Plains Anthropologist

ISSN: (Print) (Online) Journal homepage: www.tandfonline.com/journals/ypan20

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To cite this article: François B. Lanoë, María Nieves Zedeño, Danielle R. Soza, Steven L. Kuhn & Joshua D. Reuther (20 Jan 2025): Projectile points across the Northern Rocky Mountain front: the Billy Big Spring Site (Blackfeet Reservation, Montana), Plains Anthropologist, DOI: 10.1080/00320447.2025.2450202

To link to this article: https://doi.org/10.1080/00320447.2025.2450202

PLAINS ANTHROPOLOGIST, 2025, 1–24

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ARTICLE

Projectile points across the Northern Rocky Mountain front: the Billy Big Spring Site (Blackfeet Reservation, Montana)

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In the recent past, the Front Ranges of the Northern Rocky Mountains formed a permeable boundary that people repeatedly crossed for trade, subsistence, or warfare, and where people occupying different parts of western North

 DOI 10.1080/00320447.2025.2450202

America interacted. In this paper we apply a landscape approach to study pre-contact projectile point morphologies and raw materials, and related changes in the geographic affiliations of peoples using the Billy Big Spring Site, located near the Front Ranges in the Blackfeet Indian Reservation of Montana. This site contains numerous points recovered in chronostratigraphic contexts ranging in age from Late Paleoindian to Late Precontact. The sample includes types and raw materials alternatively typical of the Rockies/Plateau, the Front Ranges, and/or the Plains. Variation in the projectile point record at Billy Big Spring is consistent with the notion that, as observed in the recent past, information networks spanned a wide geographic area that englobed the Plains, the Front Ranges, and the Plateau/Rockies during most of the pre-contact period. Exceptions and changes in the geographic affiliations of people using the site can in turn be related to major environmental and demographic events that occurred in the region.

KEYWORDS projectile point, Rocky Mountains, Great Plains, boundary, frontiers, network

Introduction

A cultural landscape that evolves from mobility is inherently susceptible to the development of far-reaching information networks. The Front Ranges of the Northern Rocky Mountains (hereafter Front) illustrate this during the Late Precontact period. The Front at that time formed a physiographic and social boundary between bison hunting groups, belonging to the Algic and Siouan linguistic families, inhabiting the Plains; and groups belonging to Salish, Kootenai, Penutian, and Uto-Aztecan families dwelling in lands in the Rockies and the Plateau. This human boundary was porous as both regions were connected by dozens of mountain passes, a few of which became formal pathways. Plains and Rockies people repeatedly crossed the Continental Divide for various economic, social, and political pursuits. In practice, the Front formed a frontier (Hauser 2022; Lightfoot 1995; Parker 2006) where land and resource uses of Plains and Rockies people overlapped.

The cultural landscape of earlier pre-contact times in the Front indubitably consisted of social groups with established territories. Territorial boundaries are mostly invisible in the archaeological record because they would have been maintained socially rather than being permanently marked and actively defended (Barnard 1992; Cashdan 1983; Kelly 2013:137–165). Consequently, for much of the Precontact period archaeological remains in the Front Ranges provide little information on geopolitical identity, except perhaps for rock art (Keyser and Klaasen 2016). The cultural geography of earlier periods is instead mostly known through the lens of projectile points. While points vary in raw material and craftsmanship, the region has a solidly radiocarbon-dated sequence of diagnostic point types ranging from Paleoindian to Archaic and Late Precontact periods. Many of these types are geographically widespread, but some are confined to particular regions and assemblage diversity suggests that at different times in the past, hunter-gatherers from various origins traversed regional and interregional pathways and established networks.

Like a great many others, we assume that similarities in the forms of points across sites and over time are representative of shared conventions about appropriate design and hafting technology for projectiles. These common conventions reflect some kind of network of interaction across which information traveled. These networks do not fit comfortably with common anthropological categories. The geographic scales of most point type distributions in the North American West are much larger than areas occupied by self-identifying communities (Buchanan et al. 2019). In more recent periods, point styles do not "map onto" known cultural divisions. The lack of differentiation between, for instance, Late Precontact projectile points west and east of the Front, can be contrasted with differences in other aspects of the material record such as monumental architecture (Brumley 1988; Vickers and Peck 2009); or with the clear ethnic and geopolitical demarcations observed at first European contact (Jorgensen 1980). Rather, variation in point morphology probably reflects a diffuse, crosscutting information network. People living in the same area at the same time likely shared information that connected them to and through specific places, resources, and technologies, regardless of their ethnic and linguistic affiliation, leading them to produce morphologically and technologically similar points.

A second dimension of projectile points is relevant to discussion of the geographic connections of people who made and deposited them. As highly curated objects, points (or partially finished specimens) were probably transported long distances – again following social networks. Knowledge about locations where raw material was extracted provides an independent perspective on where people had been previously, and/or where their dominant social and trade relations lay.

Occupation of the Front since the end of the last glaciation is most commonly manifest as surface sites and shallow palimpsests (Peck 2011; Reeves 2003). While most sites were occupied once or episodically, some multicomponent sites exhibit near-complete projectile point sequences (e.g. Gryba 1983; Husted and Edgar 2002; Lanoë et al. 2022). Such sites that were repeatedly reutilized or reoccupied through time may be thought of as "persistent places" (*sensu* Schlanger 1992). Persistent places are physical repositories of the replicative and transformative practices of mobile hunter-gatherer groups and are connected to one another and to peripheries by pathways (Zedeño et al. 2009, 2013; Zedeño and Anderson 2010). They participate in the development of enculturated landscapes that embody the mapping and anchoring-in-place of individual choices, social relations of production, information networks, politics of resource access, ceremony, and social memory (e.g. Basso 1996; Feit 1994; Myers 1991; Oetelaar 2021; Zedeño and Bowser 2009; Zvelebil 1997).

Here we report on the projectile point assemblage from one such persistent place, the Billy Big Spring Site (24GL304), located on the eastern foothills of the Front, in the Blackfeet Indian Reservation of Montana. The Billy Big Spring landform, which overlooks the South Fork of the Two Medicine River, contains a pond that retained water throughout the changing environmental conditions of the last 12,000 years (Lanoë et al. 2022). A tantalizing aspect of Billy Big Spring's persistence is the site's uniquely large, diverse, and well-dated projectile point assemblage, deposited as a result of the repeated shooting of animals in its pond throughout that period. In this article we examine this assemblage to better understand how a persistent place might reveal the existence the ebb and flow of people, objects, and ideas across the northwestern Plains and Rocky Mountains, as well as the social and territorial significance of intra – and inter-site projectile point assemblage diversity.

Methods

The Billy Big Spring site (24GL304) is located in the Blackfeet Indian Reservation near East Glacier Park, Montana. The site is situated on and around a seasonally dry glacial kettle that attracted bison and other prey (Lanoë et al. 2022). Billy Big Spring lays along the ancient Old North Trail that runs just east and parallel to the Front and connects the site to important ceremonial cores such as the base of Chief Mountain and other peaks used for vision questing (McClintock 1910; Reeves 1990). The site is at striking distance from the Marias Pass – a famous travel route that historically was used by mountain and plains folks for hunting, trade, war, gaming, and ceremony (Reeves 2003). It sits at the headwaters of the Two Medicine River, which is part of the Missouri River drainage that cuts across an easily traversed terrain. A major rationale for excavating Billy Big Spring was its unique potential for informing place persistence and the evolution of the human landscape in the area. Investigating variation in the projectile point assemblage enables us to map directions of persistence, the materiality of a hunting core, and the ebb and flow of mobile hunters across these pathways.

The site was known to local historians such as H. P. Lewis and Thain White, since at least the 1940s (Kehoe 2001; White 1951). White collected at least 80 projectile points from the surface, of which only low-resolution pictures are available (White 1951). Thomas Kehoe, of the Museum of the Plains Indians (Browning, Blackfeet Reservation), first excavated the site in 1952–1954 and again in 1971, reporting the recovery of 50 projectile points or fragments (Kehoe 2001). The University of Arizona Bureau of Applied Research in Anthropology (BARA) and the Blackfeet Tribal Historic Preservation Office (BTHPO) resumed fieldwork at the site from 2016 to 2021 (Lanoë et al. 2020, 2022); they collected 92 projectile points. At that time BARA also studied artifacts and documentation from Kehoe's excavations (including the reported 50 points and four additional, unreported specimens) from the Billings Curation Center, Montana, and the Milwaukee Public Museum, Wisconsin, where Kehoe finished his career.

Projectile points studied here were recovered both in stratified contexts ($n = 107$) and on the surface ($n = 39$) (Supplementary Table 1). Stratified contexts include BARA excavations, located in three areas with distinct stratigraphy. Those three areas are dated with a combination of tephra from the Mount Mazama eruption and radiocarbon dates, the latter of which may show a discrepancy of up to several millennia due to local sedimentary and pedogenic processes (Figure 1;

Lanoë et al. 2022). Block 100 (along with adjacent blocks 300, 500, and 700; hereafter block 100) totaling 12.5 m^2, is deeper (ca. 160 cm to glacial outwash) and shows high chronological resolution, with archaeological horizons separated by hiatuses. Block 1000 (along with adjacent blocks 1300 and 1500; hereafter block 1000) totaling 9 m^2, is shallower (ca. 80 cm to outwash) and shows lower chronological resolution, resembling more a palimpsest. Nearby block 1100 totaling 4 m^2 shows intermediate characteristics (ca. 105 cm to probable outwash). All projectile points excavated by BARA have provenience information within each excavation block either by coordinates when documented in-situ, or by 1 m^2 unit and 5-cm arbitrary level when recovered in the screen.

Projectile points in stratified contexts also include those recovered by Kehoe's 1952–1954 and 1971 excavations. Kehoe excavated two adjacent trenches, located between BARA's blocks 1000 and 1100, and totaling 23.2 m^2 (250 ft^2) and 7.0 m^2 (75 ft^2), respectively (Kehoe 2001) (Figure 1). Both excavation depth and natural stratigraphy varied across the trenches, with excavation reaching 110 cm at most and encountering "glacial till" (more likely glacial outwash) ca. 80 cm in at least one occurrence. Kehoe does not mention encountering Mazama tephra; he mentions sampling bones for radiocarbon dates in his notes, but presumably dating failed as no radiocarbon dates were reported. He provides a general site stratigraphy that does not appear to take spatial variation into account. Kehoe provided in his notes detailed provenience information for most projectile points including depth below surface (in 3 cm [0.1 ft] increments) and coordinates within each 2.3 m^2 (25 ft^2) unit; as well as partial stratigraphic profiles for several units. The identification and location of each excavation unit within the trench(es), however, is unclear.

Both BARA and Kehoe collected points on the surface of the pond and on the adjacent landform, most of which are brought to the surface by seasonal cattle trampling. BARA also collected points from a test excavation (Block 200) in Kehoe's trench backfill that aimed (unsuccessfully) to find his stratigraphic profiles. Kehoe did not provide exact location for surface finds. BARA recorded the location of each surface find by GNSS and/or Total Station (Figure 1). The concentration of points in the northern and eastern portions of the pond likely relates to consistently drier ground in these areas, and consequently, more intensive survey.

We classified projectile points according to their morphology, size, other technological characteristics, and estimated chronostratigraphic age. Kehoe assigned the projectile points he recovered to five "cultural levels" which seem to crosscut natural stratigraphy. In this paper, we re-estimate the age of those points by combining Kehoe's recorded depths with additional chronostratigraphic knowledge derived from adjacent blocks 1000 and 1100.

We employed terminology and class definitions widely used in the Front and surrounding regions in classifying the points (Kornfeld et al. 2010; Peck 2011; Roll and Hackenberger 1998). Such radiocarbon-dated point types are essential for identification and dating of sites in the region, as many of them are documented in surface contexts or otherwise lack alternative adequate datable materials. We recognize that many established artifact typologies suffer from a variety of ills, ranging from imprecise class definitions to un-systematic construction (e.g. Lyman and

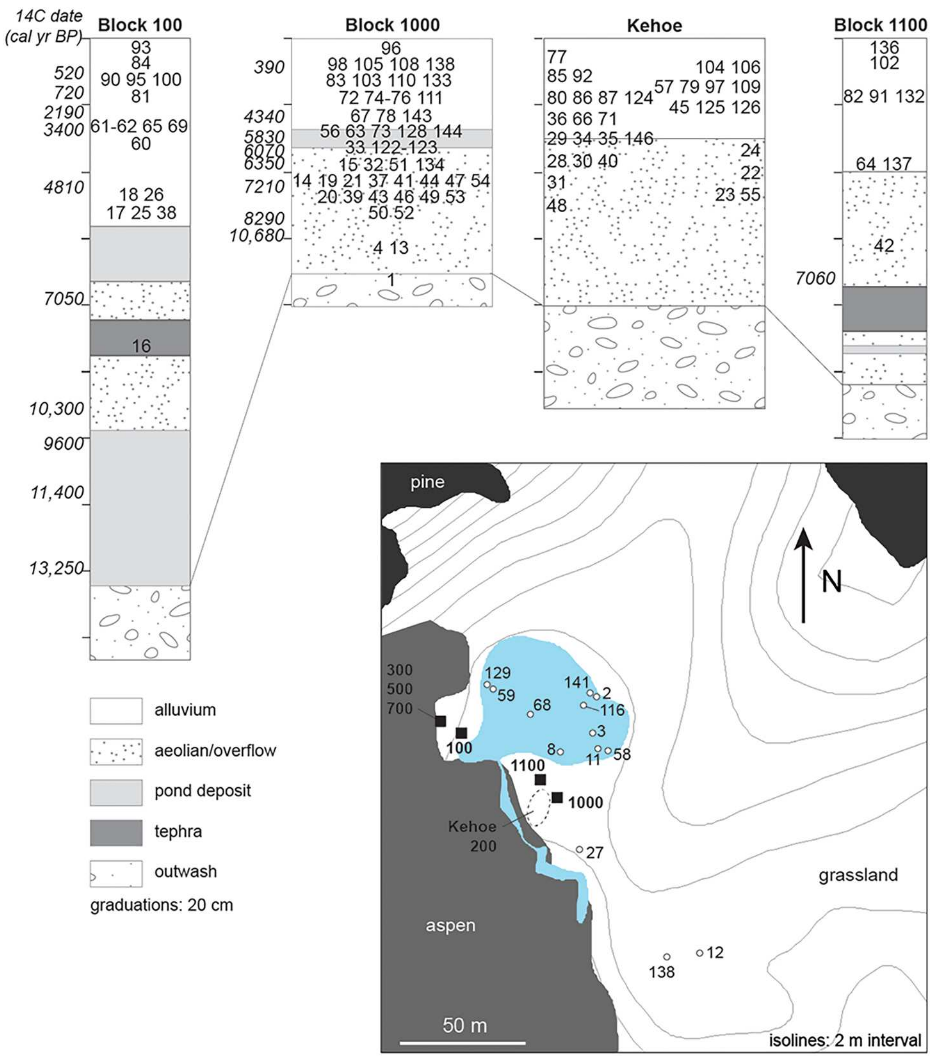

FIGURE 1 Provenience of projectile points reported in this study (numbers refer to the points depicted on further figures). Left: vertical location within stratified units. Chronostratigraphic information is derived from Lanoë et al. (2022) and Kehoe (2001), with additional radiocarbon dates in Supplementary Table 2. Right: map of the site with location of the excavation blocks (in bold) and of point specimens recovered on the surface by BARA [color online only]

O'Brien 2002; O'Brien and Lyman 2002), and that more systemically constructed classification systems may be more useful for answering a range of questions (e.g. Boulanger et al. 2022; O'Brien et al. 2014). Despite their shortcomings, existing artifact classes allow for comparisons with published results from other sites and remain the most viable approach pending systematic reclassification of the projectile points of the Front and surrounding regions. We emphasize that this study is a first attempt to address the problem using existing data, and that application of a different system for artifacts classification would almost certainly produce somewhat different results.

We compared raw materials to known regional sources based on characteristics including grain size, color, translucency, luster, and inclusions, as observed with a hand lens (10X) and a stereomicroscope (7-50X) in selected specimens. We also conducted chemical analysis for glass-like specimens. Chemical characterization followed protocols established at the University of Alaska Museum of the North and described in Reuther et al. (2011) and Coffman and Rasic (2015). It was conducted using an energy dispersive portable x-ray fluorescence (EDXRF) machine (Bruker Tracer 5 g) coupled with a collimator. Briefly, standards and artifacts were measured at 50 kV and 35 μA of current with a filter composed of 300 μm of Al, 6 μm of Cu and 1 μm of Ti, and a counting time of 200 s. Peak heights of selected elements were calculated as ratios to the Compton peak of Rh and converted into parts per million (ppm) following Glascock and Ferguson (2012). Internal standards included MLZ1100 (Batza Tena source), Corral (Oregon) source sample, and Bruker obsidian standard (730.0195), all checked within 2σ of the average. Each artifact was given a number within Alaska Obsidian Database (AOD). Measurements from this study were compared to known materials from the Northern Plains and Rocky Mountains (Kristensen et al. 2023; Kristensen, Andrews et al. 2019).

Results

Point types

The oldest stratified setting in which archaeological materials were documented lies immediately above the glacial outwash in blocks 1000 (corresponding to Kehoe's Level I) and 100, deposited during an initial sedimentation phase dated across the site landform to the terminal Pleistocene and very early Holocene (ca. 13,900–10,600 cal yr BP) (Lanoë et al. 2022) (Figure 1). Materials include, in block 100, a large lanceolate biface of poor manufacture quality (Figure 2:1) that presents a constriction at about one-third of its height, which suggests hafting and possible use as a projectile. Overall size and shape are similar to contemporaneous point types such as Hell Gap ca. 11.9–11.2 cal kyr BP (although these are typically of higher manufacture quality) and types of the Windust (or Goatfell) complex ca. 11–8 cal kyr BP (Andrefsky 2004; Kornfeld et al. 2010; Peck 2011; Reeves 2003; Roll and Hackenberger 1998; Rosencrance et al. 2024). Two additional bifacial specimens found on the surface (Figure 2:2–3), with similarly large widths but concave bases and more pronounced shoulders, also fit the morphological variability of the Windust and Nesikep (ca. 8–7 cal kyr BP) complexes (Roll and Hackenberger 1998; Rosencrance et al. 2024; Rousseau 2004). One last, fairly large surface specimen shows a stemmed shape with marked shoulders and a convex basal edge (Figure 2:12), consistent with early types such as Alberta, dated to ca. 11.1–10.2 cal kyr BP, and Boss Hill or Burmis, dated to ca. 9.4–8.1 cal kyr BP (Peck 2011).

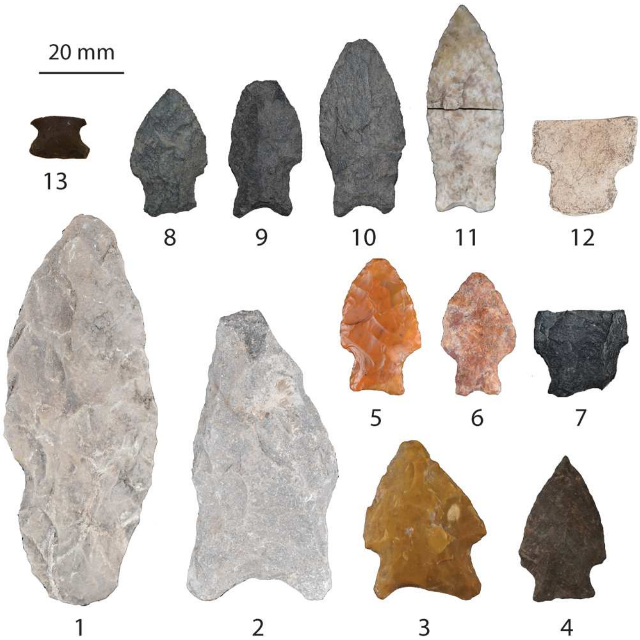

FIGURE 2 Early and possible early points from Billy Big Springs [color online only]

A later archaeological horizon, also in block 1000, includes a radiocarbon date of 8290 cal yr BP and is framed by dates of 10,680 and 7210 cal yr BP (Figure 1). Two point morphologies were recovered in this context, each of which is represented by a single specimen. A stemmed point with sloped shoulders and a straight to slightly concave base (Figure 2:4) fits the Pryor/Castle River type(s) dated to ca. 9.5–8.5 cal kyr BP (Kornfeld et al. 2010; Peck 2011). Similarly stemmed specimens with either straight or concave bases were recovered on the surface and also fit the Pryor (Figure 2:5–9) or contemporaneous Lovell (Figure 2:10–11) types, the latter having a constricted shape with less pronounced shoulders. Both morphologies, however, also occur in Middle Archaic types such as Duncan-Hanna (see below). The other in-situ specimen in this horizon is the broken base of a point with sharp notches and a straight base (Figure 2:13), consistent with the Mummy Cave (or Blackwater, Pahaska, Bitterroot) type(s) dated to ca. 8.2–7.5 cal kyr BP (Peck 2019).

One or several archaeological horizons are present across blocks 100, 1000, and 1100 immediately above Mazama tephra and include dates ranging from 7210 to 4340 cal yr BP (Figure 1). This horizon appears to correlate with Kehoe's Levels II-III. Projectile point morphology in this horizon is highly variable and includes both notched and unnotched specimens.

Notched specimens vary extensively in such diagnostic criteria as basal concavity and notch location, size, and shape. Some specimens show deep and open, almost basal side notches and straight or slightly concave bases (Figure 3:14–23), characteristic of the Maple Leaf type (ca. 7.3–5.3 cal kyr BP) (Peck 2011). Other

FIGURE 3 Notched Early-Middle Archaic points from Billy Big Spring [color online only]

specimens have high and shallow side notches and deeply concave bases (Figure 3:24–29; 27 and 29 found on the surface), characteristic of the Oxbow type (ca. 5.3–4.5 cal kyr BP) (Peck 2011). Yet other specimens show intermediary characteristics with deep and open notches and strongly concave bases (Figure 3:30–31); shallow side notches and straight bases (Figure 3:32–33); or deep side notches with straight to slightly concave bases (Figure 3:34–36). Some of those morphologies may result from the excessive wear and/or reworking of Maple Leaf (e.g. 32–33) or Oxbow (e.g. 30–31) specimens. Alternatively, they may represent other types of that period such as Gowen, dated ca. 6.7–5.9 cal kyr BP (Peck 2011); or unestablished types, as is known for instance in the Calderwood complex ca. 6.0–5.3 cal kyr BP (Peck 2011). Finally, some notched fragments found in this horizon do not present other diagnostic criteria (Figure 3:37–40).

Unnotched specimens include three morphologies that are consistent with the Cascade complex ca. 8–5 cal kyr BP (Ames et al. 1998; Andrefsky 2004; Roll and Hackenberger 1998): tear-drop shaped bifaces with convex bases (Figure 4:41–46); lanceolate bifaces or unifaces with straight to slightly concave bases (Figure 4:47–50; 52 is missing its base but appears otherwise consistent with this morphology); and an asymmetrically stemmed biface (Figure 4:51). While some of those specimens may be tools such as knives, their thickness is consistent with projectile points, and those morphologies are only found in this

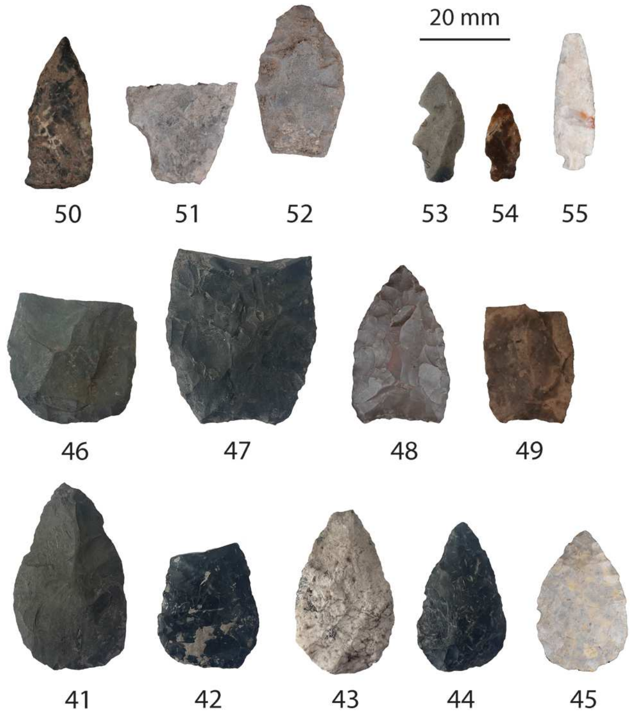

FIGURE 4 Non-notched Early-Middle Archaic points from Billy Big Spring [color online only]

chronostratigraphic horizon. An additional three specimens resembling stemmed points in this horizon are characterized by very small dimensions, but vary in other aspects of manufacture: one specimen is unifacial (Figure 4:54), another is partly bifacial (Figure 4:53), and the third is fully bifacial, very well-manufactured, with possible notches (Figure 4:55). Those small, stemmed specimens are only found in this chronostratigraphic horizon and do not have clear correlates to established types. They may not have been functional as projectiles, but instead been used for activities such as child play, as has been suggested of "abnormally" small and/or poorly-manufactured points (Dawe 1997).

The overlying archaeological horizon is present across blocks 100, 1000, and 1100 and includes dates ranging from 3400 to 2190 cal yr BP (Figure 1). This horizon appears to correlate with Kehoe's Level IV. Some specimens show lanceolate shapes with deeply concave bases (Figure 5:56–63; 58–59 from the surface), distinctive of the McKean Lanceolate type dated to ca. 4.8–3.7 cal kyr BP (Kornfeld et al. 2010; Lanoë et al. 2020; Peck 2011; Rousseau 2004). All three stemmed points recovered in this horizon present obtuse shoulders and slightly concave bases (Figure 5:64–67; 67 does not preserve the shoulder but presents a similar constriction of the neck), consistent with the Duncan-Hanna type(s) contemporaneous of McKean Lanceolate (Kornfeld et al. 2010; Lanoë et al. 2020; Peck 2011). Additional specimens recovered on the surface (Figure 2:5–11) also share this morphology. Corner-notched specimens include points with narrow necks, very

FIGURE 5 Middle-Late Archaic points from Billy Big Spring [color online only]

pronounced and almost barbed shoulders, and straight to slightly concave bases (Figure 5:8–73; 68 and 70 from the surface), characteristic of the Pelican Lake type (as defined in Peck 2011) dated to ca. 3.9–2.9 cal kyr BP. Wider-necked specimens with slightly concave to slightly convex bases (Figure 5:74–80) fit the Bracken (or Dankar) type (Peck 2011) dated to ca. 2.9–2.0 cal kyr BP.

The youngest archaeological horizon is found in the subsurface of all blocks. It overlies a date of 2190 cal yr BP and includes radiocarbon dates ranging from 720 to 390 cal yr BP (Figure 1). It appears to correlate with Kehoe's Level V. Specimens in this horizon include wide (dart-sized) side-notched points with slightly convex to slightly concave bases (Figure 6:81–89; 88–89 from the surface), characteristic of the Besant (or Sonota, Samantha) type(s) dated ca. 2.1–1.3 cal kyr BP (Peck 2011). A few specimens from this horizon (Figure 6:108–111) show notches but no further diagnostic criteria. Additional specimens are narrower (arrow-sized). They include very thin and well-manufactured triangular points with side-notches and slightly concave bases (Figure 6:90–92), characteristic of the Avonlea type dated ca. 1.3–1.0 cal kyr BP (Peck 2011). Other side-notched arrow-sized specimens (Figure 6:93–100; 94 and 99 from the surface) vary in the location and shape of their notches and bases, matching the morphological diversity seen in both Plains (Cayley or Old Woman complex) and Plateau (e.g. Kamloops complex) types, dated to ca. 1.1–0.2 cal kyr BP (Peck and Ives 2001; Roll and Hackenberger 1998; Rousseau 2004). One specimen (Figure 6:94) shows a basal indent typically associated with the Highwood (or Shoshone) type, dated to ca. 0.5–0.3 cal kyr BP (Kornfeld et al. 2010; Peck 2011). Several bifacial specimens, either triangular (Figure 6:101–104; 101 from the surface) or lanceolate (Figure 6:105–107; 107

FIGURE 6 Terminal Archaic to Late Precontact points from Billy Big Spring [color online only]

from the surface), do not have notches and may correspond to either exhausted points or preforms.

Some recovered points or fragments could not be classified. This includes distal fragments from both surface and in-situ contexts (Figure 7:122–146); as well as more complete but usually reduced specimens, recovered on the surface, and which display morphologies consistent with numerous types (Figure 7:112–121).

Specimen classification in this paper generally concurs with previously published studies of the site (Kehoe 2001; Lanoë et al. 2020, 2022), but differed in a few instances (Supplementary Table 3). Part of this discrepancy ($n = 4$) relates to our use of more current terminology for former types now considered to represent intra-type variation (e.g. Sandy Creek vs Besant); and for now-distinct types formerly considered to relate to intra-type variation (e.g. Pelican Lake vs. Bracken). Other discrepancies ($n = 6$) relate to the recent definition of some types since initial research such as Maple Leaf (Driver 1978; Peck 2011) or to reassessment of the specimens' chronostratigraphic context at the site (e.g. Pryor vs. Hanna-Duncan). Yet other mismatches ($n = 6$) reflect a more conservative approach in this paper. Further disagreement is limited to two specimens: one initially identified as Meron, a type found in Illinois ca. 2000 km from the site; and one initially identified as Besant despite its stemmed morphology.

FIGURE 7 Untyped points from Billy Big Spring [color online only]

Point raw material

Projectile points specimens at Billy Big Spring were made from numerous materials including sedimentary, metamorphic, and igneous rocks (Figure 8; Supplementary Table 5). Various kinds of cherts together make up 55% of the specimens. Most common (8%) is the yellow-blotched opaque black very fine-grained material available as cobbles in the local till of the Two Medicine piedmont lobe (Pinedale glaciation) and in secondary outwash and alluvium, here dubbed Two Medicine chert. This chert (or possibly a silicified mudstone) is visually similar to material from Elk River, thought to be widespread in the Northern Rockies (Kristensen, Allan et al. 2019), wherefrom the Two Medicine lobe originates. Various cherts of the Madison Formation, characterized by their opacity, bright colors (yellow, orange, red, brown, maroon), and black dendritic patterns (Roll et al. 2005) make up 12% of the point assemblage. Also common is Swan River chert (6%), identified by opaque whiteish colors and quartz-filled vugs (Low 1996). Other identified cherts are a minor component of the assemblage and include Knife River flint (2%) with its characteristic moderately to highly translucent dark brown color, strong UV fluorescence, white blotches, and white blueish patina (Kristensen et al. 2018); silicified peat (1%), more opaque and yellow but also showing UV fluorescence (Kristensen et al. 2018); various kinds of chalcedony (2%), with high translucency and, often, UV fluorescence (Kristensen et al. 2018); and various kinds of petrified wood (4%) with their

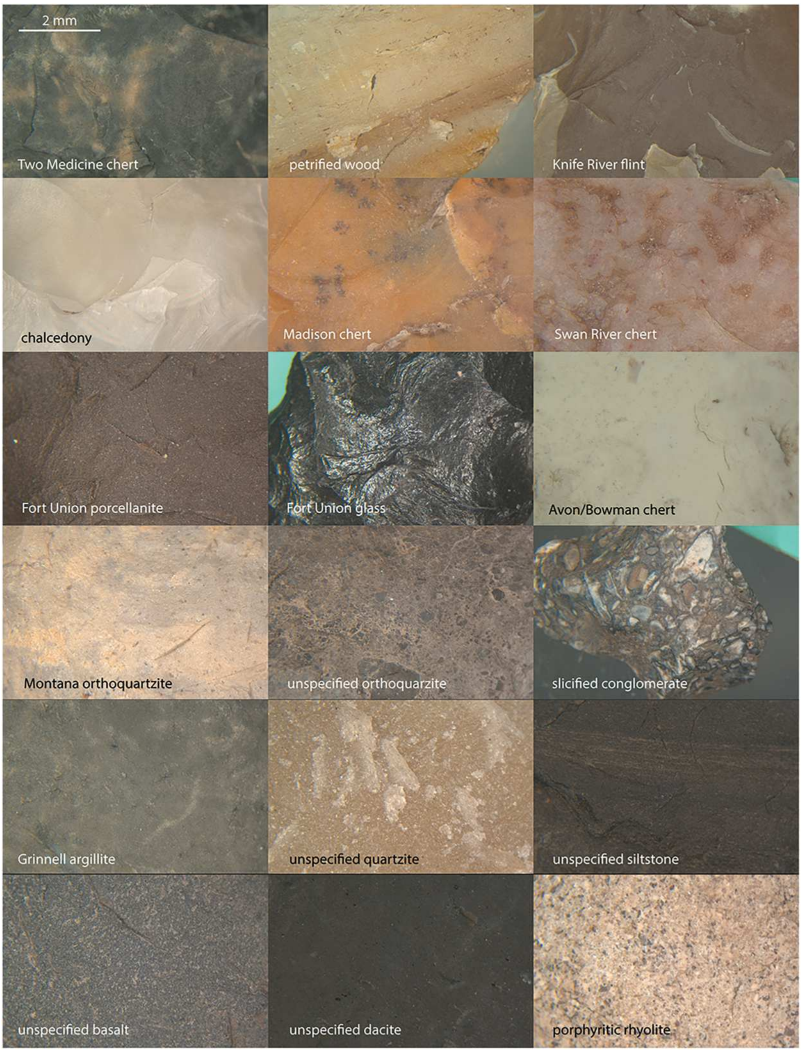

FIGURE 8 Selected raw materials used in the manufacture of Billy Big Spring projectile points [color online only]

characteristic banding and/or markers of organic structure (Kristensen et al. 2018). The remaining fine-grained sedimentary rocks with some degree of translucency were grouped as "unspecified cherts" (22%). Those vary extensively in grain size, color (black, gray, brown, maroon, red, orange, yellowish, white), translucency, and inclusions.

Other silicified sedimentary or meta-sedimentary materials represent 23% of the specimens. They include a white porcellanite with inclusions of brown chalcedony (1%), locally known as Bowman/Avon chert (Reeves 2003; Roll et al. 2005). Other porcellanites (2%) are maroonish dark brown or light gray in color as typical of the Fort Union formation (Fredlund 1976; Kristensen et al. 2020). One specimen (1%)

is made of a maroonish dark brown glass with elemental values matching those of non-volcanic glass from the same Fort Union formation (Supplementary Table 4; Fredlund 1976, Kristensen, Andrews et al. 2019). Several opaque tan materials (5%) present fine- to coarse-sand-sized (0.1–1 mm) rounded grains in an otherwise fine-grained matrix, visually similar to a group of materials known as Montana orthoquartzite (and/or Tongue River silicified sediment) (Kristensen et al. 2016). Two other materials (1%), here labeled unspecified orthoquartzites, present larger inclusions (1–3 mm) almost akin to silicified conglomerates. A fine-grained dark green argillite (2%) is presumed to be metamorphized Grinnell argillite (Reeves 2003). Other, unidentified, silicified medium- to fine-grained materials include variously colored (meta)quartzites (4%), siltstones (5%), and unspecified argillites (2%).

Igneous materials account for the remaining 21% of the specimens. Most common are basalt-like medium-grained dark gray to black materials with ashy inclusions (11%). Finer dark gray to black materials, generally with glass phenocrysts and/or vesicles, are probably dacite (5%). Obsidian specimens include Bear Gulch (3%) and Obsidian Cliff (1%) sources (Supplementary Table 4; Kristensen et al. 2023). Two lighter-colored materials appear to represent other forms of volcanic materials: one a probable rhyolite with a glass-like matrix and a high density of phenocrysts (1%); the other coarser and highly porous (1%), akin to an ignimbrite (Thompson et al. 2024).

Projectile point types vary in their raw material compositions (Supplementary Table 5). Materials used across the entire chronological sequence include Two Medicine, Madison, and Swan River cherts, petrified wood, Montana orthoquartzite, metaquartzite, siltstone, and basalt. Materials restricted to earlier types (Paleoindian and Early Archaic) include unspecified orthoquartzites, metamorphized green argillite, and dacite. Both rhyolite and obsidian are restricted to later types (Middle Archaic to Late Precontact). Knife River flint and silicified peat are restricted to the Bracken and Besant types (Late and Terminal Archaic). The remaining materials, such as chalcedony or Bowman/Avon chert, represent isolated typed/dated specimens.

Discussion

Projectile point diversity at Billy Big Spring

The unusually large projectile point assemblage, coupled with lack of evidence for other activities such as plant processing, defines Billy Big Spring as a predominantly bison hunting place that persisted for millennia. The site provides one of the most complete records of the culture history sequence of the Front, along with sites such as Sibbald Creek (Gryba 1983) and Mummy Cave (Husted and Edgar 2002). The projectile point assemblage at Billy Big Spring is highly diverse in terms of types. It includes most regionally known Archaic and Late Precontact types (Peck 2011; Roll and Hackenberger 1998). While it does not contain early Paleoindian types (e.g. Clovis, Folsom), it does include several known late Paleoindian types (Pryor, possibly Lovell and Windust), while missing others (e.g. most types of the Cody complex).

The Billy Big Spring assemblage is also highly diverse in terms of raw materials used for the manufacture of projectile points. As expected for these highly curated tools, materials are mostly exotic. Local materials such as Two Medicine chert (found at the site), and Bowman/Avon chert (several quarries less than 80 km from the site) together account for only 10% of the projectile points, in contrast to up to 81% of the rest of the lithic assemblage (Lanoë et al. 2020). Exotic sources are located in both the Plains and the Rockies. The closest source of many materials ranges from 150 to 500 km away, including Swan River chert and petrified wood in the Laurentide till (South Saskatchewan and Milk River basins); Madison chert and igneous rocks (including obsidian from Bear Gulch and Obsidian Cliff) in the Clark Fork and Missouri headwaters; Fort Union porcellanite and glass, and orthoquartzite in the Yellowstone/Powder basins. The most distant material, Knife River flint, comes from the Middle Missouri, no less than 800 km away. Several materials (e.g. metaquartzite, siltstone, argillite, various cherts) are likely to have been acquired in multiple areas.

Billy Big Spring within regional information networks

The widespread distribution of projectile point types at Billy Big Spring as well as their raw material diversity appear to indicate that the people who occupied the site participated in various information networks that englobed the Front and adjacent areas (Figure 9).

Most projectile point types found at Billy Big Spring have geographic ranges that span the Front from the Plains to the Plateau. Far-reaching types include Mummy Cave, Pelican Lake (along with Bracken and Elko), and Late Precontact Side-Notched (Ames et al. 1998; Kornfeld et al. 2010; Peck 2011; Pokotylo and Mitchell 1998; Reeves 2003; Roll and Hackenberger 1998). Other types – including Agate Basin, Alberta (along with other types of the Cody complex), Oxbow, McKean (along with Duncan-Hanna), Besant, and Avonlea – are well-known in much of the Northwestern Plains (Upper Missouri and South Saskatchewan basins) and as far west as the Kootenai or Columbia Basin (Roll and Hackenberger 1998), but often lack clear correlates in farther areas of the Plateau such as the middle Columbia or Salmon basins (Ames et al. 1998; Andrefsky 2004; Pokotylo and Mitchell 1998; Roll and Hackenberger 1998; Rousseau 2004).

Some types present at Billy Big Spring and in the adjacent Front – Windust and Cascade – appear to be more restricted to the Plateau region including the Middle Columbia, Kootenay, Clark Fork, Salmon, and Snake basins (Ames et al. 1998; Andrefsky 2004; Pokotylo and Mitchell 1998; Roll and Hackenberger 1998; Rousseau 2004), with seemingly no occurrences east of the Continental Divide except for Billy Big Spring and a few isolated finds to the north (Ives 2024; Reeves 2003). Yet other types, including Pryor/Lovell, Country Hills, and Maple Leaf, seem more endemic to the Front area ranging from the Bighorn Range north to the Canadian Rockies (Kornfeld et al. 2010; Peck 2011).

Raw materials used in the manufacture of the Billy Big Spring projectile points overall match the regional record. Raw materials originating in the Front were favored for the manufacture of projectile points regardless of types' geographic range. In particular, obsidian from Bear Gulch and Obsidian Cliff was commonly

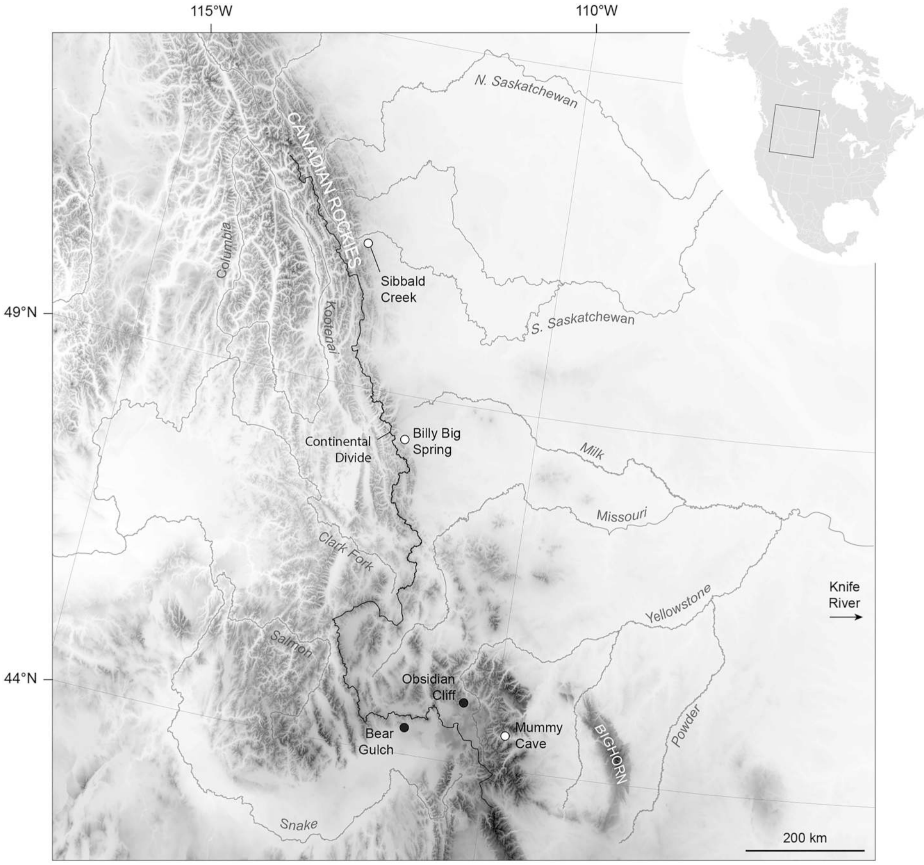

FIGURE 9 Map of the Northern Plains and Rocky Mountains, and of places mentioned in text [color online only]

used starting in the Late Archaic, as was Madison chert (Reeves 2003). Coarser materials including argillites and igneous rocks (basalt and/or dacite) were preferred for types widespread in the Plateau, such as Cascade and Windust (Reeves 2003; Rousseau 2004). At least at Billy Big Spring, materials available in the Front region, such as dacite and Madison chert, were favored for types such as Maple Leaf "endemic" to the Front. In contrast, exotic Plains materials including Knife River Flint, Montana orthoquartzite, and Swan River chert seem to have been used more exclusively for the manufacture of types widespread in the Plains such as Cody, Besant, and Avonlea (Kristensen et al. 2016, 2018; Reeves 2003).

Networks through time

The projectile points and raw materials from the Billy Big Spring site (Figure 10), and from the Front more generally, indicate that information networks centered in different areas ebbed and flowed through time. Projectile point information networks appear to have been more extensive and ranged from the Plateau to the

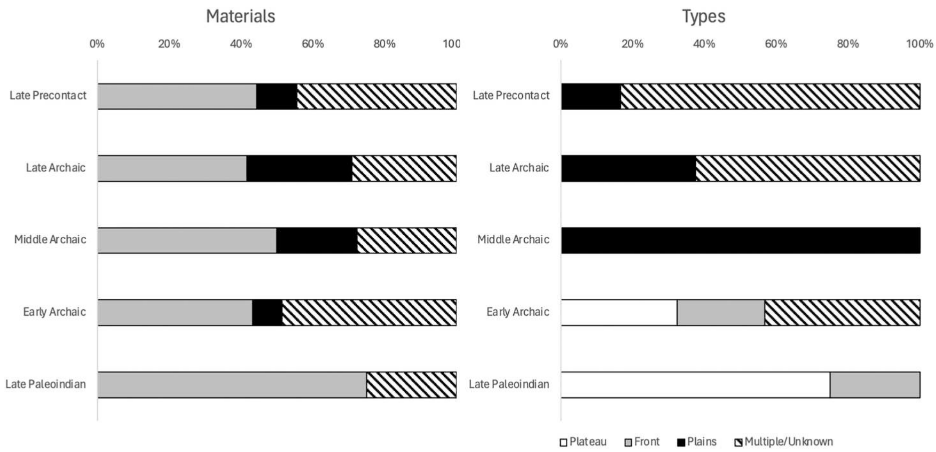

FIGURE 10 Geographic affinities of Billy Big Spring projectile points. Note that most "Plains" types reach well into the Plateau

Plains in much of the Precontact times, but particularly starting in the Middle Archaic. At least some of those types also appear to have been more standardized in either shape (e.g. Oxbow, Avonlea) or raw material (e.g. Besant; Graham 2014; Kristensen et al. 2018). This consistency in manufacture may indicate that the makers of these points either had close social connections with one another or that the points were made by few members of a group and traded across pathways. In contrast, more restricted projectile point networks (more affinities towards the Plateau, or endemic to the Front) seem to characterize the earlier Late Paleoindian and Early Archaic periods. Point types at that time also appear less homogeneous and may represent idiosyncrasies in craftsmanship and variation in the quality of readily available raw materials.

Extensive projectile point networks starting in the Middle Archaic may be related to climatic cooling and ecological stability following the Holocene Thermal Maximum. This cooling resulted in larger and more fertile grasslands and bison herds, in turn triggering growth in large-scale communal bison hunting, demography, and trade networks across both the Northern Plains and the Northern Rocky Mountains – possibly warfare as well (Walde 2006; Zedeño et al. 2014). This expansion in network orientation is indicated by the arrival of eastern copper objects and burial practices typical of Great Lakes and eastern Plains groups at that time (Millar 1981; Oetelaar 2021). An increase in the use of obsidian from the south during the Late Precontact period further suggests that networks at the time expanded into the Plains/Wyoming Basin frontier. Such extended Archaic and Late Precontact information networks do not preclude the existence of other types of social boundaries, and likely differed from those seen during the Early Paleoindian long argued to instead represent higher degrees of mobility of smaller social units (Kelly and Todd 1988; Kristensen et al. 2023).

The Late Paleoindian and Early Archaic saw more restricted networks overlapping in the Front. Environmental markers along the Front, which are visible from Billy Big Spring (Lanoë et al. 2022), indicate how environmental disturbance may have contributed to this pattern. The onset of the Holocene Thermal Maximum (or Altithermal) beginning ca. 10.6 cal kyr BP, marked a time of increased aridity on the Plains. The Front, with its perched aquifers and higher elevations might have become a refugium for mobile hunters who developed local networks. In parallel, the ashfall from Mount Mazama's eruption ca. 7.6 cal kyr BP, which probably resulted in near depopulation of the Plains (Oetelaar and Beaudoin 2005, 2016), could account for network disruptions.

Conclusion

Despite the Front forming a sharp geographic boundary, projectile points suggest that it never formed a sharp human boundary. For much of the pre-contact history, the Front functioned as a permeable frontier where information networks either crisscrossed or overlapped. This overlap in use of the Front was probably facilitated by its concentration of resources important to mobile people. Both Plains and Plateau people may for instance have been attracted toward the Front where bison wintered. One of the site's most intriguing characteristics is indeed its proximity to large late-precontact architectural complexes that focused on mass-harvesting of bison on the prairie, along with its accessibility from the west, where prey stalking at core localities was favored by hunters, particularly during the winter when the bison congregated near the Front. Lithic raw materials local to the Front were also probably important, particularly to western groups who had access to fewer readily available high-quality materials. The importance of ground water, and the resources that depended on it (e.g. wood), may also have been exacerbated during the Holocene Thermal Maximum.

Maintaining networks beyond procuring basic necessities would have been essential in times of stress, when cooperation as well as intermarriage could have facilitated the survival of small hunter-gatherer groups while discouraging total depopulation. Persistent localities such as Billy Big Spring likely offered people a level of predictability in those times and could represent the maintenance of landscape memory over multiple generations. The ebb and flow of people, objects, and ideas along the Front (tracked by our study of projectile points and raw materials), particularly the persistence of hunters at Billy Big Spring and in the surrounding region during the environmental and volcanic disturbances of the Early Holocene, illustrates how hunter-gatherer societies develop place attachments and, through replicative and transformative practices as well as network development, progressively enculturate the landscape.

Acknowledgements

Work at the Billy Big Spring Site has been a collaboration between the University of Arizona Bureau of Applied Research in Anthropology and the Blackfeet Tribal

Historic Preservation Office (John Murray, officer). It was funded through a Memorandum of Understanding between the Blackfeet Tribe and the Montana Department of Transportation, as well as National Science Foundation grant PLR-1827975 (Zedeño and Lanoë). Crew included University of Arizona staff and Blackfeet tribal members. Documentation related to this project was provided by the Museum of Plains Indians (Browning, Blackfeet Reservation), the Bureau of Land Management Billings Curation Center, the Milwaukee Public Museum, and the Museum of Anthropology at Washington State University (Samantha Fladd, director). Analytical equipment support was provided by David Killick (University of Arizona). This paper greatly benefitted from comments from two anonymous reviewers.

Funding

This work was supported by Montana Department of Transportation; National Science Foundation [grant number PLR-1827975].

Author contributions

Conceptualization: FL, MZ, SK; formal analysis: FL, DS, JR; funding acquisition: FL, MZ; investigation: FL, MZ, DS, SK, JR; methodology: FL, SK; writing draft: FL, MZ; writing review: FL, MZ, DS, SK, JR.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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Supplemental data

Supplemental data for this article can be accessed online at https://doi.org/10.1080/00320447.2025.2450202.

Data availability statement

Data for this article are presented in supplementary materials. The projectile point specimens are currently curated at the Bureau of Applied Research in Anthropology, University of Arizona, Tucson. They will be curated for long-term storage at the Bureau of Land Management Curation Center in Billings, or at the future Blackfeet Tribe curation facility in Browning.

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Article received 31/5/2024; accepted 3/1/2025