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In situ evidence for Paleoindian hematite quarrying at the Powars II site (48PL330), Wyoming

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We present results from controlled excavations at the Powars II Paleoindian hematite quarry (48PL330), located in the foothills of the southern Rocky Mountains in Wyoming. We document a deeply buried, bedrock-adjacent stratum containing in situ evidence for hematite quarrying beginning *ca.* 12,840 to 12,505 calibrated years (cal) B.P. associated with the Clovis and Plainview cultural complexes. Later occupation by the Hell Gap cultural complex intruded within previous quarry tailings and likely dates to *ca.* 11,600 cal B.P. The earliest Clovis and Plainview occupations contain a diverse assemblage of stone and faunal artifacts indicative of hematite quarrying, weaponry production and repair, and other tasks, while the later Hell Gap occupation is primarily focused on hematite quarrying and the placement of items in piles within an abandoned quarry feature. In situ archaeological deposits at Powars II are distinguished from overlying ex situ strata by sediment characteristics, bone preservation, patina development on chipped stone artifacts, diagnostic weaponry assemblages, and damage to flake margins. Nonlocal chipped stone raw materials indicate ties to much of the North American Great Plains, suggesting that Powars II hematite may be found in sites throughout the American midcontinent.

ocher | Younger Dryas | Clovis | quarrying

Significance

Red ocher (also known as hematite) is relatively common in Paleoindian sites exceeding ca. 11,000 calibrated years B.P. in the Great Plains and Rocky Mountains of North America. Red ocher fulfilled a wide range of functions within Paleoindian societies, as indicated by its association with graves, caches, campsites, hide-working implements, and kill sites. To date, the Powars II site is the only red ocher quarry identified in the North American archaeological record north of Mesoamerica. Prior studies of Powars II were based on analyses of artifacts recovered from a redeposited context. This study presents in situ evidence for red ocher quarrying at Powars II.

The Powars II site, located in the foothills of the southern Rocky Mountains in Wyoming (1, 2), is one of five hematite quarries identified in the indigenous archaeological record of the Americas, along with two definitive quarries in Quintana Roo, Mexico (3), San Ramon 15 near the coast of northern Chile (4), and Mina Primavera in the Ingenio Valley of Peru (5) (Fig. 1). Powars II was first proposed as a hematite quarry in 1986, when archaeologists observed Paleoindian artifacts associated with hematite-rich sediments in a redeposited context. Despite being known for over 30 y, the site has gone unrecognized as a hematite quarry in recent reports (3, 4) because intact quarry features had not yet been documented and published. This study addresses that need.

We report controlled excavations of intact archaeological deposits at Powars II, which documented in situ evidence for Paleoindian hematite quarrying and clarified several previously reported site phenomena. Between 2017 and 2020, we excavated a 6 × 1 m trench bisecting a previously undocumented quarry feature. This excavation documented a combination of intact and redeposited site sediments primarily comprising anthropogenic quarry tailings containing several thousand Paleoindian artifacts. Importantly, well-preserved bone yielded accurate radiocarbon dates from the site, providing unequivocal evidence for early Paleoindian use beginning *ca.* 12,840 to 12,505 calibrated years (cal) B.P. We confirm that Powars II is the oldest hematite quarry thus far documented in the Americas.

Results

The Powars II Hematite Quarry. The Powars II site is located on a 20° south-facing slope surrounded by industrial disturbances associated with operation of the Sunrise iron mine and townsite between 1880 and 1980 (Movie S1). The site escaped complete destruction but has been truncated on its southern and eastern margins due to these disturbances, which define the site's extent in these directions. Elsewhere, site extent is defined primarily by the distribution of anthropogenically displaced iron ore nodules (herein "quarry tailings"), which form a massive, erosion-resistant accumulation of debris that has kept the site intact on the steep slope since its formation.

Within the total site extent, we have identified one hematite quarry feature. The Powars II hematite quarry is visible at surface as a linear depression trending in a northeast to southwest direction (Fig. 2). It is bounded on its southeast margin by a small

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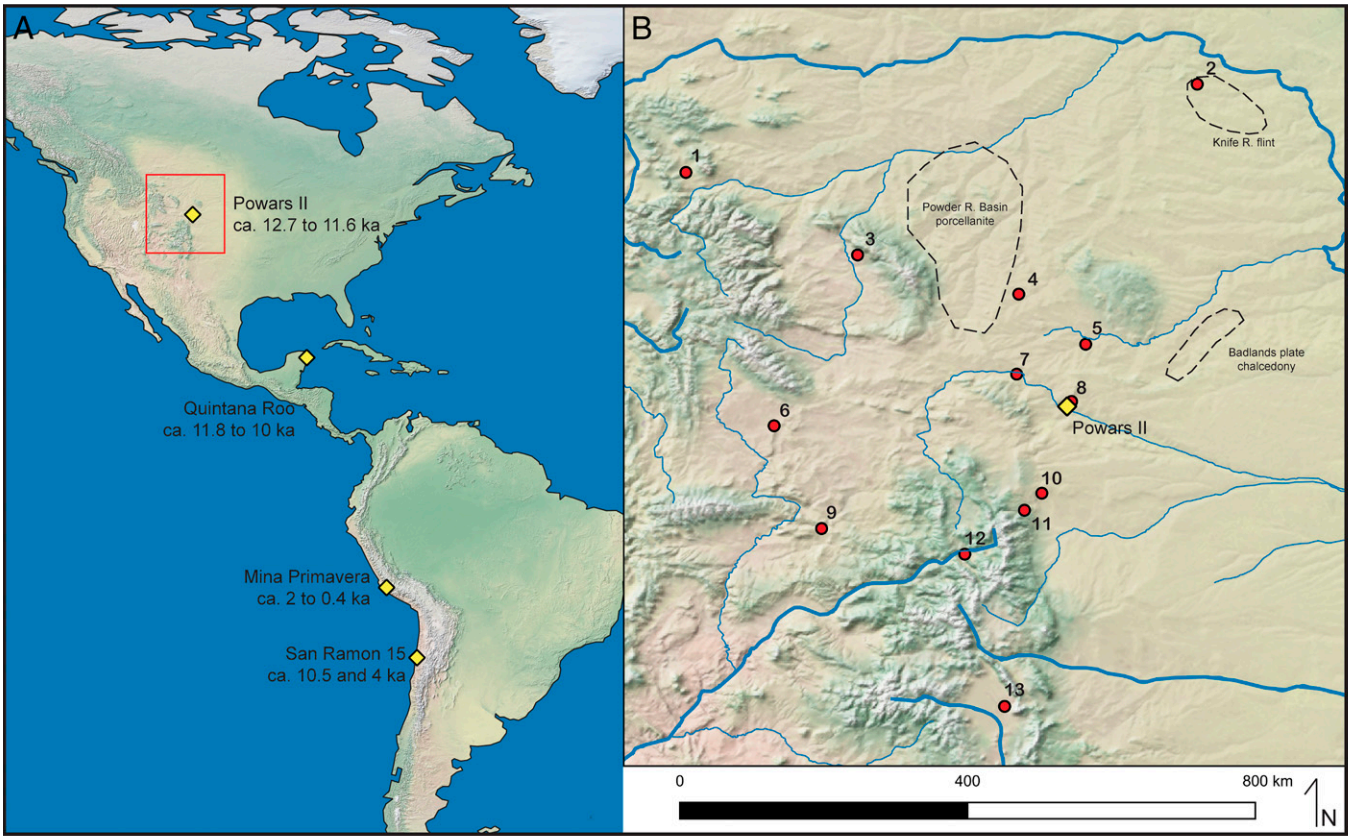

Fig. 1. Location of the Powars II site at hemispheric (*A*) and regional (*B*) scales. (*A*) Archaeological hematite quarries in the Americas and their ages. Red box in *A* refers to *B*: The High Plains, southern Rocky Mountains, and central Rocky Mountains showing the Powars II site (yellow diamond) relative to other archaeological sites older than *ca*. 11,000 cal B.P. containing hematite (red circles). Sites include 1, Anzick; 2, Big Black; 3, Hanson; 4, Carter/Kerr-McGee; 5, Agate Basin/Sheaman; 6, Krmpotich; 7, La Prele; 8, Hell Gap; 9, Kibridge-Yampa; 10, Lindenmeier; 11, Gordon Creek; 12, Barger Gulch, Locality B; and 13, Stewart's Cattle Guard.

pile of iron ore (*SI Appendix*, Fig. S1), truncated on its southwest margin by erosion, and obscured on its northeast margin by 20th-century mining haul road fill (*SI Appendix*, Fig. S2). The exposed portion of the depression measures 4.5 m northeast to southwest by 3.2 m northwest to southeast and is ∼1.2 m deep at its deepest point, growing shallower with distance from the exposed southwest margin until becoming obscured by road fill.

The quarry is surrounded by an extensive tailings deposit comprised of discarded iron ore nodules that covers an area of at least 800 intact square meters (*SI Appendix*, *Excavation Procedures* and Fig. S2). Tailings form the primary clast-sized archaeological matrix at Powars II, while fine-grained derivatives of hematite and hillslope sediments fill interstices between them. Based on evaluation of the site's exposed southern margin and limited testing, quarry tailings appear to grow thinner with distance from the quarry feature and in the upslope portions of the site. This supports the notion that tailings originated from a single quarry feature from which undesirable ore nodules were tossed aside and preferentially downhill so that site occupants could reach deeper hematite deposits. Tailings encountered during our excavation were coated by hematite particles that could be knocked loose for use as pigment, but they washed clean to a blue ore when exposed to subaerial weathering. Thus, the utility of discarded tailings as a transportable pigment source was limited compared to pure hematite, so they were discarded on site.

Quarried bedrock comprises a specularite and colloform hematite body capping ferruginous schist (6) (Fig. 2*B*). The hematite body is a silver ore that streaks red. It is soft enough to modify with hand tools and is texturally greasy, forming a slippery excavation floor. Schist is present in the floor of the excavation block at its east end and grades into a hematite body at its west end. Hematite deposits in the western half of the excavation block contain direct evidence for quarrying in the form of arcuate depressions and ledges formed by Paleoindian quarrying (Fig. 2*B*, dashed lines). In places, quarry features exposed in profile walls appear to conform closely to depressions in the hematite bedrock (Fig. 3), supporting the notion that the features we observed in the floor of the excavation block were created by people.

Conversations between Frison and site discoverer Wayne Powars in 1986 indicated that Powars made his initial discoveries at the exposed southwest margin of the quarry trench (Fig. 2*A*, landmark 2). In 1986, Frison and others placed an informal test unit opposite Powars's find location of the small, peninsula-like landform that represents the core of the Powars II site (Fig. 2*A*, landmark 1). We placed the 2017–2020 excavation trench in an east to west orientation obliquely across the quarry feature and between Powars's and Frison's excavation locations, thus bisecting the feature and linking previously investigated areas of the site (Fig. 2 *A*, landmark 4 and *B*–*D*).

Stratigraphy and Site Formation. We identified six depositional strata and nine substrata and lenses at Powars II (Fig. 3 and *SI Appendix*, *Stratigraphy*). Strata 1 through 3 represent aggradation of Late Pleistocene and Early Holocene deposits,

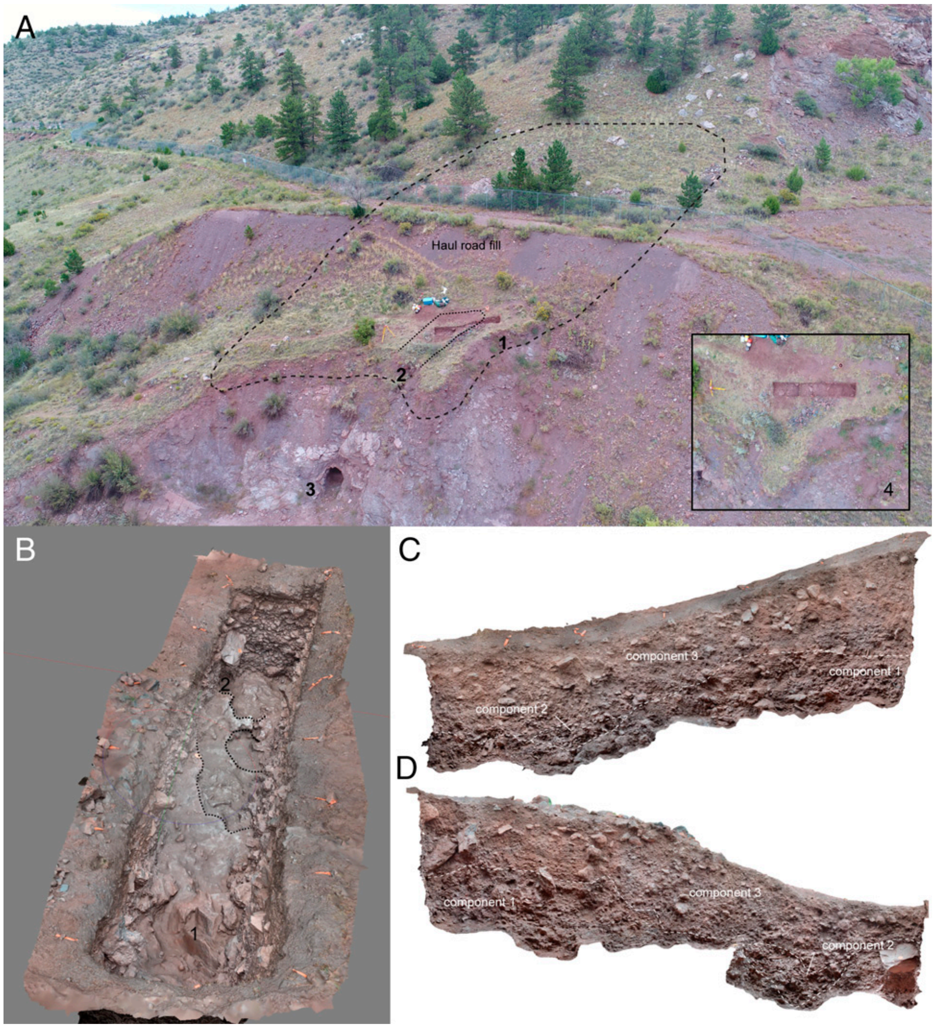

Fig. 2. Annotated overview of site settings and archaeological deposits. (*A*) Aerial drone image of the Powars II site during excavations in 2017 facing north. The 6-m by 1-m excavation trench is visible near the center of the image. The known extent of buried archeological deposits is indicated as a large dashed line, and quarry feature margins are indicated with a small dashed line (1). Location of Frison's 1986 informal test (2), location of Powars's initial discovery at south end of quarry feature (3), historic mine adit uncovered during salvage excavations between 2014 and 2017 (4), an aerial drone image looking straight down on site in 2017 to show the relationship between the archaeological trench and the quarry feature. (*B*) Three-dimensional photogrammetry rendering of the completed archaeological trench facing west. Margins of bedrock quarry pits are outlined with small dashed lines. (*C*) Three-dimensional photogrammetry rendering of the north wall of archaeological trench. (*D*) Three-dimensional photogrammetry rendering of the south wall of archaeological trench.

strata 4 and 5 represent truncation and redeposition since the site's abandonment, and stratum 6 represents early 20th-century industrial disturbance. Site sediments comprise quarry tailings, redeposited loess, and colluvium derived from exfoliated schist and sedimentary bedrock of the Guernsey Formation. Intact archeological deposits occur only in stratum 2 and features excavated into stratum 2. Here, we focus on describing stratum 2 and several aspects of site formation based on analyses of postdepositional artifact alterations. Other strata are described in *SI Appendix, Stratigraphy*.

Stratum 2 comprises two substrata, 2a and 2b. In the eastern half of the excavation block (Fig. 3), substratum 2a is extremely gravelly sandy loam containing iron ore boulders of up to several hundred pounds (Fig. 4*F*). In the western half, 2a is an extremely gravelly silty loam, where it predominantly comprises greasy, silvery hematite quarry tailings and fine-grained derivatives thereof. The upper surface of 2a formed the oldest occupation surface in the excavations, which was positioned on the tops of boulders on the east side of the block and on quarried hematite bedrock in the west. In situ artifacts of 2a are dominated by faunal fragments (Fig. 4*C*), likely a result of quarrying within 2a with bone and antler quarry tools and breaking them in the process. Substratum 2b is an extremely gravelly sandy loam overlying 2a in the eastern half of the excavation block comprising, primarily, quarry tailings and a diversity of in situ artifacts spanning many occupations.

We identified three quarry features excavated into stratum 2. A quarry feature excavated into 2a centered on unit 142E was formed during the Hell Gap occupation of the site (Movie S2) and is most visible in the south wall profile (Fig. 3). It contained at least two piles of artifacts comprising bones, antlers, and Hell Gap complex chipped stone artifacts situated within loosely consolidated cobbles (*SI Appendix,* Fig. S3). The feature is 130 cm wide at its upper surface and is 90 cm deep at its deepest portion in the south wall profile. Its upper surface is truncated by deposition of stratum 4, and it extends into both the north and south profiles, so these dimensions are minima.

Two other quarry features are less well defined and contain few artifacts (Fig. 3). Loosely consolidated cobbles exposed in the northwest corner of unit 141E comprise a quarry feature distinct from the Hell Gap quarry feature in 142E, but their stratigraphic relationship is unclear. The feature extends around

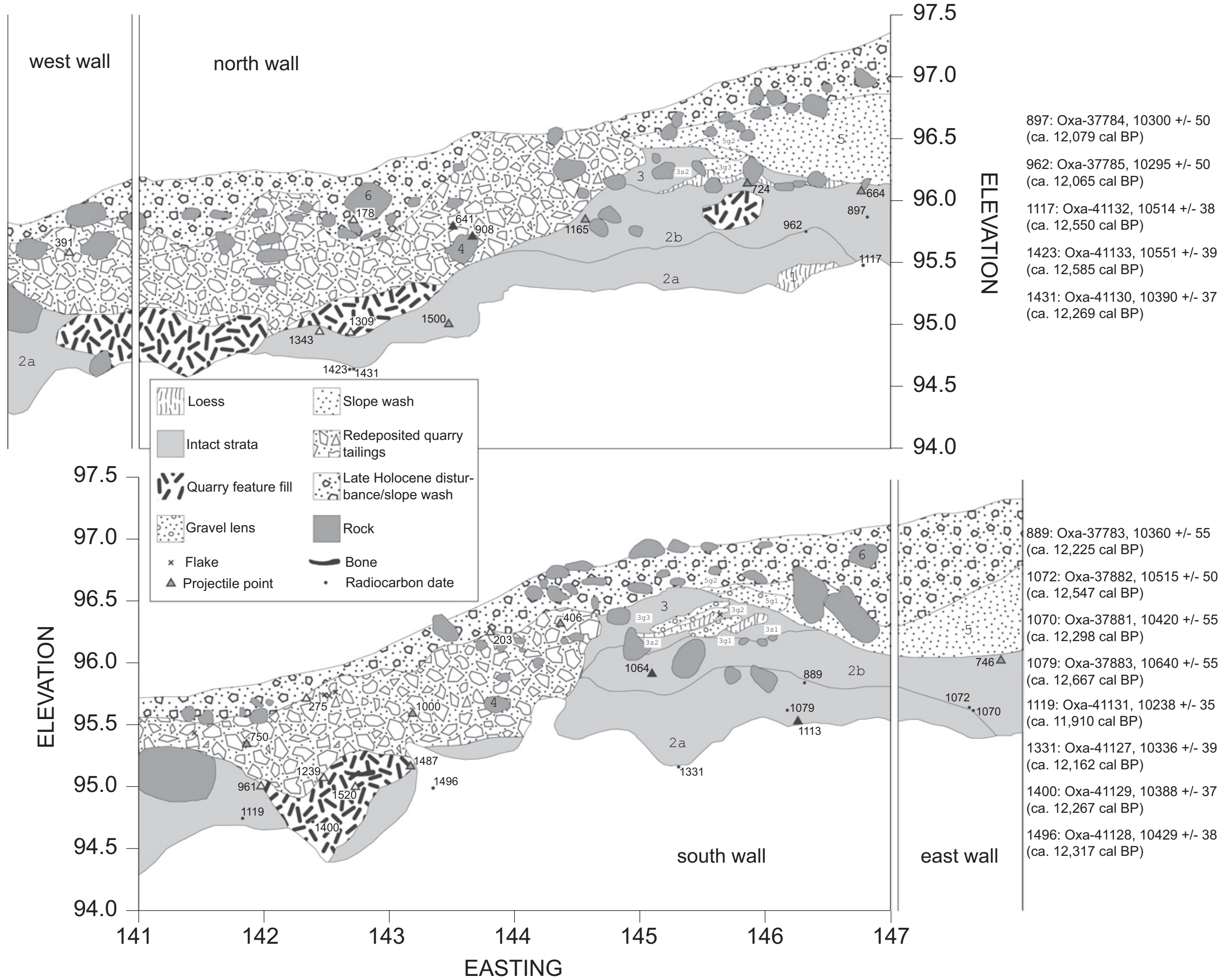

Fig. 3. Stratigraphic profiles from all four walls of the 2017–2020 excavation trench at Powars II. The south wall profile is reversed from illustrated to facilitate comparison with the north wall; cal B.P. dates denote the median.

a meter across the north wall of 141E and around 60 cm south into that unit along the west wall profile. It rests directly on bedrock along the north wall of 141E and is at least 56 cm deep, its top having been truncated by deposition of stratum 4. A third quarry feature is visible in the north wall profile of 145E. The feature is 50 cm wide and 30 cm deep and is completely subsumed by stratum 2 sediments, having been excavated during deposition of stratum 2b.

Powars II artifacts exhibit four postdepositional alterations that clarify earlier interpretations of the site assemblage and help discern between in situ and ex situ archaeological deposits (*SI Appendix, Postdepositional Alterations*). First, patina forms on the chert artifacts at Powars II due to subaerial exposure (7). Thus, when present, patina on chert artifacts was consistently located on their upper surfaces (beside artifacts in the recently displaced industrial fill of stratum 6). Chert artifacts from stratum 2 exhibit significantly less patina formation than those from strata 3 through 6 (X^2 (1, n = 599) = 192.358, $P <$ 0.0001) (*SI Appendix*, Fig. S6 and Table S5). Of the patinated artifacts, patination severity is comparable between in situ and ex situ contexts (X^2 (1, n = 599) = 0.2837, P = 0.594) (*SI Appendix*, Table S6). Therefore, comparable processes of patina formation exist between all strata, but in situ artifacts were less prone to patination due to rapid burial and limited subaerial exposure.

Second, "calcareous crust" (2) adhering to many of the surface-collected Powars II artifacts has been acknowledged since the earliest work at the site, but its origins remained unclear until these investigations. Almost all piece-plotted artifacts and rocks documented in strata 2 through 5 (but not the recently displaced stratum 6) possess calcareous crust on their undersides. Calcareous crust appears indicative of a calcic horizon formed after site stabilization wherein dissolved CO_2 present in meteoric water percolating through the site matrix was trapped beneath and then deposited on the undersides of objects. Calcareous crust tends to grow thinner with depth as objects exceed the percolation depth of meteoric water. Inorganic carbon loss on ignition results support this interpretation by showing peak inorganic carbon content around 60 cm below the surface that decreases rapidly with depth (*SI Appendix, Stratigraphy*, Table S4, and Fig. S4).

Third, 40% of piece-plotted flakes (n = 255) exhibit "edge crushing," a flake modification inferred, in prior Powars II studies, to be the result of hematite processing (*SI Appendix, Postdepositional Artifact Alterations*) (2). Edge-crushed artifacts are significantly overrepresented in ex situ strata 3 through 6

(X^2 (1, $n = 636$) = 26.7369, $P < 0.0001$) (*SI Appendix*, Table S7), and are especially common in industrially displaced stratum 6 (*SI Appendix*, Fig. S7). Thus, edge crushing appears to have occurred primarily due to artifact redeposition rather than use as quarry implements.

Lastly, a previous study suggested that the many bone fragments from Powars II were partially a result of bone tool production and that an absence of collagen many have been the result of intentional burning (1). Our recent excavations more accurately show that bone preservation improves with depth below ground surface, and that bones rapidly fragment and become depleted of collagen upon exhumation from in situ deposits. We recovered relatively few bone specimens from ex situ strata (Fig. 4*C*), and the few specimens present were poorly preserved. Conversely, bone preservation within intact stratum 2 ranges from poor to good. This pattern was apparent during excavation and supported by the results of collagen content testing (*SI Appendix*, *Radiocarbon Dating and Bayesian Modeling*), which demonstrates decreasing bone collagen content with increasing proximity to ground surface (*SI Appendix*, Fig. S8) (Pearson's r(43) = 0.4288, $P = 0.003293$).

Stratigraphy and site formation analyses support the notion that stratum 2 represents in situ site sediments at Powars II and clarify several phenomena previously noted for the site. Strata 3 through 5 were redeposited sometime after site abandonment, and stratum 6 was redeposited during the early 20th century. Thus, there are three readily identifiable analytical components for the Powars II site: the in situ artifacts of stratum 2 (component 1), artifacts from the Hell Gap quarry feature excavated into stratum 2 (component 2), and all other ex situ artifacts (component 3) (Fig. 4*A*).

Age. We tested 45 faunal bones from intact stratum 2 for collagen content, 13 of which contained enough for radiocarbon dating (*SI Appendix*, *Radiocarbon Dating and Bayesian Modeling*). All dates were derived from bone introduced into the site as quarry implements (Fig. 3) and range from 10,238 ± 35 radiocarbon years B.P. (RCYBP) (OxA-41131; *ca.* 11,910 cal

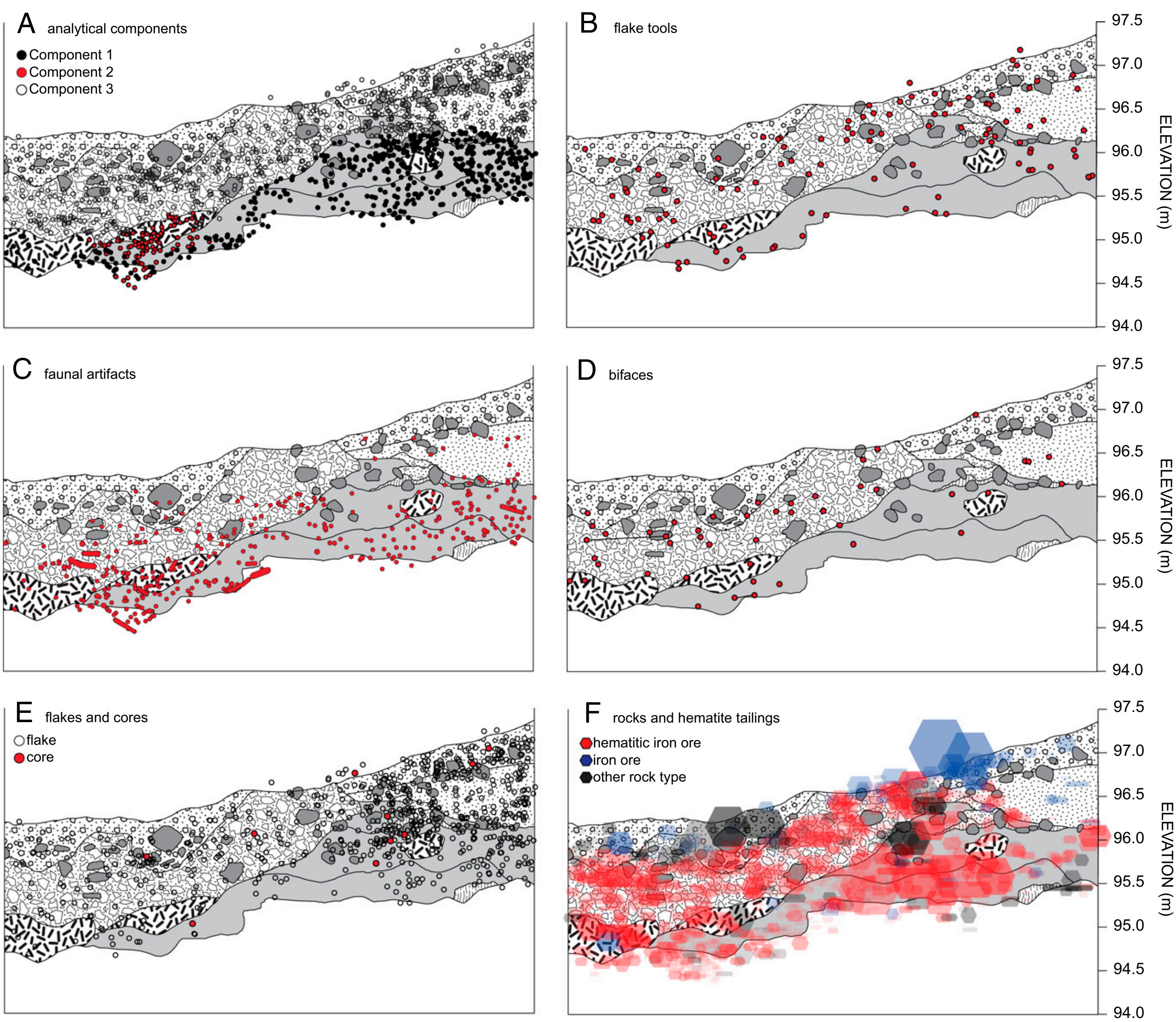

Fig. 4. Piece-plotted artifacts and rocks from the 2017–2020 investigations at Powars II presented as backplots against the north trench wall profile by category: (*A*) analytical components, (*B*) unifacial chipped stone tools, (*C*) faunal artifacts, (*D*) bifaces, (*E*) flakes and cores, and (*F*) hematite, iron ore, and other rocks. Rocks of *F* are displayed as schematic hexagons based on mapped rock easting, bottom and top elevations, and maximum length.

Table 1. Chronometric results for Powars II (stratum 2, component 1)

FS No.	P code	Percent collagen yield	C:N	Percent C	Percent N	$\delta^{13}C$ (‰)	$\delta^{15}N$ (‰)	Lab No.	Date (B.P.)	±	cal B.P. (range at 95.4% CI)	cal B.P. (median)
889	AG	0.8	3.4	42.3	14.7	−19.2	5.6	OxA-37783	10,360	55	12,480–11,945	12,225
897	AG	2.2	3.4	41.5	14.4	−12.9	5.8	OxA-37784	10,300	50	12,465–11,830	12,080
962	AG	1.2	3.3	42.1	14.9	−11.3	10.1	OxA-37785	10,295	50	12,460–11,830	12,065
1070	AG	2.8	3.3	41.5	14.5	−17.5	4.1	OxA-37881	10,420	55	12,610–12,000	12,300
1072	AG	2.2	3.3	41.2	14.4	−17.6	4.1	OxA-37882	10,515	50	12,690–12,195	12,545
1079	AG	1.9	3.3	40.5	14.1	−18.2	6.5	OxA-37883	10,640	55	12,735–12,495	12,665
1331	AG*	4	3.3	31	11.1	−17.4	4.2	Oxa-41127	10,336	39	12,465–11,940	12,160
1496	AG*	2.7	3.2	33	11.8	−17.8	4.5	Oxa-41128	10,429	38	12,605–12,095	12,315
1400	AG*	3.9	3.2	33.6	12	−19.1	4	Oxa-41129	10,388	37	12,480–12,000	12,265
1431	AG*	3.9	3.3	34.6	12.4	−18.7	5.1	Oxa-41130	10,390	37	12,480–12,005	12,270
1119	AG*	1.6	3.3	43.8	15.5	−17	3.3	Oxa-41131	10,238	35	12,095–11,760	11,910
1117	AG*	4	3.3	31	11.1	−16.2	4.7	Oxa-41132	10,514	38	12,675–12,330	12,550
1423	AG*	6	3.3	32.4	11.6	−17	5	Oxa-41133	10,551	39	12,685–12,480	12,585

All dates are derived from bison bone fragments.

B.P.) to 10,640 ± 55 RCYBP (OxA-37883; *ca.* 12,670 cal B.P.) (Table 1). We failed to date component 2 due to poor collagen preservation, and all dates derive from component 1. Bayesian modeling results estimate the start of cultural occupation associated with component 1 to between 12,840 and 12,505 cal B.P. and its end to between 12,260 and 11,750 cal B.P. (*SI Appendix*, Fig. S5). In tandem with an estimated duration of 265 y to 1,020 y, the modeled output suggests that component 1 saw multiple cultural occupations rather than a single, discreet episode. The data also confirm our suspicion that two nonprovenienced bone artifacts previously dated to 8,020 ± 30 RCYBP (Beta-445766; collagen fraction with no reported quality control parameters) and 9,250 ± 30 RCYBP (Beta-442511; carbonate fraction) (1) were unreliable, most likely contaminated with younger ^{14}C.

Artifacts. Here, we report 1,223 artifacts recovered from our investigations at Powars II (excluding most artifacts recovered from screen): 494 from component 1, 94 from component 2, and 634 from component 3 (Table 2 and Fig. 4*A*). Component 1 is associated with diagnostic artifacts of the Clovis and Plainview cultural complexes (Fig. 5 *P*–*V* and *SI Appendix*, *Artifact Typology*), and radiocarbon dates are consistent with these typological categories. Our modeled starting age estimate for component 1 of 12,840 to 12,505 cal B.P. overlaps with several estimates for the terminal age of Clovis (8–10), and our total occupation span overlaps entirely with age estimates for the Plainview (elsewhere "Goshen") cultural complex (11). Component 1 was created during multiple occupations over a period of no less than 265 y. Thus, the temporal relationship between Clovis and Plainview at Powars II is currently unclear, but it is likely that Clovis slightly predates Plainview given their known temporal relationship elsewhere.

There are four types of bifaces from Powars II, and component 1 contains examples of them all, including biface blanks, projectile point preforms, ultrathin knives, and "large bifaces" (Fig. 4*D* and *SI Appendix*, Fig. S9 and *Artifact Typology*). Further, component 1 contains a diverse assemblage of flake tools possessing use retouch, notches, end scrapers, and other types of unifacially retouched margins (Fig. 4*B* and *SI Appendix*, Fig. S10 and *Artifact Typology*). Flakes and core fragments indicate that flintknapping was a common activity during component 1 occupations (Fig. 4*E* and *SI Appendix*, Fig. S11*F*).

A notable bone specimen from component 1 is a piece of cortical bone split lengthwise and modified by oblique hatching on one surface and rounding on the other (Fig. 5*N*). This artifact is likely the fractured distal end of a Paleoindian bone rod, which is proposed to have been used as a component of spear point hafts (12). Six pieces of freshwater mussel shell from component 1 were likely used to produce beads of the sort previously discovered at Powars II (2), although the fragments are not visibly modified. Component 1 contains 186 other piece-plotted faunal specimens, many of which possessing evidence for use as digging tools, and these are discussed more thoroughly below.

Table 2. Summary of piece-plotted artifacts by component for Powars II

	Component				
Tool type	1	2	3	ND	Total
Faunal artifacts	187	67	99	0	353
Core total	3	1	6	0	10
Flake total	246	14	400	0	660
Flake tool total	34	4	74	0	112
Use retouch	18	1	41	0	60
Unifacial retouch	16	3	33	0	52
Biface total	13	3	32	1	49
Blank	1	0	3	0	4
Preform	6	3	13	1	23
Ultrathin	2	0	10	0	12
Large biface	2	0	2	0	4
Small fragment	2	0	4	0	6
Projectile point total	9	5	14	0	28
Clovis	1	0	2	0	3
Plainview	6	0	4	0	10
Hell Gap	0	5	4	0	9
Nondiagnostic	2	0	4	0	6
Hammerstones	0	0	3	0	3
Abraders	0	0	1	0	1
Manuports	2	0	5	0	7
Total	494	94	634	1	1,223

Chipped stone counts include a small number of artifacts from screen. ND, not determined.

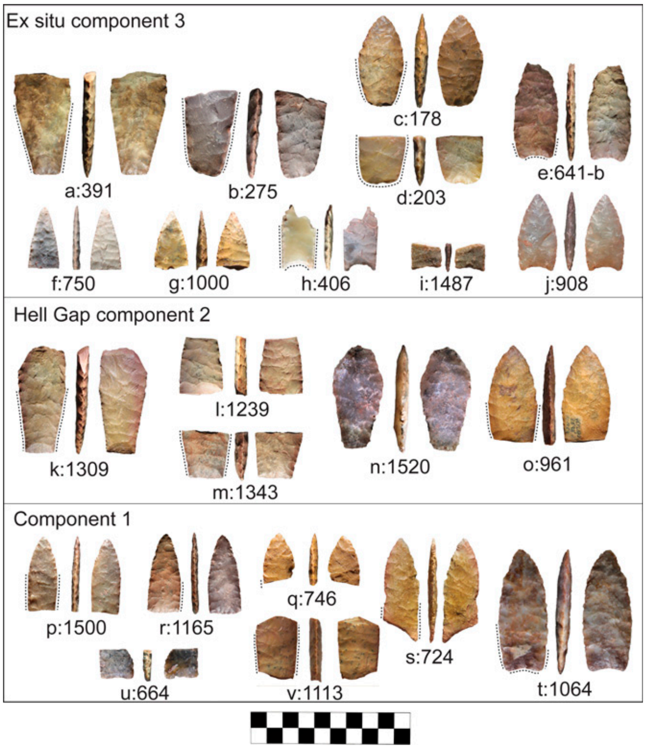

Fig. 5. Diagnostic projectile points organized by site stratum. Dashed lines denote extent of ground edges. Typological designations are (*A*) Hell Gap; (*B*) Hell Gap; (*C*) Hell Gap; (*D*) Hell Gap; (*E*) Clovis; (*F*) Plainview; (*G*) Plainview; (*H*) Plainview; (*I*) Plainview; (*J*) Clovis; (*K*) Hell Gap; (*L*) Hell Gap; (*M*) Hell Gap; (*N*) Hell Gap; (*O*) Hell Gap; (*P*) Plainview; (*Q*) Plainview; (*R*) Plainview; (*S*) Plainview; (*T*) Clovis; (*U*) Plainview; and (*V*) Plainview. Catalog numbers in Figure refer to those noted for Fig. 3 projectile points.

Component 2 is associated with a Hell Gap cultural complex quarry feature. Component 2 must date younger than component 1, because it is excavated into it. Our terminal age estimate for component 1 of 12,260 to 11,750 cal B.P. is consistent with an inferred date of *ca.* 11,600 cal B.P. for component 2 based on age estimates from the nearby Hell Gap site (13). Unlike component 1, component 2 appears to represent a single behavioral event associated with excavation and backfilling of a quarry pit. We acknowledge that some artifacts may have been displaced from component 1 during component 2 quarry pit excavation, but we suspect they represent a minority of component 2 artifacts. The quarry pit is notable for its density of projectile points (Fig. 5 *K*–*O*), biface preforms (*SI Appendix*, Fig. S9 *N*–*P*), and faunal artifacts for such a small portion of the site, all of which commonly found placed in small piles within the feature (*SI Appendix*, Fig. S3). Flake tools (*SI Appendix*, Fig. S10 *N*–*P*) and flakes are less common in component 2.

A modified rib (Fig. 6*M*) recovered from component 2 found in direct association with a Hell Gap point is notched on both edges, exhibiting minima of 48 notches on one edge and 22 on the other (Movie S2). On the longer edge, every three to six notches is slightly longer, with a total of nine long notches. This artifact is unique in the Paleoindian record, but the hatching is comparable to that on bone rods of the East Wenatchee cache (14). Component 2 contains 66 other piece-plotted faunal specimens.

Ex situ component 3 contains a mix of all artifact types from components 1 and 2 and other items not recovered from either in situ component. Artifacts unique to component 3 include three gravers (*SI Appendix*, Fig. S10 *E* and *F*), three hammerstones, and a grooved sandstone abrader (*SI Appendix*, Fig. S11 *A*–*D*). Given the constituents of components 1 and 2, we suspect that most component 3 stone artifacts besides diagnostic Hell Gap points and preforms were originally derived from component 1. As previously noted, component 3 contains less fauna than expected, due to site formation processes that destroyed faunal artifacts.

We identified raw materials in the chipped stone tool assemblage on the basis of macroscopic characteristics (*SI Appendix*, Table S8). Predominant local raw materials include orange, dendritic chert of the Hartville Formation, and several varieties of metaquartzite. These raw materials combined comprise 74% of all piece-plotted chipped stone artifacts. Definitive nonlocal materials include Knife River flint (Fig. 5*U* and *SI Appendix*, Figs. S9*O* and S10 *G*, *K*, and *Q*) (500 km), Powder River Basin porcellanite (250 km to 400 km), and White River Group Badlands plate chalcedony (Fig. 5 *H* and *J* and *SI Appendix*, Fig. S10*D*) (200 km to 300 km) (15) (Fig. 1). Nonlocal raw materials of widespread abundance in the region include other sources of White River Group silicates (16), petrified wood, Goose Egg/Phosphoria Formation chert, and Morrison Formation quartzite (Fig. 5 *A*, *E*, and *K*–*M*). Nonlocal raw materials for which positive identification is likely include Alibates silicified dolomite (Fig. 5*T*) (800 km) and Edwards Plateau chert (Fig. 5*R* and *SI Appendix*, Fig. S10 *H*, *L*, and *M*) (1,400 km to 1,600 km), but we remain conservative in these assignments until more-thorough sourcing studies are conducted. The presence of Edwards Plateau chert at Powars II would rank among the longest transport distances thus far documented for northern Plains Early Paleoindian sites (17). Its presence in the comparably aged Lindenmeier site (150 km south) supports the notion that it was occasionally transported or exchanged between the southern and northern Plains (18). Other unidentified raw materials may be derived from distant sources as well, but we were unable to confidently assign them to source areas. Notably, raw materials of the Rocky Mountain interior present in sites of comparable age such as obsidian (19) and Green River, Bridger, and Troublesome Formation cherts (20) are absent from Powars II (2), suggesting a strong connection to the Plains rather than Rocky Mountains environment.

Paleoindians incorporated fauna into the site primarily as a means of quarrying hematite, using long, thin elements like ribs (Fig. 6 *A*–*G*), antlers (Fig. 6 *J*–*L*), and long bones (Fig. 6 *H* and *I*) to extract the mineral (*SI Appendix*, Table S9). At least 168 faunal artifacts (47%) exhibit evidence for human modification. Cutmarks and striations were likely created by prying bones against rock while quarrying, and polish is present on the blunted ends of bones and antlers used to quarry hematite. Most faunal artifacts were likely used as digging implements, but not all possess direct evidence for use, having been broken at nonmodified portions. Positively identified genera include *Bison* sp., *Odocoileus* sp., *Antilocapra americana*, *Canis* sp., and freshwater mussel (likely *Lampsilis* sp.). *Bison* sp. dominates the assemblage, especially if one assumes they represent all size class 4 fragments (82% of specimens identifiable to element). A single palmate antler fragment from component 2 is likely caribou (*Rangifer tarandus*), given their known Pleistocene distributions (21). Some antler fragments could have belonged to either *Odocoileus* or *Cervus canadensis*, based on size, but all antler fragments fall within the *Odocoileus* range of variation. The presence of definitive *Odocoileus* but not *Cervus* bones supports the notion that all antlers (besides a single palmate fragment) are *Odocoileus*.

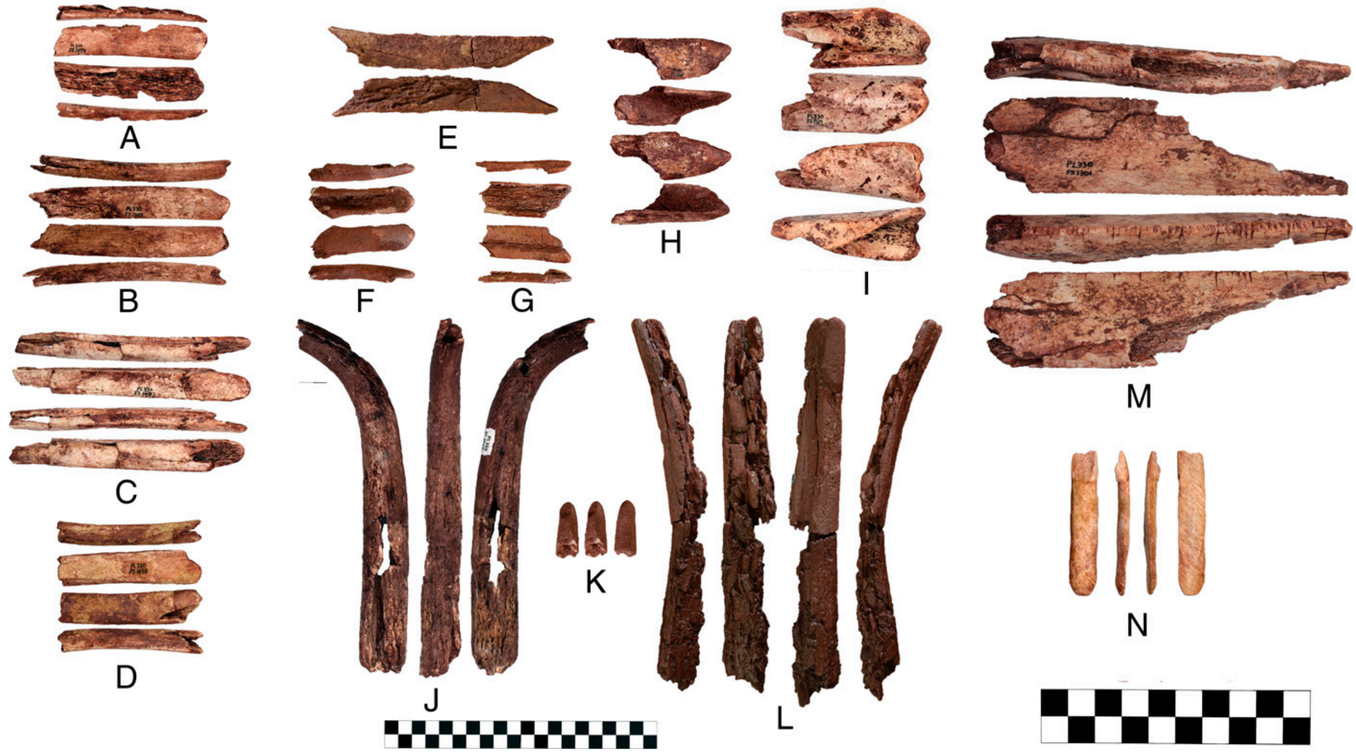

Fig. 6. A selection of modified faunal artifacts from Powars II: (*A–G*) abraded and polished rib segments, (*H* and *I*) green-fractured long bone fragments blunted and polished on one end, (*J–L*) antler fragments blunted and polished on distal tips, (*M*) unique incised bone artifact, and (*N*) likely bone rod fragment.

Discussion

Intact artifacts and features at Powars II demonstrate unequivocal evidence for hematite quarrying by Paleoindians beginning *ca.* 12,840 to 12,505 cal B.P. and continuing through the Hell Gap complex *ca.* 11,600 cal B.P., thus establishing Powars II as the oldest hematite quarry identified in the Americas. Beyond its status as a hematite quarry, the Powars II artifact assemblage is itself one of densest and most diverse of any thus far discovered in the early Paleoindian record of the Americas. The site contains over 30 chipped stone tools per square meter, some of the oldest canid remains from an American archaeological site (22), and rare and/or unique faunal artifacts, among other distinctions. Despite the richness of our excavated sample, the site is known to contain artifacts that we did not recover within our 6-m^2 excavation, most notably Folsom and Agate Basin type spear points (1) and shell beads (2). Further, we note that Clovis points comprise a minority of points from our excavation but most from prior salvage excavations (1), raising the possibility of lateral variation in site use (i.e., different quarry areas operating at different times). Further excavation of the estimated 800 m^2 remainder of the site will certainly reveal complexity not captured by our sample.

With recognition that further excavation may refine our interpretations, the current evidence from Powars II suggests two primary periods of site use. The earliest use is associated with artifacts of the Clovis and Plainview cultural complexes in component 1, whose occupants quarried hematite with bones and antlers, produced and repaired weaponry, and performed other tasks associated with the extensive stone tool assemblage over a period of several hundred years. Based on our excavated sample and consistent with previous studies (1, 2), most Powars II artifacts appear associated with the early Paleoindian occupations of component 1. After an occupational hiatus of possibly a century or more, the site was occupied by individuals of the Hell Gap complex. This later occupation (component 2) excavated through the tailings of earlier occupants to reach hematite bedrock and deposited artifacts in piles within a quarry pit that likely represents a single behavioral event. The Hell Gap occupation appears behaviorally distinct from earlier occupations, because it is confined to the central portion of the quarry feature created during earlier occupations, and Hell Gap occupants do not appear to have undertaken flint knapping or chipped stone tool use.

Hematite is relatively common in Plains and Rocky Mountains Paleoindian archaeological sites exceeding *ca.* 11,000 cal B.P., and it appears to have possessed a wide range of functions, both symbolic and prosaic, within Paleoindian society (23). Hematite has been recovered in virtually every Paleoindian archaeological context, including caches (24), burials (25, 26), animal kills (27), adhering to hide working tools (28, 29), and in campsites (30–33) (Fig. 1). Geochemically sourced Powars II hematite from the Hell Gap (32) and La Prele mammoth sites (27) demonstrates its importance in Paleoindian mobile tool kits. Given the presence of hematite within mobile tool kits alongside the widespread chipped stone raw material network present at Powars II, we suspect that red ocher from other Plains and Rocky Mountains Paleoindian sites may be sourced to Powars II.

Materials and Methods

We excavated each 1 m by 1 m unit in a single meter squared in 5-cm levels. Excavations piece-plotted chipped stone and bone artifacts 2 cm or larger to millimeter precision with a total station and rocks 10 cm or larger using rulers and line levels to centimeter precision. Excavators noted the location (top/bottom/both) of patina and calcareous crust formation on artifacts and recorded artifact orientation and inclination in 2017. Excavations discontinued recording orientation and inclination after realizing that all artifacts were interspersed within large rocks that influenced their orientation and inclination at hyperlocal scales. For each rock, excavators documented its type, maximum length, easting, northing, top elevation, and bottom elevation. Screening was initially passed through 1/4-inch mesh to remove large rocks and artifacts, and all material that passed through the screen was collected with a funnel into buckets. Bucketed material was then passed through 1/16-inch mesh to remove silts. All remaining material was stored, and final processing of these materials is ongoing. See *SI Appendix* for additional methods.

Samples were processed for radiocarbon dating at the Oxford Radiocarbon Accelerator Unit (ORAU). Bones were first manually cleaned by air abrasion and cut using a small diamond disk. Fragments were chemically pretreated and targeted for "collagen" (following the use of this term in refs. 34–36) by means of an acid–base–acid protocol, gelatinization, and Ezee filtration (ORAU pretreatment code "AG") (37). Where consolidants were present, chemical pretreatment was preceded by a series of solvent washes (acetone/methanol/chloroform), and the pretreatment code was given an asterisk, for example, AG*. Once collagen was obtained, samples were placed into tin capsules and combusted in an elemental anlyzer (EA) (Carlo-Erba NA-2000) coupled to a continuous flow-isotope ratio mass spectrometer (CF-IRMS) (Sercon 20/20). This allowed for measurement of elemental ratios (CN) and stable isotope values (δ13C and δ15N), which are used for quality assessment in radiocarbon dating (37). Samples were graphitized according to ref. 38, and radiocarbon measurement was undertaken following ref. 39, using High Voltage Engineering Europa or Mini Carbon Dating System (Ionplus) accelerator mass spectrometers.

Small discrepancies in artifact counts between Dataset S1, Table 2, and *SI Appendix*, Table S8 occur for two reasons. First, around three dozen artifacts recovered near the beginning of the project were mistakenly cataloged with previous salvage artifacts. These artifacts are accounted for in field notes but were unavailable to study for laboratory analyses. Second, some significant artifacts recovered from screens are included in Table 2 and *SI Appendix*, Table S8, but not in Dataset S1, which only includes piece-plotted artifacts.

We identified faunal specimens through direct comparison to modern faunal collections housed at the University of Wyoming Department of Anthropology. Comparative specimens included the bones and/or antlers of *Bison bison*, *Alces alces*, *C. canadensis*, *R. tarandus*, *A. americana*, *Odocoileus hemionus*, *Ovis canadensis*, and *Canis lupus*. We assigned all specimens for which size class is identifiable to one of three size classes, 2 through 4. *Canid* remains are assigned to size class 2, *Rangifer*, *Antilocapra*, and *Odocoileus* to size class 3, and *Bison* to size class 4. We assigned specimens identifiable to size class but not species only to size class, but we suspect these specimens belong to one of the three ungulates for which identifiable bones are present (*Bison* sp., *A. americana*, and *Odocoileus* sp.).

We identified chipped stone raw materials on the basis of macroscopic comparison to comparative specimens housed at the University of Wyoming. Comparative specimens include a wide range of materials from throughout the Great Plains and Rockies. Most important for this study are Edwards chert, Alibates silicified dolomite, White River Group plate chalcedony, Powder River Basin porcellanite, and Knife River flint. Chipped stone specimens categorized as "other unidentified material" subsume a wide range of predominantly cryptocrystalline raw materials. Some specimens are completely patinated to the point of obscuring raw material characteristics, while others bear no resemblance to comparative specimens at our disposal and could not be identified with confidence.

Data Availability. All study data are included in the article and/or supporting information. Artifacts are stored at the Sunrise Historic and Prehistoric Preservation Society in Sunrise, WY and may be accessed by request to author Zeimens.

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