

Withering Snow and Ice in the Mid-latitudes: A New Archaeological and Paleobiological Record for the Rocky Mountain Region

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ABSTRACT. In the mid-latitude mountains of North America, archaeological materials have been identified in association with kinetically stable “ice patches” that attracted animals and their human predators. The stable ice in these features exhibits little internal deformation or movement and can preserve otherwise perishable materials for millennia. Eight prehistoric sites have been identified in association with perennial ice patches within the Greater Yellowstone Area of Montana and Wyoming. Surveys in Colorado have produced paleobiological samples, but no definitive archaeological sites. Archaeological remains include ancient wooden dart shafts and fragments, wooden artifacts of unknown function, a wrapped leather object of unknown function, butchered animal remains, and chipped stone artifacts. Fragments of weapons ranging in age from 200 to 10 400 years suggest long-term continuity in ice patch hunting in the region. Paleobiological specimens range in age from several hundred to nearly 8 000 years. Bighorn sheep (*Ovis canadensis*) is a presumed prey species, but the remains of bison (*Bison bison*) and other large ungulates also occur. Ice patches offer important insights into the use of high-elevation environments by Native Americans. Efforts are ongoing to build and maintain awareness of these resources among federal land managers and the public.

Key words: climate change, ice patches, organic artifacts, dart shaft, foreshaft, bighorn sheep, bison, Rocky Mountains

RÉSUMÉ. Dans les montagnes de latitude moyenne de l’Amérique du Nord, du matériel archéologique a été repéré dans des « névés » cinétiquement stables où évoluaient certains animaux de même que leurs prédateurs humains. La glace stable de ces névés présente une déformation ou un mouvement interne minime, ce qui permet de préserver des matériaux périssables pendant des milliers d’années. Huit sites préhistoriques ont été répertoriés dans les névés pérennes de la grande région du Yellowstone se trouvant au Montana et au Wyoming. Au Colorado, des levés ont permis de prélever des échantillons paléobiologiques, mais aucun site archéologique définitif. Parmi les restes archéologiques retrouvés, notons d’anciennes tiges et d’anciens fragments de propulseurs en bois, des artefacts en bois dont la fonction est inconnue, un objet enveloppé en cuir dont la fonction est inconnue, des restes d’animaux dépecés et des artefacts en pierre taillée. Des fragments d’armes âgés de 200 à 10 400 ans laissent entrevoir que la chasse a été pratiquée dans les névés de la région pendant très longtemps. L’âge des spécimens paléobiologiques varie de plusieurs centaines d’années à près de 8 000 ans. Le mouflon d’Amérique (*Ovis canadensis*) y est une espèce-proie présumée, et des restes de bisons (*Bison bison*) et d’autres grands ongulés s’y trouvent également. Les névés permettent de mieux comprendre comment les Autochtones utilisaient les milieux en haute altitude. Les responsables fédéraux de la gestion des terres et le public déploient des efforts constants pour sensibiliser les gens à ces ressources.

Mots clés : changement climatique, névés, artefacts organiques, tige de propulseur, préhampe, mouflon d’Amérique, bison, montagnes rocheuses

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INTRODUCTION

In recent decades, archaeological and paleobiological materials have been identified in association with thinning and retreating perennial snow and ice patches in the mid-latitude Rocky Mountains of North America, in areas of Colorado, Montana, and Wyoming (e.g., Lee et al., 2006; Lee, 2010, 2011). This report focuses on the results of a composite survey of ice patches within the Greater Yellowstone Ecosystem (GYE) on the Custer, Gallatin, and Shoshone National Forests and in Yellowstone National

Park (Fig. 1). Surveys began in 2006 and are ongoing; however, heavy snow cover during the September 2008, 2009, and 2011 survey windows precluded physical observation of most areas where ancient core ice might be present. At this juncture, it appears that precipitation in late winter and early spring is the principal factor in defining productive versus unproductive research years.

In the Yellowstone region, as in other alpine areas, mountain glaciers appear to be retreating (Seifert et al., 2009). Specific glaciers studied by the Beartooth Climate Change Project (BCCP) suggest that thinning is universal,

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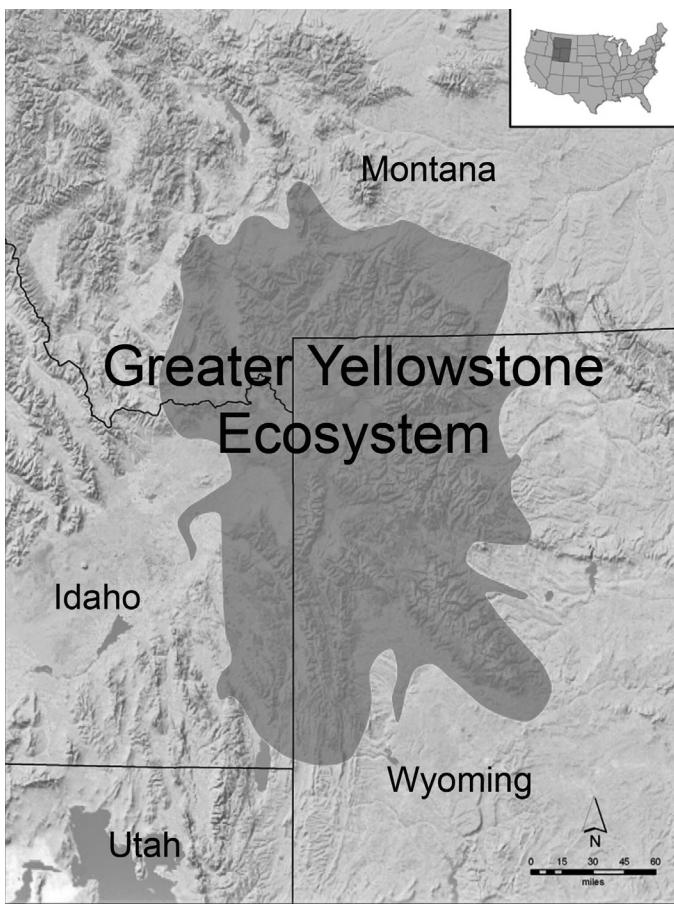


FIG. 1. Overview of core research area centered on the Greater Yellowstone Ecosystem. Map: Joshua M. Robino.

but rates are variable, ranging between 0.1 and 2.5 m per year during the period from 1952 to 2003 (Seifert et al., 2009:3–5). This rate equates to nearly 60 m of thinning in some locations. In concert with data on reduction in areal extent, which has been observed to be as high as 50% at some glaciers (Seifert et al., 2009: Fig. 2), this change serves as an imperfect proxy for melting at snow and ice patches.

Ice patches “breathe” at a different rate than glaciers, and their extent and thickness can be dramatically altered by major snowfall events. The effect of these events on core, ancient ice in the mid-latitudes is unevaluated. A comparison of historical minimum ice patch extents (MIPE) for two test locations within the GYE between the years 1932 and 2003 reveals that, relative to their averages, ice patches have experienced dramatic melting at certain points—notably 1932, 1987, and 1994 (Lee et al., 2009: Fig. 3). MIPE can help researchers to focus field inventory toward ice patches where newly exposed materials might be expected and avoid trips to other ice patches when the snowfield boundary exceeds the historical minimum (Lee et al., 2009). This selection technique is most effective if previous surveys have examined the forefield area of a given ice patch for artifacts in past high-melt years. Research in Colorado has shown that temperatures rarely drop below freezing

beneath high-altitude snowbanks, and organic matter is subject to decomposition for much of the year (Holtmeier, 2003:81). Thus, artifacts will disintegrate quickly after they melt free of protective ice, even when reburied by subsequent snowfalls.

ICE PATCH IDENTIFICATION AND SURVEY

High elevation (tree line and above) sites in the GYE indicate a variety of cultural activities ranging from provisioning to ceremonial fasting or vision-seeking (Lahren et al., 2002; Lahren, 2006; Adams, 2010; Scheiber and Finley, 2010). Recently available documentation and artifacts collected by the late Vern Waples indicate a continual (if likely seasonal) human presence in high-elevation areas of the northern GYE since the late Paleoindian period (Anon., 2006).

Ice patch sites are a largely unrecognized component of the alpine archaeological record. Artifacts are most frequently encountered along the downslope margin of ice patches and in the off-ice area immediately below the ice patch—the forefield. Artifacts collect here as they slide off the ice, are transported by fluvial action, or both. If an ice patch has a large, relatively low-slope surface, artifacts can be found directly on the ice surface (see 48PA3147 below, as well as Hare et al., 2004; Dixon et al., 2005). In these instances, artifacts may be in association with thick aggregates of animal dung that form as lag deposits when droppings become concentrated following periods of melting. Given the preponderance of hunting implements found in association with these features, it is likely that cyclical congregations of prey were the attraction bringing human hunters to the ice patches.

While no ethnographic record of ice patch hunting has been identified for the GYE, the intersection of people and prey at ice patches can be grounded in a Saami hunting ethnography (Ryd, 2010). In northern Sweden, reindeer escape parasitic flies by going to snow patches. The cold air associated with snow patches interferes with the parasitic flies’ ability to reach the reindeer. If the reindeer can hear insects buzzing off-ice, they are often unwilling to leave the snow patch even when confronted by human hunters. Consequently, Saami can routinely approach and harvest reindeer at these locations. Ion and Kershaw (1989) have noted similar caribou behavior in the Northwest Territories, and Andrews et al. (2012a) have demonstrated overlap between the summer movement of radio-collared caribou and ancient ice patch hunting stands.

Other sources indicate that permanent snow patches were used for other purposes besides taking big game. For example, Kusugak (2002) notes that for Inuit, permanent snow patches are a favorite source of water for tea, and VanderHoek et al. (2007) and Andrews et al. (2012b) suggest that small game (e.g., ground squirrels) can be harvested near these features. It is the loss of tools and discard of other items in their context of use that make the ice patch

phenomenon so remarkable. Ice patches afford archaeologists and Native people the opportunity to view complete hunting systems, including the oft-missing organic element, in the systemic context in which they functioned, as opposed to the inorganic and fragmented remnants that are the usual grist of archaeological assemblages in other contexts.

The exact number of ice patches present in the GYE is unknown; however, Fountain's (2009) review of USGS maps suggests a minimum of 400 glaciers and perennial snowfields in the Montana portion of the Beartooth and Absaroka mountain ranges alone. Depending on parameters for minimum size and proximity, this number could easily be doubled. These features range in elevation from 2639 m to 3713 m (Fountain, 2009), with overflights and map observations suggesting they vary widely in areal extent depending on seasonal conditions. Some historically mapped features appearing to possess archaeological potential have completely disappeared during high-melt years like 2007. This finding, which is consistent with those of the BCCP, suggests that ice patch resources are indeed threatened.

Several factors appear to influence an ice patch's potential to contain archaeological material: 1) relative isolation of ice patches from one another, which seems to concentrate activity toward a given location; 2) proximity to lower-elevation, ice patch-free country; and 3) relative ease of access, such as proximity to human and animal travel corridors (passes). Depending on the degree of melt and local conditions, in some years ice patches can appear to have a black halo, particularly on their downslope sides, that is due to organic material (e.g., animal feces and windblown plant matter) sloughing off the surface.

In the GYE, the ice patch identification process involves using virtual globes (VG) and other sources of publicly available satellite and aerial imagery to scan a given area of snow and ice that exhibits the characteristics outlined above. VGs such as Google Earth (earth.google.com) and NASA's World Wind (worldwind.arc.nasa.gov) play a significant role in this endeavor; however, other online utilities like Flash Earth (flashearth.com) and proprietary imagery are invaluable. VGs can easily manipulate complex geospatial data in three dimensions to maximize topographic relief and to focus on the northeast-facing exposures where ice patches persist at this latitude. Most of the ice patches surveyed in the GYE are in areas managed as wilderness; access has been limited to aerial reconnaissance and pedestrian travel.

As of the close of the last season of productive survey (2010), more than 50 high-potential ice patches had been surveyed for archaeological materials. Given the temporally narrow survey window and relatively high cost associated with pedestrian access, it is prudent to concentrate resources on areas that seem to have the highest probability of exposing archaeological materials. GYE surveys have not focused on low-potential ice patches that do not conform to the criteria identified above.

SITES AND ARTIFACTS

This paper provides an overview of the extent and nature of the archaeological and paleobiological material being recovered in association with ice patches in the Rocky Mountains. The focus is primarily on the GYE. Because of the high population density in areas surrounding the GYE and the accessibility of these ice patches relative to those in more northern areas, we do not provide physiographic place names. The recovered artifacts represent the heritage of Native American peoples. The artifacts are treated with care, and most collected materials from the GYE will be accessioned at the Billings Curation Center (BCC) in Billings, Montana, under accession number BCC-0727. Artifacts collected in Yellowstone are curated with the park under YELL-2522.

Although artifacts are occasionally found on glaciers, they are primarily recovered at smaller, perennial snow and ice features, or "ice patches," that persist in many mountainous regions as a result of seasonal accumulations of windblown snow. Ice patches are not massive enough to become glaciers, although snow in these locations can eventually turn into ice through the process of nivation. The term "ice patch" as used here does not refer to the highest-elevation snow and ice that occur along jagged arêtes thousands of feet above the timberline; rather, it refers to permanent snow and ice at the lowest elevations.

Eight prehistoric sites have been identified in association with perennial ice patches within the Greater Yellowstone area of Montana and Wyoming. These include two sites with chipped stone artifacts in close association with ice patches, and six ice patch sites with ancient organic artifacts. Of the latter, five of the sites produced only a single organic artifact. One of these five locations melted out completely in 2006; the other four retain substantial snow and ice. The sixth site with organic artifacts comprises two distinct but proximate ice patches with artifacts. (In some early conference presentations, I referred to this location as two distinct sites, but I have since combined them and refer here to the two areas as loci within a single site.) One locus yielded a single wood artifact, and the second contained 15 wood or bone artifacts. Substantial snow and ice remain at the second locus.

24CB2047

Archaeological site 24CB2047 lies above the modern tree line at an elevation of 3219 m (10 561 feet) above modern sea level (amsl) on a slightly sloping, alpine-vegetated surface about 25 m from a small ice patch. Notable artifacts include a unifacial scraper made from Tongue River Silicified Sediment (TRSS) and a biface midsection made from an indistinct tan chert (chipped stone artifacts were left on site). Artifacts appear to be associated with the ice patch as well as a meltwater fen. The TRSS is not local, and the nearest abundant outcrop is ca. 350 miles to the east (Porter,

1962; Ahler, 1977; Keyser and Fagan, 1987). Its presence at the site illustrates an ancient connection between Native American groups accessing this ice patch and those groups accessing the TRSS source areas in what is now present-day northwestern South Dakota. A bighorn sheep radius was also found nearby. The association of the artifacts with the ice patch is suggestive of a small lithic scatter that might result from a kill episode on an ice patch and subsequent butchering near the water.

When the site was first visited in late August 2006, the entire surface of the ice patch was actively melting and covered with a thin veneer of organic material cut by rivulets of running water coursing off the surface. Two tree stumps rooted in their growth position were discovered in the downhill edge of the melting ice (Lee, 2007, 2008). The trees were at least 30 cm in diameter and clearly distinct from the krummholz forms that dominate at the tree line in the region today. Because the trees were found at the beginning of a multi-year archaeological survey of melting perennial snow and ice patches and their significance was uncertain, sections of the remaining outer growth rings from the trees were collected for radiocarbon dating (24CB2047.1 and 24CB2047.2). Subsequent years of survey in the GYE and elsewhere revealed that trees and other paleobiological specimens are frequently encountered at or above the modern tree line in ice patches in the Rocky Mountains (e.g., Benedict et al., 2008; Lee, 2008, 2011; Lee and Benedict, 2012). The paleobiological sites appear to overlap with the lowest elevations where permanent snow and ice exist today.

Both trees at site 24CB2047 were identified as spruce (*Picea engelmannii*) (Lukas, 2008). Fortunately, an independent survey dedicated to modeling the biophysical setting of deadwood above the tree line in the immediate vicinity of the site (Bunn et al., 2004) revealed whitebark pine (*Picea albicaulis*) to be the current species growing at the timberline. Currently, the tree line is drawn below 9800 feet (2987 m) on USGS topographic quads, but recent aerial photography suggests that it is moving up. The two trees returned remarkably concordant radiocarbon ages that, when calibrated, suggest they died between 8718 and 8945 calendar years ago (Table 1). Their demise may have followed the end of the Holocene thermal maximum (e.g., Clague and Mathewes, 1989), when the niche in which they were living became less habitable. Carrara's (2011) work with tree remains recovered from a tarn in the northern San Juan Mountains of Colorado and Benedict's (2011) work with the remains of ectomycorrhizal sclerotia in the tundra uplands of the Colorado Front Range suggest that between 10 400 and 6200 cal BP, the tree line in the Rocky Mountains was approximately 80 m to 150 m (150 feet to 500 feet) higher than at present. Both of the tree stumps at 24CB2047 are extremely weathered, consistent with Decay Class 5 (bark absent, log sapwood layers heavily flaked and easy to remove, log circumference flattened) or Class 6 (little structural integrity from outside to inside of log, but wood still present) as established by Brown et al. (1998). Weathering

of this nature suggests significant cumulative exposure of the trees in the past.

24CB2174

Site 24CB2174 lies on a plateau well above modern tree line at 3255 m (10 680 feet) amsl. This elevation puts it above the higher early and middle Holocene tree lines described by Carrara (2011) and Benedict (2011). The wooden artifact fragment recovered at this location (24CB2174.1) is of uncertain function, but given the complete absence of other wood at this ice patch, it is almost certainly a manuport. The flat ring profile suggests that the artifact was made from stave-cut wood taken from the outer portion of a large timber pine tree (cf. *Pinus albicaulis*) that was more than 100 years old (Lukas, 2008). It was radiocarbon-dated to ca. 6200 cal BP (Table 1). The artifact appears to be broken; only a 25 cm long portion was recovered. It is uniformly tapered from a maximum dimension of ca. 30 mm near the mid-point of the long axis to a beveled end. It appears to have been cut to achieve this morphology; however, there is no clear indication of how this was accomplished. The area of the GYE in which the site is located is characterized by several plateaus that are amenable to cross-country travel, and the artifact may represent the remains of a walking stick (Fig. 2). It may also be a remnant of a "digging stick." An artifact of a similar morphology and assigned function was recovered at Mummy Cave in northwestern Wyoming (Husted and Edgar, 2002: Plate 30d).

24CB2175

An artifact recovered at site 24CB2175, located higher up on the same plateau at 3414 m (11 200 feet) amsl, was not immediately recognized as a human-made implement (24CB2175.1). It was collected primarily because it was an anomalous piece of wood recovered at an ice patch well above the elevation of other ice patches visited in the GYE. The subsequent recovery of artifacts at site 48PA3147 (see discussion below) suggests that the 24CB2175 artifact is a shaft fragment of either an arrow or a dart, although it bears no obvious cultural markings other than its morphology. The location where it was recovered is simply too high for the wood to have grown in situ. No other wood was observed at the ice patch, which strongly suggests that the recovered fragments were brought onto the site. The artifact dates to ca. 1300 cal BP (Table 1) and is made from a pine sapling (cf. *Pinus albicaulis*) (Lukas, 2008) trimmed of its branches. It is weathered and warped by moisture and bears the imprint of a hoof, which suggests that it was trampled by an animal while saturated (wet) (Fig. 3). Such trampling is consistent with the location's presumed attraction for animals. The shaft is 10 to 11 mm wide and roughly contemporary with the widespread adoption of bow-and-arrow technology around 1400 cal BP (Frison, 1991; Husted and Edgar, 2002). Site 24CB2175 lies within one of three geographic areas that the BCCP analyzed extensively using

TABLE 1. Radiocarbon determinations on organic artifacts and paleobiological samples recovered in the Greater Yellowstone Area.

Site and artifact number	Sample description	^{14}C Age BP ¹	$\delta^{13}\text{C}$	Cal BP ages $2\sigma p = \geq .05$	Relative probabilities for age ranges	Mean of calibrated age ranges (cal BP)	Lab number	Figure
Organic artifacts:								
24CB2174.1	stave-cut, tapered shaft	5370 ± 15	-22.8‰	6118–6150 6177–6217 6236–6274	0.18 0.53 0.27	6134 6197 6255	CURL-8846	2
24CB2175.1 24CB2246.1	sapling, shaft fragment stave-cut shaft fragment	1393 ± 30 215 ± 20	-22.0‰ -26.3‰	1279–1348 149–187 270–303	1.00 0.49 0.39	1314 168 287	NZA-32326 CURL-9656	3 4
24CB2247.1	sapling, shaft fragment	4380 ± 20	-24.2‰	4866–4977 5013–5034	0.92 0.08	4922	CURL-13524	no photo
GHG1.1 48PA3147.1.2	plaited leather and bark sapling, complete dart foreshaft	1495 ± 20 9230 ± 25	-21.7‰ -23.0‰	1334–1410 10281–10497	1.00 0.08	1372 10389	CURL-13529 CURL-9635	5 7
48PA3147.7	sapling, shaft fragment with ownership marks	6695 ± 20	-19.8‰	7511–7542 7558–7595	0.32 0.66	7527	CURL-9640	8A, 9
48PA3147.8	sapling, beveled shaft fragment	6560 ± 40	-26.3‰	7422–7516	0.91	7469	NZA-32328	8B
48PA3147.14	burned wood	4115 ± 20	-25.5‰	7536–7562 4529–4652	0.10 0.60	7549 4591	CURL-11683	no photo
48PA3147.9	sapling, foreshaft fragment	3985 ± 20	-27.4‰	4669–4703 4758–4809	0.13 0.27	4686 4784	CURL-11673	no photo
48PA3147.5 48PA3147.15	spirally fractured, cut marked bone stave-cut, tapered shaft	2210 ± 25 1710 ± 20	-19.7‰ -25.1‰	2151–2318 1552–1637 1646–1694	1.00 0.67 0.33	4433 4492 1595	NZA-32961 CURL-11664	10 no photo
48PA3147.1	sapling, shaft fragment	1169 ± 30	-26.7‰	984–1033 1049–1174	0.18 0.82	1670 1009 1112	NZA-32327	6
Paleobiological samples:								
24CB2047.1	rooted tree	7935 ± 15	-18.6‰	8643–8792 8820–8865	0.70 0.13	8718 8847	CURL-8843	no photo
24CB2047.2	rooted tree	7955 ± 15	-19.3‰	8915–8974 8716–8816 8823–8979	0.14 0.33 0.65	8945 8766 8901	CURL-8845	no photo
48YE1537	wood fragment	640 ± 15	-22.8‰	560–598 632–661	0.60 0.40	579 647	CURL-10167	no photo

¹ Dates are by accelerator mass spectrometry. Calibrations were done with CALIB 6.0 using the IntCal09 calibration curve and are presented as years before present (1950) (<http://intcal.qub.ac.uk/calib/>).



FIG. 2. Two views of stave-cut wood specimen (24CB2174.1). Photographs: Tara L. Hornung.

remote sensing data (Lee et al., 2009). The location appears to have melted out on occasion in the past, and it was relatively free of snow and ice in 2006, when the artifact was collected.

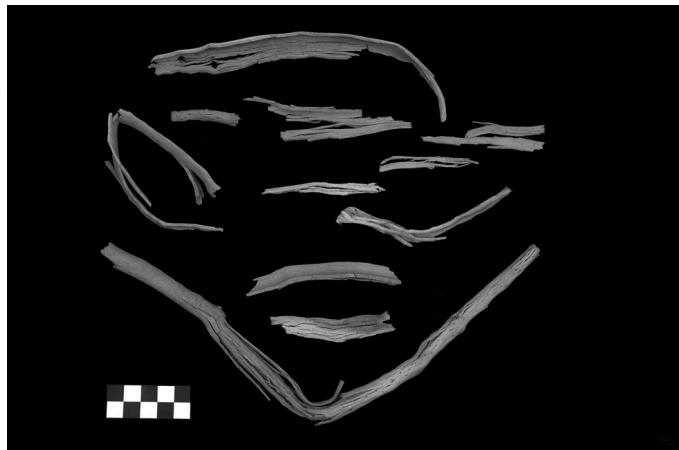


FIG. 3. Shaft fragments (24CB2175.1). Photograph: Tara L. Hornung.

24CB2246

The ice patch associated with site 24CB2246, at ca. 0.5 km (1800 feet) long, is the largest surveyed in the GYE. Its elevation is approximately 3180 m (10 424 feet) amsl. Although no prehistoric archaeological materials were recovered at this location during the first two seasons of fieldwork, the feature was suspected to have archaeological potential because numerous historic beer cans with well-preserved lithography were present in portions of the forefield. Late in 2007, a broken fragment of a stave-cut piece of wood (24CB2246.1) was recovered from the forefield of this ice patch (Fig. 4). The wood was identified as birch (*Betula* spp.) (Lukas, 2008) and radiocarbon-dated to ca. 225 cal BP. The ring profile is flat, suggesting that the stave was removed from a large tree. The cut stave was shaped and smoothed to create a round shaft in a process likely similar to the manufacture of stave-cut arrow shafts recovered in Alaska and elsewhere (e.g., Dixon et al., 2005). The presumed shaft fragment measures 97 mm long and tapers from a diameter of 13 mm to 10 mm. Its relative diameter is more consistent with dart than arrow technology; however, that interpretation is inconsistent with the general chronology for the introduction of the bow and arrow, as noted above. Consequently, the shaft fragment may represent a different kind of artifact altogether. It is heavily damaged (broken) on the proximal (non-tapering) end.

24CB2247

At 3090 m (10 137 feet) amsl, site 24CB2247 is the lowest-elevation ice patch in which an organic artifact has been recovered in the GYE. Although we noted the existence of this ice patch from a distance during previous years of survey, it appeared to be in a gully that would flush artifacts away. Consequently, we did not prioritize survey at this location until 2010. The ice patch is actually perched on a small bench immediately above the gully, and it appears to be relatively stable. A subsequent review of remote sensing data examined by the BCCP (Lee et al., 2009) revealed



FIG. 4. Two views of stave-cut wood shaft fragment (24CB2246.1). Photographs: Tara L. Hornung.

the location has probably held snow and ice continuously over the last 70+ years. In 2010, we recovered a shaft-like piece of wood lying in an area of organic-rich lag along the recently exposed lateral margin of the ice patch. That shaft is made on a sapling trimmed of its branches and was radiocarbon-dated to 4922 cal. BP. It appears to have a purposefully cut end, which may have functioned as a scarf joint to attach the recovered piece to another portion of a composite tool.

GHG1

This artifact may represent the first ice patch artifact recovered in the GYE. It was collected by hikers in the late summer of 1990 and kept in their freezer until 2010, when it was given to the author. The artifact is composed primarily



FIG. 5. Plaited leather and bark artifact (GHG1.1). Photograph: Nicholas L. Jarman.

of plaited or twisted (not braided) leather partially covered with a coiled, blackish wrapping of organic material that may be bark from a chokecherry tree (*Prunus virginiana*) (Fig. 5). Chokecherry bark blackens as it ages (Crowder et al., 2004), and it is used for ornamental purposes by Native Americans (Thomas Roll, pers. comm. 2011). The artifact was collected on “melting snow” in the vicinity of a glacier that has been analyzed with repeat aerial photography by Dr. Edward Chatelain, Valdosta State University, Georgia (pers. comm. 2010). We examined the purported location where the artifact was found in 2010, and it appears the permanent snow and ice features in the area have undergone a significant decrease in snow and ice since the 1950s. The artifact was radiocarbon-dated to ca. 1372 cal BP, and it is being kept in a freezer at the BCC pending tissue analysis.

48PA3147

Site 48PA3147 is the most extensive in terms of the number, variety, and age of recovered organic artifacts. The site lies at an average elevation of 3136 m (10 290 feet) amsl and comprises two distinct ice patches with artifacts ranging in age from 1000 to 10 400 years. The first locus contained a single organic artifact and the second had 15 wood or bone artifacts (see Table 1 for a complete list of radiocarbon-dated artifacts from this site). The artifact recovered at the first locus (48PA3147.1) is a shaft fragment radiocarbon-dated to ca. 1000 cal BP (Table 1). It is made of a sapling identified as birch (*Betula* spp.; Lukas, 2008); it is trimmed of its branches and is 24 cm long and 13 mm wide (Fig. 6). The artifact is straight and appears well preserved despite being broken. It is consistent in size with other shaft fragments recovered in the adjacent ice patch. When this ice patch was first surveyed in 2007, the entire surface was covered in a mat 10–20 cm thick of decomposing organic material composed of bison and bighorn sheep dung, as well as carcass parts and hair. The smell of decay was overwhelming and reminiscent of the strong ammonia stench common at swine feedlots. Subsequent major snowfall in the spring of 2008 has precluded additional substantive survey.

Substantial snow and ice remain at the second locus, where the oldest ice patch artifact in the world was



FIG. 6. Two views of shaft fragment (48PA3147.1). Photographs: Tara L. Hornung.

recovered in 2007 (Lee, 2010). Artifact 48PA3147.12 is a presumed dart foreshaft that dates to ca. 10 400 cal BP (Lee, 2010). This foreshaft is extremely long (107 cm) compared to younger examples (e.g., Tuohy, 1982). Lee (2010) cites Harrington's Gypsum Cave material as an example of a short(er) main shaft or shaftment that might have worked with such a long foreshaft. Knowledgeable colleagues have suggested that this piece might also represent part of a composite main shaft. In that case, it would likely have been distinct from the fletched part of the shaft, which would have saved some effort in the event of breakage or loss. Notable features of the foreshaft include a split haft for mounting a

projectile point, three parallel ownership marks, and a symmetrically tapered base that decreases from 12.5 to 3.6 mm over a span of ca. 10 cm (Fig. 7).

In Lee (2010), I suggested that ownership marks imply social protocols that allowed individual hunters to be identified after successful hunts. Ethnographic observations indicate that ownership marks occur on hunting weapons designed to remain in the bodies of large game. They typically consist of simple lines and can be specific to either an individual or a community (Boas, 1899). These types of relatively simple geometric shapes are distinct from other types of ornamentation (Boas, 1899). Similar ownership marks have been identified on ice patch hunting implements recovered in the northern Rockies (Hare et al., 2004; Dixon et al., 2005). The ownership marks on the foreshaft are on the thinnest portion of the shaft near the projectile point haft. If the shaft broke off inside the animal, this portion could link the hunter to the kill, and it would be relatively easy to rework the remaining portion of the foreshaft to attach another projectile point.

Taking this idea further, the ability to differentiate weapons on the basis of distinctive marks suggests that other elements of these artifacts (e.g., projectile points) were neither distinctive nor indicative of the person using the weapon. For example, particularly skilled individuals within a band or group may have crafted most of the technically demanding points, thereby making ownership marks on shaft portions of the weapon necessary to help hunters recover their weapons after use. The presence of ownership marks on a weapon at this remote hunting site, combined with the difficulty inherent in hunting the probable prey species, bighorn sheep, suggests either that ice patch hunting was a group activity or that the foreshaft recovered at this site was used in other group hunting situations. Assuming bighorn sheep were the target species, additional support for the group hunting hypothesis comes from a ca. 7700 cal BP sheep net recovered in northwestern Wyoming (Frison et al., 1986). Operating this net, which is roughly 50–65 m long and 1.5–2 m high, would have required multiple individuals.

In Lee (2010), I also argued that the foreshaft is contemporary with the Paleoindian age Cody complex, which is notable for its diversity of projectile point forms and patterns of landscape use (e.g., Muniz, 2005; Knell, 2007). It is worth noting that the foreshaft may also belong with a regional variant of a Paleoindian Foothill/Mountain tradition, such as the Alder complex (Davis et al., 1989). Regardless, the morphology of later Paleoindian projectile points tends toward narrower bases (Muniz, 2005). Such bases would have worked well with the ca. 9 mm haft, which is tapered and rounded to enhance penetration (Fig. 7B).

Other artifacts from the second locus at 48PA3147 include more recent shaft fragments dating to 7500 cal BP and ranging in diameter from 16.5 to 18.9 mm. One of these fragments (48PA3147.7) has five parallel oblique marks embossed on the surface (Fig. 8A and Fig. 9). The similarity of these marks to those on the foreshaft described above suggests they might also be considered ownership marks.

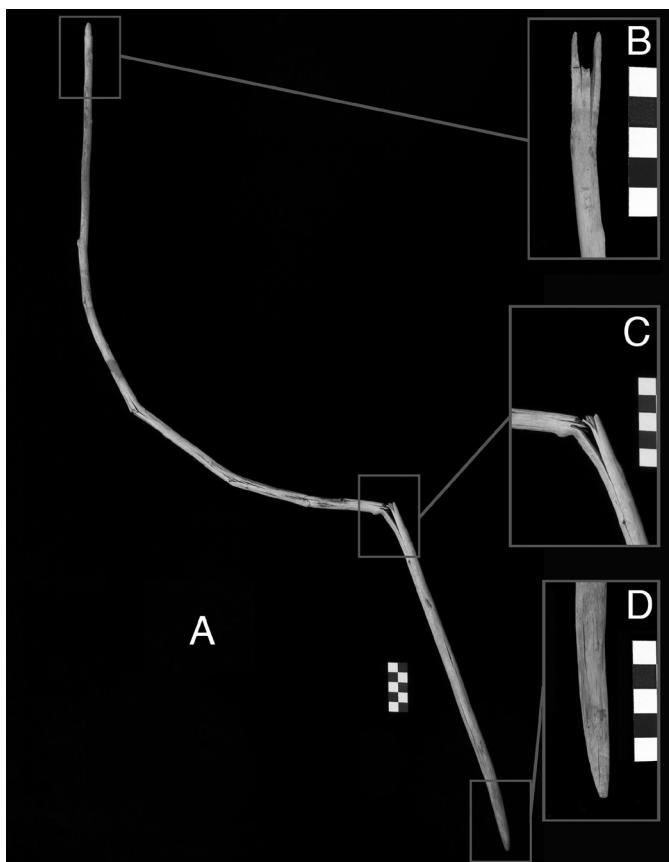


FIG. 7. Composite image of presumed dart foreshaft (48PA3147.12), showing A) the complete artifact, B) the haft, C) the break at midsection, and D) the tapered base. Photographs: Tara L. Hornung.

This artifact is similar in overall preservation, appearance, and age to two other shaft fragments, one of which (48PA3147.8) appears to have a beveled end (Fig. 8B). The beveled end may have facilitated its being socketed or attached via a scarf joint to another as yet unidentified element. Joints of this type have been observed on some Yukon Territory ice patch artifacts (Hare et al., 2004).

The question of prey remains open, but the recovery of spirally fractured and cut-marked bone morphologically consistent with bighorn sheep (*Ovis canadensis*) indicates that they were a target species (Fig. 10). Although earlier research in Colorado was particularly focused on the presence of cranial and post-cranial elements of bison (*Bison bison*) at high-elevation locations (Lee et al., 2006; Lee and Benedict, 2012), it is also true that the remains of bighorn sheep, elk (*Cervus elaphus*), and mule deer (*Odocoileus hemionus*) are regularly observed at mid-latitude ice patches. Anecdotal observations suggest that bison and sheep remains are probably represented by random skeletal elements (Lee and Benedict, 2012); however, in many instances, the skulls attract more attention among scientists and recreationalists alike, since they are an easily recognizable indicator of a given species. Bison remains have been observed at numerous ice patches in the GYE, but it is unlikely that bison was the primary target species at site 48PA3147. Correspondence from Dr. Don Pattie (forwarded



FIG. 8. Two views of shaft fragments: A) sapling shaft fragment with five parallel oblique ownership marks (48PA3147.7), and B) beveled sapling shaft fragment (48PA3147.8). Photographs: Tara L. Hornung.

to the author by Dr. James B. Benedict) indicates that Pattie collected at least two bison skulls, as well as the skull caps and horn cores of at least 13 bighorn sheep, in the forefield of the 48PA3147 ice patch in 1962. At this site in particular, skulls appear to be disproportionately represented, and this fact may have symbolic significance; however, the presence of the cut mark and cracked bone suggests that some quasi-residential activities occurred here as well. In conjunction with the samples of burned wood collected at this location, the wind shadow created by the landform that produced the ice patch might indicate that the location was a reasonable



FIG. 9. Detail of sapling shaft fragment (48PA3147.7) with five parallel oblique ownership marks. Photograph: Tara L. Hornung.

(and extremely proximate) campsite following a successful hunt.

Bighorn sheep provide a variety of useful materials, including hide and fur for clothing and boots (e.g., Husted, 1978:59 and Plate 38b:103), horn for tools, and meat. Harris (1978) notes that the most prevalent species represented at Mummy Cave in northwestern Wyoming was bighorn sheep, which was recovered in 36 of 38 excavation levels, and that there appeared to be no age or sex discrimination in the sheep hunting.

48YE1537

Ice patch reconnaissance in Yellowstone National Park resulted in the rediscovery of archaeological site 48YE1537 (Lee, 2011), which was originally recorded during a survey of the eastern edge of the Gallatin Mountain Range (Vivian and Mitchell, 2005). The site lies at an elevation of 2932 m (9620 feet) amsl. Artifacts were observed within 25 m of the downslope edge of the ice patch. During the reconnaissance of the ice patch forefield, previously unrecorded flake concentrations were noted in active and dry run-off channels. The active run-off channel originates below the area of core ice. Several USGS aerial photos suggest that even in extreme melt years, the core ice in this location provides a continuous source of water for a meltwater lake. Unfortunately, this ice patch was very large when it was surveyed in 2008, and most of the expected forefield area was obscured by fresh or recent snow.

The archaeological assemblage consists of at least 50 pieces of lithic debitage, a few flake tools, and two temporally diagnostic projectile points that are consistent with Pelican Lake corner-notched projectile points found elsewhere in the park (Vivian and Mitchell, 2005:Plate A-1E). All of the artifacts observed at 48YE1537 were made of obsidian. Six obsidian artifacts representing the range of macroscopic variation observed at the site were collected and submitted to the Geochemical Research Laboratory, directed by Richard E. Hughes, for trace element analysis. All six artifacts were consistent with Obsidian Cliff volcanic glass from Yellowstone National Park (Lee, 2011).



FIG. 10. Two views of a spirally fractured and cut-marked forelimb fragment from a bighorn sheep (48PA3147.5). Photographs: Tara L. Hornung.

The temporally diagnostic artifacts suggest that a component of the site dates to the Lamar Valley subphase, ca. 3000 to 1600 BP (Vivian and Mitchell, 2005: Fig. 56), which closely approximates Frison's (1991:101–103) date range for Pelican Lake. Pelican Lake projectile points are characterized as relatively large, corner-notched projectile points that were probably used with atlatl technology (Wettlaufer, 1955). The projectile point in the run-off channel below the ice patch might indicate that a formal tool (e.g., a dart) was lost in the snow during a hunting episode at the ice patch, and that at some subsequent time, the dart melted out, became permanently exposed, and was transported away from the patch by fluvial action (Lee, 2011). Although the amount of exposure necessary to destroy the organic components is unknown, it would surely be measured in decades if not single years. The debitage at 48YE1537 might represent the remains of butchery activities associated with game taken on the ice patch.

The ice patch in this location bears notable similarities to other ice patches from which archaeological materials have been recovered, such as those in the Yukon Territory (Hare et al., 2004) and the Bonanza Patch in Wrangell-St. Elias National Park (Dixon et al., 2005). The ice patch meets all of the critical criteria identified at the beginning of the paper, including 1) relative isolation from other ice patches; 2) proximity to lower-elevation, ice patch-free country; and 3) relative ease of access. In addition, its proximity to the meadow-covered top of the mountain and to excellent game habitat and its broad, flat surface, which is conducive to congregating and resting animals, also suggest that this ice patch holds exceptional potential.

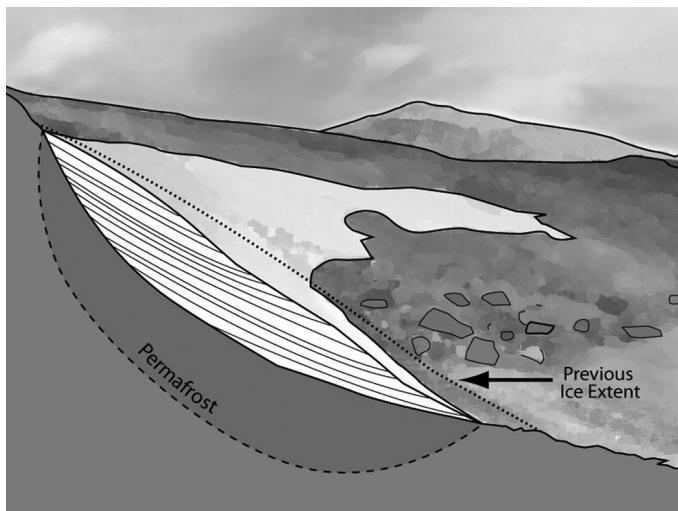


FIG. 11. Stylized depiction of a mid-latitude ice patch with permafrost lens at base. The striped area depicts a stylized, side-cut view of an ice patch with lag surfaces in a nivation hollow. Illustration: Eric G. Parrish.

DISCUSSION

As in other areas of North America, most of the artifacts recovered in association with ice patches in the GYE relate to hunting; however, there are examples of other artifacts, including the digging or walking stick at 24CB2174 and the twisted leather and bark artifact at GHG1, that hint at broader uses for these features. Benedict (1992) and others have suggested that family bands and larger groups seasonally used alpine environments elsewhere in the Rocky Mountains. The presence of non-hunting artifacts may suggest family groups that included both genders. VanderHoek et al. (2007) have argued for the presence of women along with men in the Alpine on the basis of a squirrel hunting snare at an ice patch in the Tangle Lakes region of Alaska. The recovery of a basket fragment at an ice patch in the Wrangell Mountains of Alaska by Dixon et al. (2005) may support this contention. This suggestion comes as no surprise, of course. Native people have a long and complex relationship with high-elevation areas, which is embodied in their traditional knowledge of spirits, places, land use, and ecology. High-elevation projects that reveal ancient sites vividly countermand a popular public perception of these environments (tree line and above) as “wilderness, devoid of humans and their activities” (*sensu* the Wilderness Act, 16 U.S. C. 1131–1136, 78 Stat. 890) (Lee, 2008). Alpine sites nearly always bespeak seasonality—summer or fall—and reflect patterns of seasonal movement with livestock or spiritual and functional provisioning. With regard to the latter, alpine regions can contain unique biotic resources (e.g., Benedict, 2007) as well as lithic resources (e.g., Adams, 2006).

The discovery at 48PA3147 of an artifact 10 400 years old suggests that some ice patches may be bed-frozen and underlain by permafrost (Fig. 11). When this permafrost formed is an open question, but the age of at least this one artifact suggests that it likely occurred before the mid-

Holocene warm period or the Altithermal. It is possible that ice in this location may date to the Younger Dryas. The elevation of archaeologically productive ice patches in the GYE yielding organic artifacts ranges from 3136 to 3414 m (10 290 to 11 200 feet), with the majority of these patches lying at 3200 m (10 500 feet) or less.

The importance of non-permanent snow banks to denizens of the High Country is undemonstrated, but given the right conditions, they may have been used in a similar manner. The role of snow and ice in the lives of the ancestral peoples of North America is important and understudied. Future research is warranted and should include areas of the normally arid High Plains and other locations where annual snow and ice drifts significantly affect water availability.

To date, resource managers in Regions 1 and 2 of the United States Forest Service and in Glacier, Rocky Mountain, and Yellowstone National Parks have taken a proactive stance regarding the identification of ice patches with archaeological potential. Unfortunately, the field efforts in recent years have been hampered by extensive, late-lying snow during the September 2008, 2009, and 2011 survey windows. Although the ground around target ice patches is obscured and somewhat protected by the snow, there is still reason to worry about the safety of buried artifacts. Research indicates that temperatures rarely drop below freezing beneath impermanent high-altitude snowbanks in Colorado (Holtmeier, 2003:81) and presumably elsewhere in the Rocky Mountains. Consequently, materials released from ancient ice into a forefield area and subsequently reburied may continue to decompose for much of the year.

SUMMARY

Without doubt, our planet’s changing climate is tangible in mid-latitude ice patches. Ice patch artifacts provide a way to capture public interest and to educate people about the effects of global warming. The research and teaching potential of ice patches in the mid-latitude Rocky Mountains extends beyond archaeology; these patches represent a storehouse of paleoecological data broader in range than that usually recovered in glaciers at this latitude.

Ice patches represent a uniquely synergistic opportunity to galvanize the interest of Native Americans, archaeologists, federal resource managers and the public. Toward that end, the Montana Archaeological Society highlighted GYE ice patch research on its Archaeology Month poster for 2010.

As noted by Lee and Benedict (2012), the exposure of ancient artifacts and paleobiological materials by the retreat of moisture-starved and heat-ravaged ice patches provides a resonant image of the impact of climate change on heritage resources in the Rocky Mountains. Additional field seasons are planned for the GYE, and many other areas in the western United States are also amenable to survey. Ice patches in mountains of the American West are an unusually accessible portion of the Earth’s cryosphere, and they

form a bridge to issues of stewardship and collaboration, providing multiple opportunities to explore topics ranging from the loss of artifacts through illegal collection to artificially expedited taphonomy.

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