the late 1950s, but the application of Accelerator Mass Spectrometry (AMS) in radiocarbon dating (developed in the 1970s) allows archaeologists to date very small samples up to 1,000 times smaller than samples needed for conventional radiocarbon dating (Beta Analytic 2017; University of Arizona AMS Laboratory 2017). Radiocarbon ages do not measure cultural activity directly, but rather the time since the death of a plant or animal represented by the sample. Generally speaking therefore, the most robust ages for an archaeological site are those that are from known stratigraphic contexts, can be duplicated, demonstrate stratigraphic consistency (e.g., older ages at the bottom), and are in association with cultural artifacts or features (see Figures 11 and 12).

At EfPk-1, radiocarbon samples were collected based on the following criteria: (1) they were relatively large, (2) they were associated with buried soils, (3) they were within fine sediment layers, and (4) they were in association with other artifacts and/or cultural features such as hearths (confirmed by magnetic susceptibility; see Figure 12). These criteria increase the likelihood that the samples were not transported into the site by flooding, and that the ages resulting from analysis would be representative of cultural activity at the site. In order to provide a more complete data set, and to evaluate the temporal relationship between EfPk-1 and EfPk-2, 10 radiocarbon ages, derived from samples collected from EfPk-2 in 2013 are also presented here (Vivian 2014). Tables 2 and 3 present a summary of the results of radiocarbon dating at EfPk-1 and EfPk-2, respectively.

4.7 Soil micromorphology

Soil micromorphology is stratigraphy on a microscopic level (Figure 13). It involves field collection of undisturbed

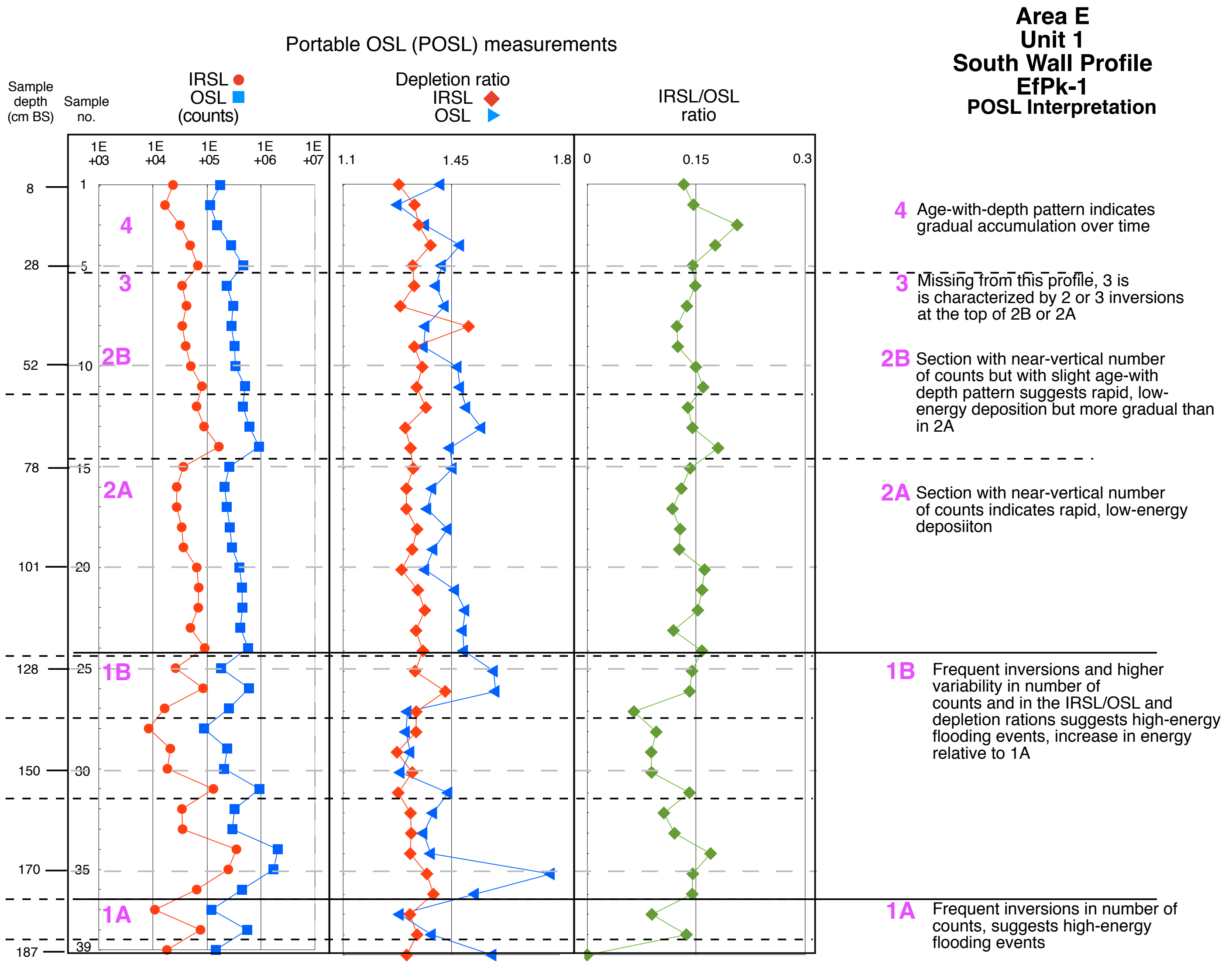

Figure 10. Example of POSL profile from Unit 1, EfPk-1, demonstrating characteristics common to most of the sampled profiles in this study. From Gilliland et al. 2016:78.

blocks of soil, which are then impregnated with resin and sliced into very thin sections that are mounted on glass to produce microscope slides. These slides are then examined under various magnifications (e.g., 25x, 40x, 100x, and 200x) and light sources (e.g., plane polarized light, oblique incident light, or under crossed polars). The method is the equivalent of examining a wristwatch that is intact, versus examining a wristwatch that has been smashed into tiny pieces, put in a plastic bag, and shaken (which is akin to bulk sampling, see 4.2, above). The intact samples provide information about how the different components of the soil fit together, how they originated, and how they function together (Kubiëna 1970). Samples are systematically described according to standard methods (Bullock et al. 1985; Stoops 2003) prior to interpretation, which is based largely on a combination of comparisons with previously published research and experience.

At EfPk-1, samples for micromorphology were collected from five hearth-type features exposed along the riverbank in the vicinity of the D2 profile at the southern end of the landform. An additional hearth-type feature was sampled from the northern part of the landform, directly over the basal cobble layer of the Area C excavations. A buried soil sample (called a control) was also obtained from the Area C stratigraphy, for comparison with the hearth samples. Table 4 provides a list of features observed in thin section and their interpretation (see Gilliland and Bolton 2017 for details).

4.8 Palaeoenvironmental analysis

Palaeoenvironmental studies provide the wider environmental context for human activity. Understanding past environments is a key aspect of understanding cultures of the past, because environments influence cultures, and vice

Figure 11. Example of bone that is unsuitable for obtaining an age for cultural activity at EfPk-1. Bone is associated with gravel and cobble layer (dashed lines) and no other associated artifacts or observable soil horizon. Suggests bone was deposited by flooding and is present as a result of fluvial, not human activity. Bone is therefore not a good sample for obtaining an age for cultural activity at EfPk-1.

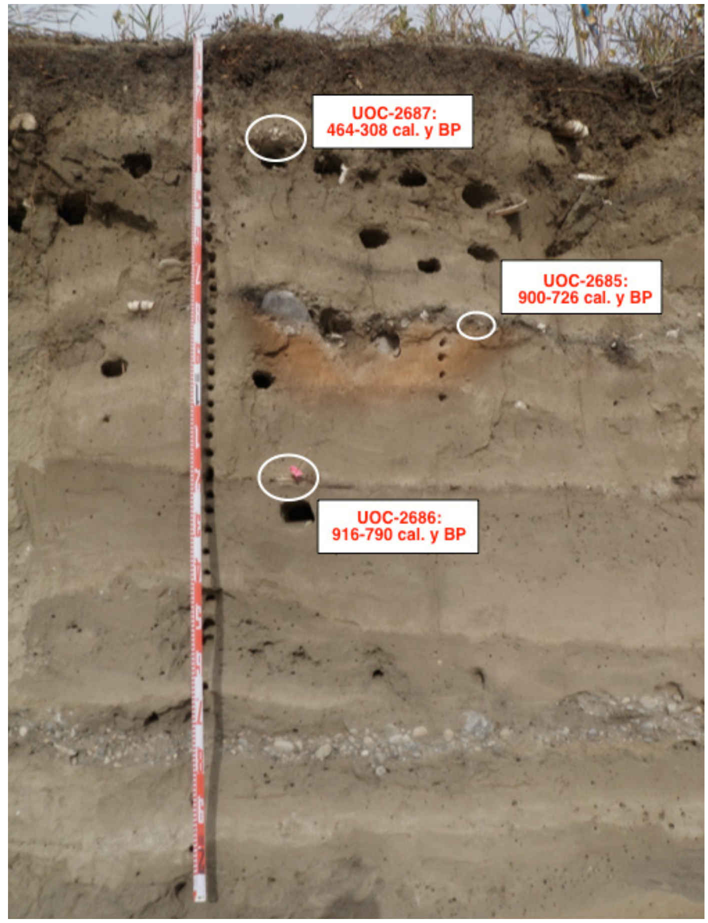

Figure 12. AMS radiocarbon ages in stratigraphic context, D2 profile, EfPk-1. All samples were collected from artifact-bearing soils developed in fine-grained sediments. From Gilliland and Bolton 2017:18.

Table 2. AMS radiocarbon ages for EfPk-1. From Gilliland and Bolton 2017:19.

UOC no.[a]	Catalog no.[b]	Profile	Depth (cm bs)	AMS ^{14}C age (BP)	2σ age range (cal yr BP)[c]	Mean (cal yr BP)	Median (cal yr BP)
			Area C				
UOC-2682	2684–2688	Area C 661N 189E	57	1237 ± 22	1263–1075	1181	1188
			Area B				
UOC-2684	4194–4195	Area B Unit 19/19A	150	1259 ± 22	1279–1098	1217	1222
UOC-2683	4150	Area B Unit 19/19A	175	1328 ± 22	1299–1186	1265	1276
			D2				
UOC-2687	3816	D2 Profile	35	328 ± 22	464–308	386	385
UOC-2685	3845	D2 Profile Feature D2-3-H1	78	866 ± 22	900–726	774	767
UOC-2686	3827	D2 Profile	115	925 ± 22	916–790	851	854

Note: All measurements conducted on bone samples collected under Archaeological Permit 15-147. Calibration conducted using OxCal 4.2 (Bronk Ramsey 2009) and the IntCal13 calibration curve (Reimer et al. 2013).

[a] Analyzed at the A.E. Lalonde AMS Laboratory at the University of Ottawa.

[b] Samples with a range of catalog numbers represent a group of bones that were physically in contact when recovered during excavation. As such, they were submitted as a group but it is assumed, since they were all of considerable size, that the laboratory chose one sample to process from each group. 2684-2688 were 5 pieces of unidentifiable ungulate bone that were each larger than 50 mm and together weighed 168.8 g. Samples 4194–4195 were two pieces of unidentifiable mammal bone that were each between 25 and 50 mm in size and together weighted 5.5 g.

[c] cal yr BP = "calendrical equivalent years before present," which in the case of radiocarbon ages is AD 1950.

Table 3. AMS radiocarbon ages for EfPk-2. From Gilliland and Bolton 2017:20. See Gilliland and Bolton (2017) or Vivian (2014) for stratigraphic and landscape contexts.

UCIAMS No.[a]	Catalog no.	Profile	Depth (cm bs)	AMS ^{14}C age (yr BP)	2σ age range (cal yr BP)	Mean (cal yr BP)	Median (cal yr BP)
Locality 1							
157173	5012	Component 1	30	305 ± 15	431–305	381	396
157174	5015	Component 2	60	860 ± 15	790–732	762	762
157189	5014	Component 2	60	890 ± 15	903–741	818	794
157175	5021	Component 4	130	900 ± 15	906–762	842	861
157188	5018	Component 4	130	910 ± 15	910–785	851	865
Locality 2							
157176	5024	Component 1	30 to 60	305 ± 15	431–305	381	396
157177	5025	Component 2	230	960 ± 15	928–798	864	852
157191	5026	Component 2	230	940 ± 15	920–796	853	849
157178	5027	Component 3	300	945 ± 15	923–796	854	849
157190	5029	Component 3	300	960 ± 15	928–798	864	852

Note: All measurements conducted on bone samples from EfPk-2 were collected under Archaeological Permit 13-248. Calibration conducted using OxCal 4.2 (Bronk Ramsey 2009) and the IntCal13 calibration curve (Reimer et al. 2013).

[a] Analyzed at the W.M. Keck Carbon Cycle AMS Laboratory at the University of California, Irvine.

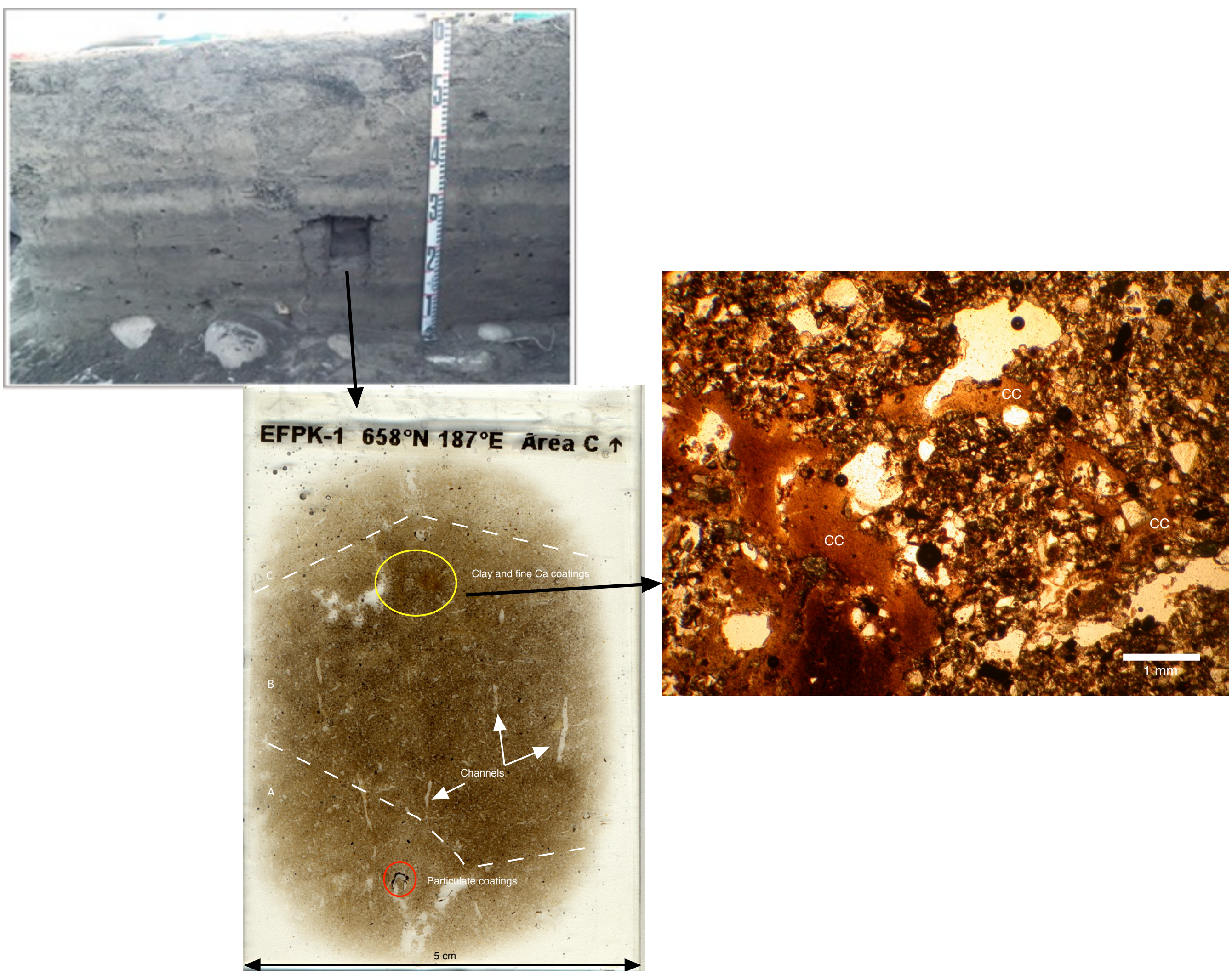

Figure 13. The link between field stratigraphy and soil micromorphology, Area C profile "control" soil, EfPk-1. Image in bottom centre is a scan of the microscope slide produced from the sample collected from the field stratigraphy (upper left). Image on right is part of the thin section (indicated with yellow circle), as viewed in plane-polarized light. cc = clay coating.

Table 4. Micromorphological indicators used as basis for interpreting samples in this study. From Gilliland and Bolton 2017:30.

Micromorphological Indicator	Type	Process
• Charcoal, charred material • Reddened grains • Brightly coloured mineral grains or sediment lenses[1] • Micritic features superimposed with organics or containing calcium carbonate pseudomorphs of prismatic oxalate crystals (ash)[2]	Burning	Cultural
• Bone fragments • Ceramics • Tabular/platy, angular lithic fragments: microdebitage[3] • Amorphous possible phosphatic features[4]	Occupation	
• Anorthic (i.e., redeposited) sediment fragments[5] • Silty pedofeatures[6] • Dark brown to black opaque particulate coatings on voids	Landscape instability	Cultural or Environmental
• Illuviation of limpid to dusty clays, Fe (Figure 13) • Increased organic content	Landscape stability, pedogenesis	Environmental
• $CaCO_3$ pedofeatures[2]	Wet/dry cycles	
• Linear/banded basic distribution[7]	Floodplain deposition	
• Excrements • Microstructure: highly vughy, crumb, channel, chamber • Silt-sized organic material integrated into groundmass • Crescentic b-fabric[7] • Compaction features • Intact and/or fresh roots	Bioturbation	

References: 1. Goldberg and Macphail (2006:59); 2. Durand et al.(2010); 3. Angelucci 2010; 4. Mallol et al 2007, Mentzer 2014; 5. Macphail and Goldberg (2010); 6. Kühn et al. (2010); 7. Stoops (2003).

versa (see section 2, above; Crumley 1994). One of the ways this relationship can be studied is through the analysis of plant (e.g., seeds, plant fragments, charcoal) or faunal macrofossils (e.g., snails, insect remains) that are separated from bulk soil or sediment samples using a wet screening method (Figure 14; Beaudoin 2007).

In this study, samples were collected from the hearth-type features in the D2 and Area C profiles, in order to obtain key palaeoenvironmental and cultural information, such as the types of plants that grew in the immediate area, what types of food or medicinal plants may have been in use, or what type of materials were used for fuel. The palaeoenvironmental samples were submitted to Dr. Alwynne Beaudoin of the Royal Alberta Museum (RAM). Mr. Matthew Bolton of the RAM subsequently processed, analyzed, and reported the results (Bolton 2017).

5. The secrets: conclusions

The results of the analyses presented above were interpreted along with the stratigraphy using an integrated approach in order to address several of the long-standing questions about the FM Ranch Campsite, including:

Figure 14. Processing palaeoenvironmental samples using wet screening method. Image courtesy Dr. Alwynne Beaudoin, Royal Alberta Museum.

1. When did people first occupy EfPk-1?

AMS radiocarbon ages for EfPk-1 indicate that the oldest occupations of the site took place at least 1,300 years ago. The oldest occupations were located along the western boundary in the northern and central portions of the landform. The two sets of radiocarbon ages, obtained for EfPk-1 and EfPk-2, support long-held assumptions that the two sites are connected and contemporaneous, but they demonstrate that the bison jump/campsite association at the southern portion of the site dates to no earlier than about 850 years ago (see Gilliland and Bolton 2017).

2. How many occupations have there been?

At least seven occupation periods are present at EfPk-1 (see Gilliland et al. 2016). However, all seven of these are not likely to be present in any one area of the site; for example, the earliest occupations of the site are not present in the southern portion of the landform (see point 1, above).

3. What is the extent of the site? Does it include the entire landform or just the southern portion next to EfPk-2 (the FM Buffalo Jump)?

Cultural deposits are present across the entire landform, indicating that people inhabited the entire area at various times. However, our data indicate that the landform most likely developed first in the north and west, and only later in the south and east. Cultural activity, therefore, took place at different areas of the landform at different times, as various portions of the terrace developed and became stable. The site thus does not represent a series of occupations that are continuously expressed across the landform.

4. What were people doing there? Did they primarily process bison kills, or were there other important activities?

Although some of the activities at the southern portion of the landform were likely associated with processing kills related to EfPk-2, our work suggests that the earliest occupations in the north were likely unrelated, and may in fact have been associated with the adjacent killsite, EfPk-5, to the west.

5.1 More questions, more answers

As the stratigraphic work at EfPk-1 proceeded, additional questions arose that were addressed in part by our detailed geoarchaeological and palaeoenvironmental work including:

5. The hearth-type features at EfPk-1 all look different—what do these differences reflect? How were these hearths used? What are their contents?

Micromorphological, palaeoenvironmental, and bulk sediment analyses of the sampled hearth-type features at EfPk-1 indicate that there is considerable variability in the use-history of these features, as summarized in Table 5 (see also Gilliland and Bolton 2017).

6. What types of fuel were used?

Wood fuel predominates, although there are variations in the species used (e.g., conifers [Pinaceae], probably including spruce [*Picea* spp.] and pine [*Pinus* spp.], and hard-

Table 5. Summary interpretation of thin section and palaeoenvironmental samples, EfPk-1. From Gilliland and Bolton 2017:47.

Sample	Interpretation Summary
Area C Soil (control) 658N 187E 32–39 cm BS	- An occupation surface but not centred on a combustion feature in this location at time of occupation. - Low abundance of indicators for cultural activity and burning. - Total P, magnetic susceptibility measurements relatively low, consistent with low artifact recoveries (Gilliland et al. 2016). - Thin section characteristics reflects postdepositional processes acting on the sediments, including soil formation and landscape disturbance, either natural (i.e., erosive flooding) or cultural (e.g., occupation of overlying soils or modern cultivation).
Area C Combustion feature 659N 187E 61–69 cm BS (F1 and F2)	- Near-complete fuel combustion, possibly due to stirring/mixing during use. - Formed *in situ,* possibly on existing occupation surface. - Late stage lithic reduction taking place in area of feature. - Conifer wood (possibly yellow pine) among that used as fuel. - Total P and magnetic susceptibility data indicate relatively intensive, possibly repeated use.
D2-1-H1 102 cm BS (F3)	- Two cultural phases, separated by either culturally or naturally deposited sediments. - May represent living surface followed by hearth activity or two episodes of hearth activity. - More cultural indicators in first (lowest) cultural phase than second. - Unburned bone predominates, suggests low to moderate heat exposure. - Charcoal size suggests feature buried relatively soon after use. - Use of twigs and possibly cherry wood (*Prunus virginiana*) for fuel. - Total P concentrations are relatively low suggests low intensity of cultural inputs into the feature.
D2-2-H1 95 cm BS (F4)	- Two cultural phases, separated by either culturally or naturally deposited sediments, possible period of abandonment. - First cultural phase may not be associated with combustion, possibly is occupation surface. - Second cultural phase appears associated with combustion and more intensive than first. - Likely represents living or activity surface followed by hearth activity. - Bone colour indicates alteration by high temperatures, although in thin section, mostly unburned bone observed. - Seeds may have been naturally or culturally introduced, and may represent fuel, food, medicinal use if cultural. - Use of wood for fuel (willow or poplar [e.g., *Salix* or *Populus* spp.], spruce [*Picea* spp.] for fuel). - Organic globules recovered from floatation sample may represent solidified tree resin from cherry or pine families(e.g., *Prunus* or Pinaceae spp.). - Amorphous material at top of thin section may represent resin or represent cooking residue/fats. - Total P concentrations suggest relatively high abundance of cultural inputs. - Magnetic susceptibility suggests relatively low intensity heating.
D2-2-H2 95 cm BS	- Two cultural phases—first is likely an occupied surface, second is a combustion feature, or could represent successive combustion events. - Relatively high magnetic susceptibility values support the interpretation that the feature represents multiple heating events. - Mixed use history: about 50% unburned bone, with the rest calcined or burned. - Wood used for fuel (*Salix* or *Populus*). - Survival of large charcoal fragments suggests lower temperature burning, or less weathering following feature use.
D2-2-H3 89 cm BS	- Interpreted as a secondary deposit of material burned at relatively low temperatures. - Fine globules likely resin. - Larger burned and calcined bone suggest possible use of bone for fuel, although wood is primary fuel source, mixture of taxa. - Floating charcoal suggests lower temperature burning. - Coniferous wood charcoal also consistent with interpretation of globular organic material as resin. - Elevated Total P concentrations suggest high intensity cultural inputs, may reflect organic residues, such as fats from cooking. - Magnetic susceptibility measurements are relatively low, supporting interpretation of low temperature combustion.
D2-3-H1 77–81 cm BS	- Interpreted as representing one cultural period of burning (although could have been used several times before abandonment). - May have been subjected to more intense, higher heat fires. - Elevated magnetic susceptibility measurements suggest high intensity heat and repeated or prolonged burning. - Denser charcoal indicates higher temperature combustion. - Bone charcoal suggests bone used as fuel, which would produce lower temperature fires. - Possibly mixed fuels used, given evidence for high temperature heat (difficult to achieve with bone fuel). - Possible phosphatic features may reflect cooking residues/fats. - Possible tree resin present. - Elevated Total P indicates abundant cultural inputs into the feature, likely associated with processing bison kill. - Thin section and palaeoenvironmental analyses suggest feature was buried rapidly, shortly after use.

Note: Description and interpretation summary based on Gilliland and Bolton (2017) and Bolton (2017).

woods such as poplar [*Populus* spp.], willow [*Salix* spp.], and cherry [*Prunus* spp.]). Bone, which would have produced lower-temperature fires than wood, was likely used as the predominant fuel type in one of the features, and in addition to wood in another (Table 5; Gilliland and Bolton 2017).

5.2 Secrets remain

Although our 2015 work has addressed many of the long-standing questions about EfPk-1, it has also resulted in more questions about the site's occupation history that could direct future studies. These questions include:

1. What is the relationship between the northern portion of EfPk-1 and the adjacent killsite EfPk-5?
2. What is the relationship between EfPk-5 and EfPk-2? Was the EfPk-5 area abandoned when EfPk-2 started to be in use 850 years ago?
3. EfPk-1 is located on a terrace that developed and changed over time. How did this evolution relate to the timing of occupation of the different parts of the site?
4. Excavations in the oldest, central portion of EfPk-1 in 2015 ended at 2 metres below surface, but did not encounter basal cobbles at that point. Are older occupations present at the site in this location?

5.3 Further work

Our work is an example of a project that integrates a science-based, stratigraphic approach with archaeological investigations to produce meaningful, robust interpretations of cultural and environmental processes. However, as with all science, the results from these analyses must continually be re-evaluated and developed to further understandings of the past. In Canada, science-based investigations at archaeological sites tend to be under-represented in the literature, particularly within the subfield of cultural resources management (CRM), so there are many opportunities for further work in this area. The following are suggestions for best practices and future research that could address key archaeological issues, not only those that remain at the FM Ranch Campsite, but those that apply more broadly to studies in Canada and in CRM:

1. Ensure effective expenditures of resources allocated to building site chronologies. Systematically document the stratigraphic context of sites and collected samples, particularly those submitted for radiocarbon or other chronometric dating. Ensure that, chronometric ages obtained for sites are interpreted within stratigraphic contexts, or at least are tangibly connected to the main report in which the stratigraphy is illustrated.
2. Experiment, collaborate, and publish. Our work at EfPk-1 is among several studies that demonstrate the usefulness and relative affordability of analyses such as phosphorus content, magnetic susceptibility, and POSL in archaeology. However, there are relatively few studies that focus on these analyses within the context of ancestral First Nations sites. This is due, in part, to the lack of field opportunities and resource availability—problems that could be addressed through collaborations between CRM and university-based archaeologists and community groups. These collaborations could focus on conducting experimental archaeological studies that explore and evaluate science-based methods in relation to different cultural practices and depositional processes. For example, research could address how variations in magnetic susceptibility measurements relate to heat intensity or repeated hearth use on the Canadian plains or in the boreal forest. The results of these studies should be reported in accessible, peer-reviewed publications, or other online, open-source media.
3. Continue to develop existing methods. Although this study has demonstrated that methods such as magnetometry survey can be successful in detecting buried features as a means to target areas for archaeological excavation, the method has limitations. One of the primary limitations, from an archaeological perspective, is that it is able to detect features within a single depth range. Gibson (2017) is addressing this limitation through the development of a magnetometer that can detect features at multiple depths. This equipment has the potential to improve precision and increase the applicability of magnetometry, while maintaining affordability.

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