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Terminal Pleistocene human occupation of the upper Copper River basin, southern Alaska: Results of test excavations at *Nataeł Na'*

John T. White[a,*], Auréade Henry[b], Stephen Kuehn[c], Michael G. Loso[d], Jeffrey T. Rasic[e]

[a] *Center for the Study of the First Americans, Department of Anthropology, Texas A&M University, 4352 TAMU, College Station, TX, 77843, USA*
[b] *Université Côte D'Azur, CNRS, UMR 7264 CEPAM, France*
[c] *Department of Physical and Environmental Sciences, Concord University, 1000 Vermillion St, Athens, WV, 24712, USA*
[d] *Wrangell-Saint Elias National Park and Preserve, PO Box 439, Copper Center, Alaska, 99573, USA*
[e] *Gates of the Arctic National Park and Preserve and Yukon-Charley Rivers National Preserve, 4175 Geist Rd, Fairbanks, AK, 99709, USA*

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A B S T R A C T

After decades of debate, the homeland of the First Americans is now generally understood to be northeast Asia; however, the process of Late Pleistocene peopling remains unresolved. As more archaeological sites south of the continental ice sheets are discovered that predate the opening of the interior "ice-free" corridor, interest in a coastal Pacific dispersal route has grown, and previously overlooked regions proximal to the Pacific coast have become a central focus of exploration efforts. The Copper River basin of southern Alaska is one such region. Here we present the results of 2019 archaeological excavations at *Nataeł Na'*, a buried and stratified archaeological site situated along the upper Copper River. The site contains a robust occupation dating to the late Younger Dryas climate reversal as well as an earlier occupation dating to the late Allerød interstadial. This discovery demonstrates that Pleistocene hunter-gatherers inhabited the Pacific basin of southern Alaska during the same time Clovis peoples inhabited temperate North America. The occupations at *Nataeł Na'* join a growing body of evidence suggesting that the early inhabitants of eastern Beringia were geographically more widely dispersed than previously documented.

1. Introduction

Although the precise timing of initial human dispersal throughout the Americas is still highly debated (Ardelean et al., 2020, 2021; Becerra-Valdivia and Higham, 2020; 2021; Bennett et al., 2021; Boëda et al., 2021; Bourgeon, 2021; Bourgeon et al., 2017; Chatters et al., 2021; Davis and Madsen, 2020; Davis et al., 2019, 2020; Fiedel et al., 2020; Goebel et al., 2022; Coutouly, 2021; Krasinski and Blong, 2020; Potter et al., 2021; Vachula et al., 2019, 2020; Williams and Madsen, 2020), current genomic analyses predict that a dispersal out of Beringia to temperate North America occurred shortly after the Last Glacial Maximum ~19,000–14,000 calendar years before present (cal BP) (Moreno-Mayar et al., 2018a, Moreno-Mayar et al., 2018b; Raghavan et al., 2014, 2015; Rasmussen et al., 2014, 2015; Reich et al., 2012; Sikora et al., 2019; Tamm et al., 2007; Willerslev and Meltzer, 2021). Technological similarities between lithic artifact assemblages recovered from northeast Asia and northwest North America have long suggested a Beringian connection (Dixon, 1999, 2001; Goebel, 2004; Hoffecker, 1996; Hoffecker et al., 1993, 2020; Pitulko et al., 2017), though the exact nature of this connection still eludes us (Goebel and Hoffecker, 2017; Krasinski and Blong, 2020; Pratt et al., 2020). There is general agreement, however, that if such dispersal occurred prior to ~15,000 cal BP (as the increasingly robust record south of the Canadian ice sheets suggests [Davis et al., 2019; Dillehay et al., 2008; Halligan et al., 2016; Jenkins et al., 2012; Shillito et al., 2020; Waters et al., 2018]), then humans likely followed a route along the Pacific coast of northwest North America, as this 'corridor' appears to have been ice-free and habitable by ~17,000 cal BP (Ager, 2019; Ager et al., 2010; Darvill et al., 2018; Lesnek et al., 2018; Shaw et al., 2019). The alternative interior corridor east of the Canadian Rocky Mountains did not become a viable route until sometime between 14,900 and 13,200 cal BP (Froese et al., 2019; Heintzman et al., 2016; Margold et al., 2019; but see Potter et al., 2018). Even if dispersal from Beringia occurred after the opening of the interior corridor, the coast likely still facilitated human dispersal (Goebel et al., 2008a; Lindo et al., 2017; McLaren et al., 2015, 2018, 2021; Waters, 2019).

* Corresponding author.
E-mail address: j.w@tamu.edu (J.T. White).

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The Beringian Standstill model (Tamm et al., 2007) posited that the populations ancestral to the First Americans were isolated in Beringia long enough to experience a significant genetic bottleneck (Hoffecker et al., 2014, 2016; Moreno-Mayar et al., 2018a; Sikora et al., 2019). More recent full-genome studies have further complicated our understanding of the timing and population structure of the first human entry into the Americas (Moreno-Mayar et al., 2018a, Moreno-Mayar et al., 2018b; Sikora et al., 2019) and the nature and location of any potential "standstill". These studies identified at least two distinct populations which contributed to the genomes of subsequent Native Americans (Moreno-Mayar et al., 2018a; Sikora et al., 2019). One, referred to as the Ancient Beringians (Moreno-Mayar et al., 2018a), has been identified in the genomes of two Early Holocene child burials from Upward Sun River in interior Alaska (Moreno-Mayar et al., 2018a; see also Potter et al., 2014b). The other is known only from its contribution to later populations. Some suggest that this "ghost population" inhabited the southern coastal regions of Beringia (Davis and Madsen, 2020; Moreno-Mayar et al., 2018a; Sikora et al., 2019) and may represent the long-envisioned coastal Paleoindians of southern Alaska (e.g., Dixon, 1999). This "ghost population," however, also might be expressed in the Tanana basin's Nenana Complex, which predates the Upward Sun River burials by more than two millennia and is characterized by distinctive technology (Pratt et al., 2020:92). The apparent importance of an unknown coastal population to the peopling of the Americas has been garnering increased attention, highlighted by the discovery of ancient human footprints estimated to predate 13,000 cal BP on Calvert Island, British Columbia (McLaren et al., 2018, 2021), though it is also important to note that if southern Alaska was populated from the north by groups wielding Nenana Complex technologies, they may not have reached the coast at all. Regions south of the Alaska Range, including the Copper River basin, may yield important discoveries that can help to clarify the connection, if any, of known interior populations to heretofore unknown populations that may have inhabited the southern Beringian coast.

Despite increasing evidence supporting the coastal migration theory (Braje et al., 2020; Davis and Madsen, 2020; Lindo et al., 2017; McLaren et al., 2014, 2015, 2018, 2019; Moreno-Mayar et al., 2018a; Raghavan et al., 2014, 2015; Sikora et al., 2019), the current archaeological record of Alaska does not support it (Potter et al., 2014a; Pratt et al., 2020). Although at least fifteen archaeological sites are now known from Alaska that date to the Allerød interstadial and earlier (i.e., ≥13,000 cal BP) (Goebel and Potter, 2016), all of this evidence, including Alaska's oldest dated site Swan Point (Holmes, 2011), is situated well into Alaska's interior, north of the Alaska Range (Dixon, 1999, 2013; Goebel and Potter, 2016; Holmes, 2011; Potter et al., 2014a; Rasic, 2011), more proximate to the 'opening' of the interior corridor than the coastal corridor (Fig. 1). South of the Alaska Range, nearer the coast, the earliest known occupations date to only 12,600 cal BP in the Susitna Valley and later along the coast itself (Ackerman, 1992; Blong, 2018; Dumond, 1975; Dumond and Bland, 1995; Dumond et al., 1977; McCartney and Veltre, 1996; Reger and Wygal, 2016; West, 1996a, 1996b; West et al., 1996a; 1996b, 1996c; Wygal, 2018; Wygal and Goebel, 2011, 2012; Wygal and Krasinski, 2019), more than a millennium after the earliest evidence of humans in Alaska's interior. On the southcentral Alaskan coast there are no known Late Pleistocene sites (Ackerman, 1992, 1996; Davis, 1996; Dumond and Bland, 1995; Reger and Wygal, 2016; Steffian et al., 2002; Workman, 1998), and the earliest evidence of a regional maritime adaptation dates to only ~7500 cal BP in the Kodiak Archipelago and adjacent regions (Ackerman, 1992; Dixon, 2013; Dumond and Bland, 1995; Steffian et al., 2002; Wygal and Krasinski, 2019); it should also be noted, however, that there is an equally apparent paucity of firmly dated sites within the interior ice-free corridor itself (Waters, 2019, but see Smith and Goebel, 2018). This picture is complicated by the likelihood that Pleistocene-aged sites may have been inundated during Early Holocene sea-level transgression in many parts of coastal Alaska (Dixon, 1999; Hoffecker and Elias, 2007; Potter et al., 2018). Regions proximal to the coast, but not directly impacted by sea level change, have been recognized as potentially important to our understanding of peopling events in the far north. The Copper River basin represents one such region.

Until recently, the only evidence of Pleistocene-aged human activity in the upper Copper River basin (i.e., the region today largely encompassed by Wrangell-Saint Elias National Park and Preserve) has been indirect: Wiki Peak obsidian, sourced from south of the Alaska Range, occurs in archaeological contexts across interior Alaska and Yukon, including the earliest components of such sites as Broken Mammoth in the Tanana Valley, Walker Road and Moose Creek in the Nenana Valley, and Little John in the westernmost Yukon (Goebel, 2011; Goebel et al., 2008b; Reuther et al., 2011) (Fig. 1). While past research in the Copper River watershed focused on melting alpine ice patches yielding Late Holocene, ~3075 cal BP, perishable artifacts (Dixon et al., 2005) and recent villages in the Gulkana area (Cooper, 2012; Hanson, 2008; Holmes and McMahan, 1986), in 2016 National Park Service archaeologists identified *Nataeł Na'* (NAB-00533), a buried multi-component prehistoric site located in the upper Copper River basin between the Alaska Range and Wrangell Mountains (Fig. 2) (Reininghaus, 2019). Limited test excavations identified two discrete cultural components at two separate loci. At Locus A, a combustion feature was dated to ~12,000 cal BP, while at Locus B two separate features were dated to ~4500 and ~3200 cal BP (Reininghaus, 2019). In 2019 a team from Texas A&M University, Principal Investigator: T. Goebel, expanded test excavations at *Nataeł Na'* to further investigate Locus A's ~12,000 cal BP component. Following our 2019 excavations consultations were held with representatives of the Ahtna[1] Intertribal Resources Council to name the site in accordance with existing Alaska Native placenames. Here we present new results relating to this early occupation and report the discovery of an even earlier component dating to the Allerød interstadial, both at Locus A. The latter represents the first evidence of human occupation in the north Pacific watershed of southern Alaska dating to the time of Clovis in temperate North America.

2. Geographic-geomorphic setting and background

Nataeł Na' is located along the upper Copper River on a low, southwest-trending ridge (~780 m above sea level [m asl]) about 20 km southeast of the village of Slana, between the Wrangell Mountains (to the south) and Mentasta Pass of the Alaska Range (to the north) (Fig. 2A). The Copper River's braided channel is incised, with steep slopes ascending to high terraces on both sides. Tanada Creek, which flows from Tanada Lake to join the Copper River 4 km northwest of *Nataeł Na'*, is situated ~150 m to the north of the site (Fig. 2B). The site's landform is composed of Late Pleistocene sands of an unknown depth, capped by successive aeolian deposits up to 50 cm thick (see Fig. 4). These aeolian deposits extend into the Holocene, with discontinuous tephra pockets present near the top of the sequence. The basal sands resemble nearby deltaic deposits, exposed in the banks of Tanada Creek, which exhibit clear foreset beds and occur at elevations ranging from ~766 to 785 m asl, comparable to a known high-stand (nominally 777 m asl) (Wiedmer et al., 2010) of Glacial Lake Atna (Ferrians, 1989; Reininghaus, 2019:31; Smith, 2019). These observations suggest that the ridge at *Nataeł Na'* is a remnant of a glacio-fluvial delta that formed where the Copper River debouched into a Late Pleistocene glacial-dammed lake. The position of Glacial Lake Atna's multiple evident shorelines shifted through the Late Pleistocene, and we lack

[1] We use the spelling 'Atna' when referring to Glacial Lake Atna because it more closely corresponds to traditional translations of Native placenames in the traditional indigenous language. When referring to legal entities such as the Intertribal Resources Council and Alaskan Native Corporation, however, we use the spelling 'Ahtna' to correspond with the officially recognized names of these entities.

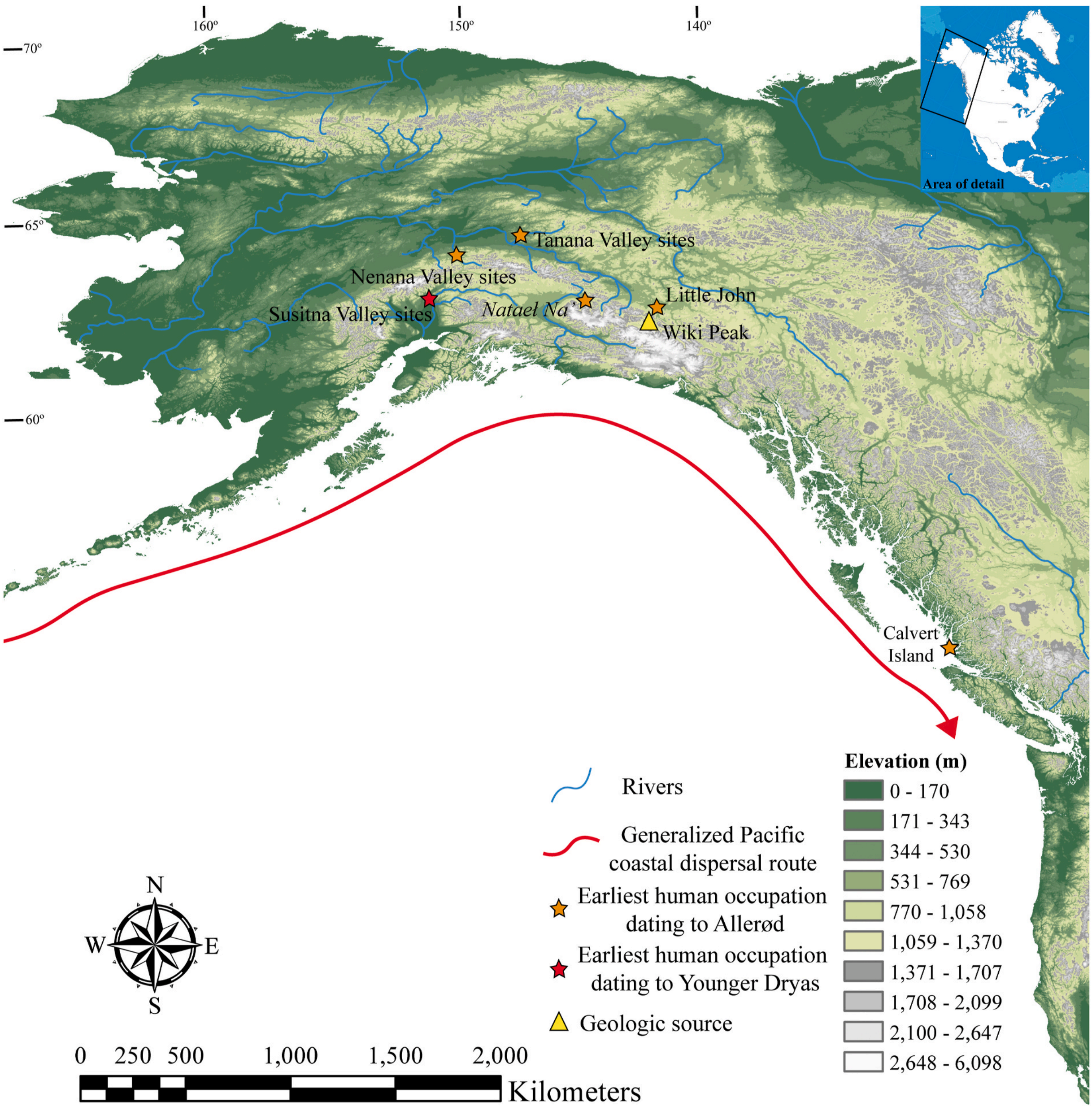

Fig. 1. The northern Pacific rim of North America showing the location of *Natał Na'* in relation to important archaeological sites and geologic sources mentioned in the text. Arrow marks generalized coastal migration route (Digital Elevation Model by NASA et al., 2010).

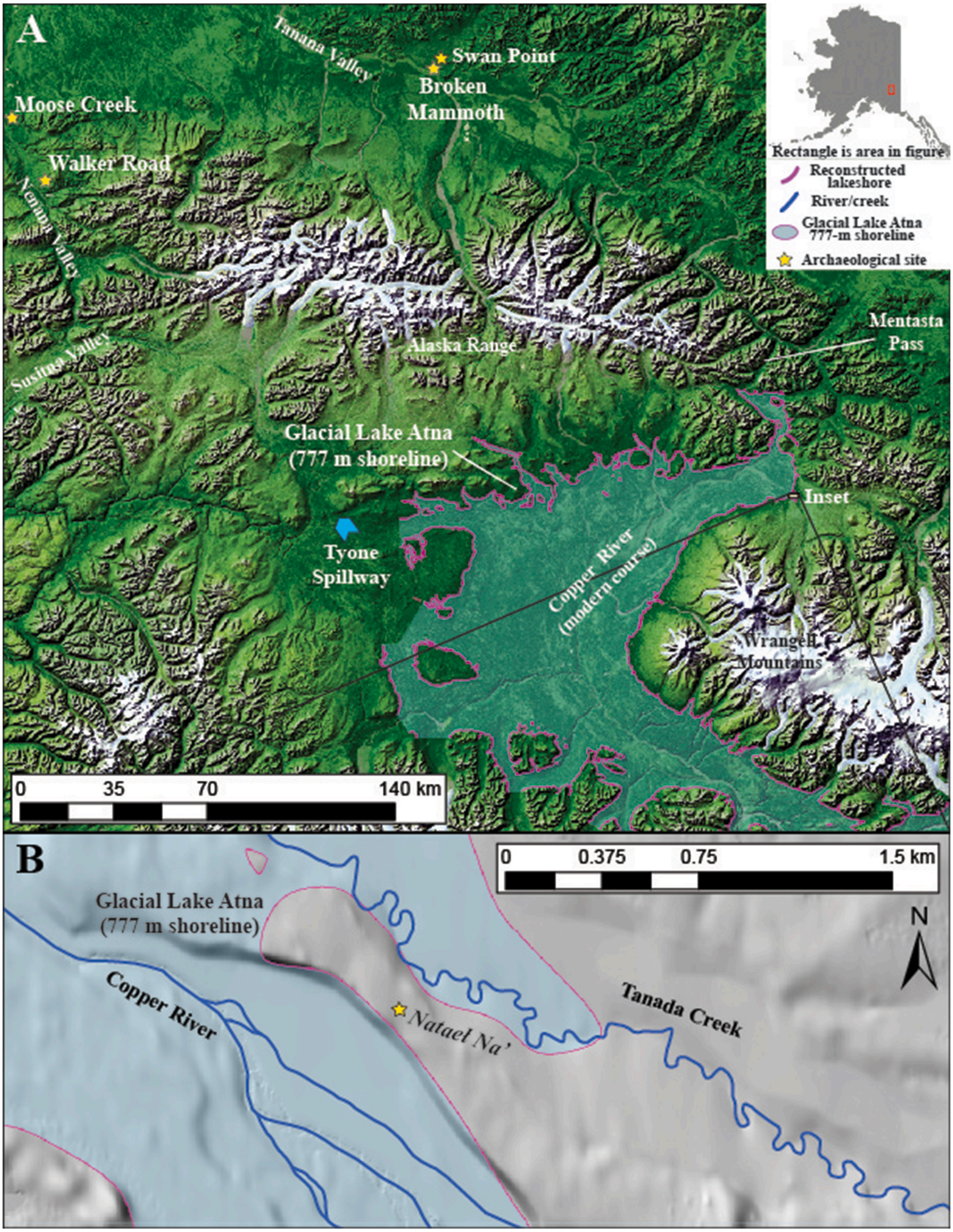

Fig. 2. Location of *Nataeł Na'* and important locations mentioned in the text. (A) Interior and southern regions of Alaska showing the Alaska Range, Glacial Lake Atna (denoted by its 777-m shoreline, extant between approximately 17,000 cal BP and 11,000 cal BP), and the Tyone spillway into the Susitna Valley. Open areas in the shoreline polygon represent the locations of ice-dams that constrained the lake until they were overtopped. No abandoned shorelines are visible at these locations because they were under glacial ice when the lake was present. (B) Location of *Nataeł Na'* in relation to Tanada Creek, the Copper River, and the reconstructed shoreline of Glacial Lake Atna.

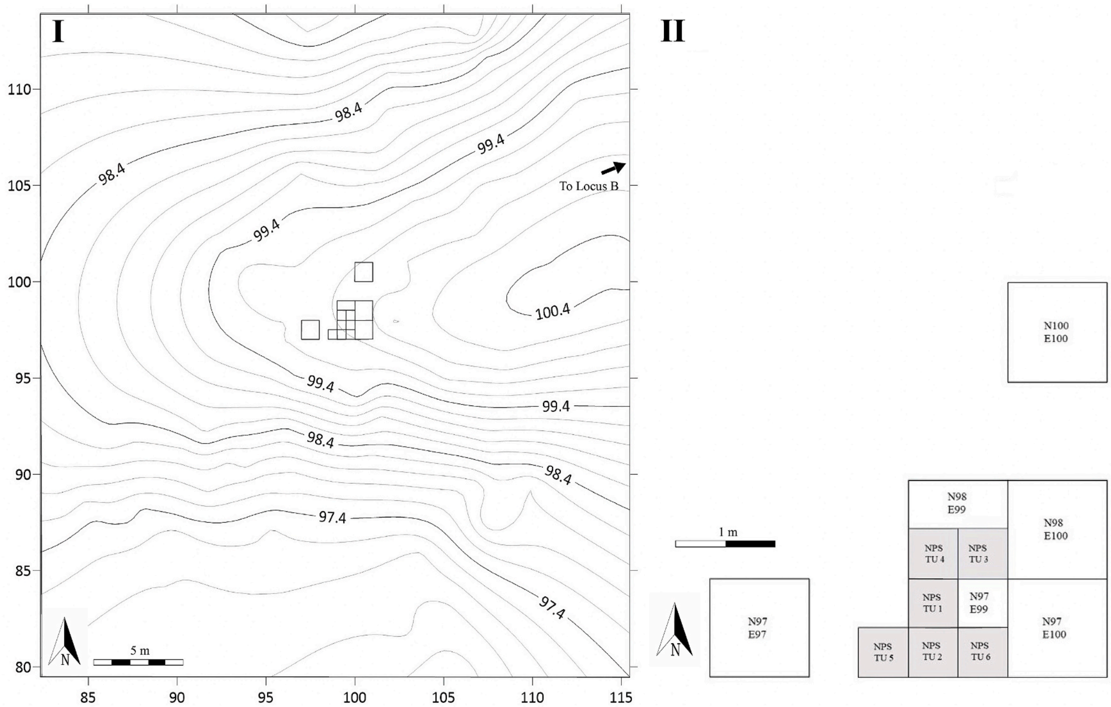

Fig. 3. (I) Topographic map of *Natael Na'* and the landform upon which the site is situated. Elevations are in meters and relative to the site datum (arbitrarily set at 100.0 m). (II) Planview of the excavations, with previously-excavated NPS test units shaded gray.

clear evidence of precisely when the lake occupied the 777 m asl shoreline adjacent to *Nataeł Na'*, but existing radiocarbon dates suggest that the lake was either directly adjacent to *Nataeł Na'* during its occupation (Fig. 2B) or a few meters below it (Smith, 2019) and still easily accessible from the site. Additionally, optically stimulated luminescence (OSL) dating of deltaic sediments exposed along the banks of nearby Tanada Creek conducted in 2019 confirms that the deltaic geomorphology of the region dates to the Late Pleistocene (Supplementary Text S4 in SOM).

Today the region is covered with spruce-dominated boreal forest and small patches of low-lying wetland. Regional pollen records, however, suggest that this ecosystem did not become established until the Early Holocene when coniferous species invaded the basin from the north (Ager, 1989). During the late glacial, the region was instead an herbaceous/shrub tundra dominated by sedges and dwarf birch (Ager, 1989; Ager and Sims, 1981).

National Park Service (NPS) archaeologists discovered *Nataeł Na'* in 2016 during compliance survey (Reininghaus, 2019). Following shovel testing along the entire landform, preliminary testing centered on and expanding shovel test pits which produced artifacts identified two (seemingly) separate cultural loci: five 50×50-cm units at Locus A confirmed the presence of a late-glacial cultural component, and five 1x1-m units at Locus B indicated a Middle Holocene component (for further discussion of Locus B see Reininghaus, 2019). A cryoturbated combustion feature at Locus A, likely a hearth (Reininghaus, 2019) though micromorphological analysis has not been undertaken to confirm this (Mentzer, 2012), contained abundant charcoal and cracked stones. Charcoal from the feature yielded seven consistent radiocarbon assays indicating this component dates to 12,190–11,325 cal BP (Reininghaus, 2019:32). NPS testing recovered an assemblage of 1522 lithic artifacts from both loci.

In 2019, archaeologists from the Center for the Study of the First Americans, Texas A&M University, expanded excavations at Locus A, opening an additional 4.75 m^2 (Fig. 3) to investigate the geologic context and lateral extent of the cultural deposits associated with the Pleistocene-aged combustion feature. We exposed more of the feature itself and mapped a dense scatter of lithic artifacts surrounding it. In addition, we encountered a distinct cultural component stratigraphically below the feature, expressed by a small assemblage of lithic debitage and isolated charcoal fragments. We recovered a total of 839 lithic artifacts as well as charcoal, sediment, and tephra (ISGN BOF00000A, BOF00000B, and BOF00000C) samples from Locus A. Our research plan emphasized the need to increase our understanding of the geologic context of the Pleistocene occupation at Locus A, independently verify its age, and attempt to determine the lateral extent of cultural deposits. We also highlighted the importance of leaving portions of the site undisturbed, with particular emphasis on preserving portions of the previously identified combustion feature, so that it retained sufficient integrity to qualify for inclusion on the National Registry of Historic Places, in accordance with the wishes of the local Ahtna community. As such, the 2019 excavations were somewhat limited in scope, and we acknowledge that the resulting assemblages may ultimately be too small to prove fully representative of the ancient human behavior at the site. Here, however, we present our results and those interpretations we feel can be realistically made based upon this sample. In 2020 and 2021 consultations were held between representatives of the Ahtna Intertribal Resources Council and Wrangell-Saint Elias National Park and Preserve to determine the appropriate name for the site. *Nataeł Na'*, the Alaska Native name for nearby Tanada Creek that means 'roasted salmon creek' in the Ahtna language, was selected as the site's name.

3. Materials and methods

3.1. Excavation

Our excavation followed standard archaeological excavation methods, using small hand tools and sifting all excavated sediments through 1/8-inch (3.175 mm) mesh to recover small artifacts. Our excavation took place in 1-m blocks (Fig. 3B), each divided into four 50×50-cm quadrants. We used a Leica total station to record the three-

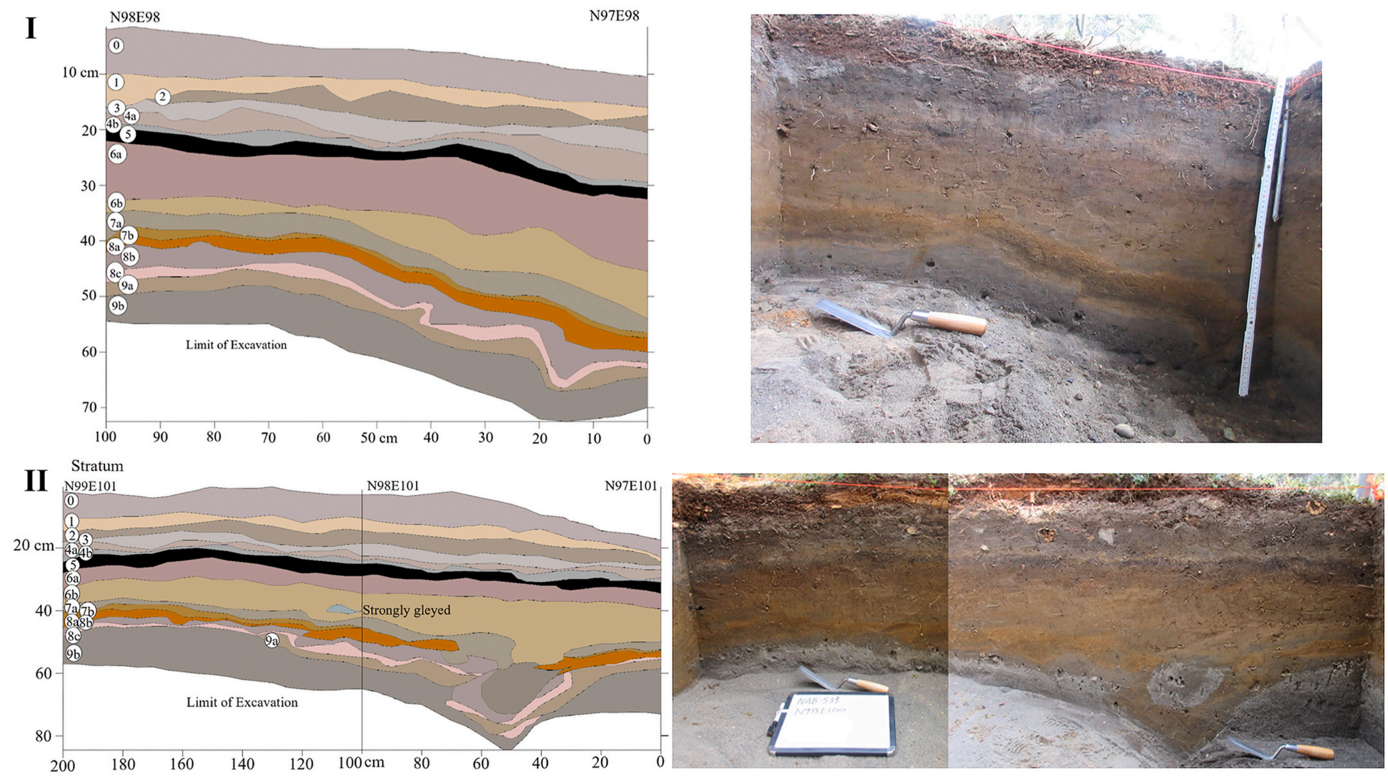

Fig. 4. Stratigraphic profiles from 2019 *Natael Na'* excavations, Locus A; (I) east wall (E98 line) of N97E97; (II) east wall (E101 line) of N98E100 and N97E100. Sedimentary strata are described in section 4.1, Table 1, and Supplementary Text S5.

point provenience of all artifacts recovered *in situ*. When large-sized artifacts (n = 29) were recovered *in situ* and confidently undisturbed, trend and plunge measurements were recorded using compasses with integral clinometers to support analysis of the impact of cryoturbation on the site. We also visually analyzed geomorphic features such as solifluction lobes and ice-wedge pseudomorphs (Fig. 4) as they were exposed in both plan-view and profile as part of this effort.

3.2. Lithic refit analysis

Lithic refit analysis was conducted at Texas A&M University during 2020. We chose to exclude all lithic artifacts smaller than ~5 mm in diameter from our refit analysis because of the difficulty of accurately identifying refits of such small artifacts, even rearticulation to larger artifacts (Laughlin and Kelly, 2010). We visually examined each artifact and compared it to artifacts with similar color, composition, and grain structure, essentially identifying Minimum Analytical Nodules (*sensu* Larson and Kornfeld, 1997). We tested all artifacts identified as potentially originating from the same analytical nodule manually for rearticulation, which we only considered a confirmed refit if the artifacts could be fully rearticulated without any unexplained gaps or other mismatches.

3.3. Geochemical analysis

We performed geochemical analysis on all obsidian artifacts and a subset of the basalt artifacts recovered from *Natael Na'*. The basalt artifacts were drawn from the assemblages excavated from Locus A during the 2018 and 2019 field seasons. We excluded basalt artifacts that did not have precise provenience within the site, as well as those lacking striking platforms (with the exception of formal tools and utilized expedient flake tools, some of which did not retain platforms). We chose this sampling strategy to avoid duplicate analyses of flake fragments and associated flake shatter (Andrefsky, 2005) and to ensure precise associations could be identified by our analyses. As such, we did not include artifacts recovered during the initial 2016 NPS shovel testing because horizontal provenience was not recorded for those artifacts. We likewise excluded basalt artifacts recovered in the screen or from uncertain contexts (e.g., wall-fall). We analyzed all recovered obsidian artifacts because this material represents such a small portion of the assemblage and because it can be sourced more effectively than basalt.

We conducted geochemical analyses of the basalt artifacts at Texas A&M's Department of Anthropology during summer 2021, using a Bruker Tracer III-SD portable x-ray fluorescence (pXRF) analyzer, while we analyzed the obsidian artifacts at the National Park Service Fairbanks Administrative Facility using a Bruker Tracer 5i pXRF analyzer. In both cases we employed standard methodologies as described by Reuther et al. (2011) and Phillips and Speakman (2009). We selected this method because pXRF analysis is non-destructive, inexpensive, and relatively quickly accomplished. Ten elements were measured for the obsidian artifacts: Potassium (K), Manganese (Mn), Iron (Fe), Gallium (Ga), Thorium (Th), Rubidium (Rb), Strontium (Sr), Yttrium (Y), Zirconium (Zr), and Niobium (Nb). For the basalt artifacts we measured seven: Mn, Fe, Rb, Sr, Y, Zr, and Nb.

We positioned the cleanest and flattest available surface of each artifact over the detector window of the analyzer. We selected a relatively long run time of 5 min for our basalt analysis and performed two runs (with results averaged during the data transformation and visualization process, Supplementary Figs. S1–S3 in SOM) on each artifact to ensure accuracy, as basalt can be difficult to characterize using pXRF (Fertelmes, 2014). We took care to position artifacts with the same point on the same surface facing the emitter for both runs except in cases where larger crystals that could return unrepresentative results were visible near the surface, or if all surfaces retained noticeable sediment from excavation.

We used the S1Calprocess conversion system (Drake, 2018) to process the raw data generated by the Tracer III-SD and to convert the geochemical spectra to concentration values (parts-per-million [ppm]). These values were input into a Microsoft Excel spreadsheet, and the mean value for each element was calculated from both runs of each artifact. These data were input into the GAUSS Run-Time Module 8.0 statistical software (Aptech SystemsInc., 2006) for analysis and visualization. This program makes use of code created by the Archaeometry Laboratory at MURR (Missouri University Research Reactor) to visualize geochemical data and assist archaeologists in interpreting results from ceramic and lithic artifacts (Glascock, 2021). Once all artifacts had been analyzed we created biplots comparing the values of each pair of elements and performed principal component analysis (PCA) on the data to visually analyze their distribution for the possibility of internal differentiation of the basalt sub-assemblage.

We analyzed 270 basalt artifacts using pXRF (see section 3.3), all of which were included in the subsequent statistical analyses. We performed a principal component analysis (PCA) using the geochemical data from our pXRF analysis of the basalt subsample, with each element reported in ppm. We then used the PCA results to run a k-means cluster analysis, following Carlson (2017), to determine if the clustering visible in the PCA results was statistically significant. We identified four distinct basalt clusters in the data (Supplementary Figs. S4 and S5 in SOM). Finally, we conducted a Kruskal-Wallis test, chosen because it is suitable for analyzing non-parametric data, to compare the lithic technology represented in each basalt cluster (Supplementary Text S3 in SOM contains full statistical methods).

3.4. Location and accession of archaeological materials

All collections associated with *Nataeł Na'* are housed at Wrangell-Saint Elias National Park and Preserve in Copper Center, Alaska. Our study included all cultural materials recovered from Locus A, including accession catalog numbers WRST 21470–21472, WRST 23683–23987, and WRST 24056–24458. Samples subjected to destructive analyses, including charcoal and tephra samples, have been reported as such but have not been fully deaccessioned from the collection.

4. Results

4.1. Stratigraphy and radiocarbon dating

We identified the same nine stratigraphic units that Reininghaus (2019) described, four of which we subdivided based on visible evidence of soil-formation processes (Table 1). The basal unit exposed during our excavation is a coarse gray sand with intermittent pockets of small, rounded gravels 1–3 cm in diameter (Stratum 9b) overlain by a gray silty sand (9a) with intermittent rounded gravels and small cobbles 3–8 cm in diameter scattered across its surface. Stratum 8 is composed of unweathered reddish-brown silt (8c), dark yellowish-brown sand (8b), and strong brown silty sand (8a). Stratum 7 is a deposit of sandy silt grading upward to silt, likely a wind-blown loess. Its lower unit is a thin Stratum (7b) of unweathered sandy silt, while its upper unit (7a) is a gleyed band of silt, which we have interpreted as the lowermost paleosol; it is not, however, obviously paired with a preserved A horizon. The middle paleosol (contained within the silts of strata 5 and 6) contains a moderately humified but well-defined A horizon (5) with numerous inclusions of intact charcoal (Fig. 4), as well as a complex B horizon with an upper sub-horizon showing signs of weak oxidation (6a) and a lower sub-horizon with signs of gleying (6b and 6c). Sub-Stratum 6c was encountered only intermittently across the excavation. The paleosol and abundant charcoal (Stratum 5) likely represent a naturally burned surface. The uppermost paleosol (preserved in the silts of strata 3 and 4) contains a weakly humified Ab horizon (3) and paired B horizon of gleyed silt (4). It represents Late Holocene soil formation. Stratum 2 is the modern B horizon, composed of lightly gleyed silt. Stratum 1 is the modern A horizon, composed of silt and organics (complete descriptions of all identified strata are available in Supplementary Text S5 in SOM). At the modern O/A contact we located several discontinuous pockets of tephra. The tephra glass geochemistry is very similar to Late Holocene tephras of Mount Redoubt and Crater Peak of Mount Spurr, but the coloration of the shards is more similar to known eruptions of Crater Peak than to Mount Redoubt (Supplementary Text S7, Supplementary Figs. S7 and S8, and Supplementary Table S7 in SOM; see also Wallace, 2003; Zander et al., 2013).

Stratum 9 was formed by deltaic deposition, likely during Glacial Lake Atna's Allerød high-stand. Stratum 8 represents aeolian deposition after the lake receded slightly, abandoning the delta that formed Stratum 9. The overlying strata formed through repeated sequences of aeolian deposition during and after the Younger Dryas, with Stratum 5 experiencing a significant natural fire event during the Late Holocene.

During our 2019 excavations we identified as many as three cultural components at Locus A. From the bottom upward, Component 1 is composed of a small lithic artifact assemblage recovered from Stratum 8c, the lowest and thinnest silt layer. Component 2 is mostly contained within Stratum 6b, the loess package representing the lower buried B horizon (i.e., 2Bg in Table 1), though smaller numbers of artifacts also occur in sub-Stratum 6a above and Stratum 7 below. This component is associated with the Locus A materials reported by Reininghaus (2019). We, too, recovered charcoal representing the component's combustion feature, directly associated with abundant lithic artifacts. Component 3 is known from Locus B (see Reininghaus, 2019) and is not reported further here, except as it pertains to discussions of the broader history of occupation at *Nataeł Na'*. Component 4 consists of a small assemblage of lithic artifacts recovered from above Stratum 5. No features were associated with this component, and stratigraphically it is younger than any components previously identified at either locus (Reininghaus, 2019).

We recovered charcoal samples opportunistically throughout the excavation and used them to gain chronological control over three strata (8c, 6 [a and b], and 5) (Table 2; Supplementary Table S4), identifying all charcoal taxonomically whenever possible (Supplementary Text S6 in SOM). Two pieces of charcoal from Stratum 8c, too small to be taxonomically identified while retaining enough mass for radiocarbon dating, yielded ages of 11,120 ± 30 (UGAMS-43757) and 11,100 ± 30 (UGAMS-44758) ^{14}C BP, indicating that the associated artifacts of Component 1 date to the Allerød interstadial of the late glacial. A single sample of charcoal (identified generically as Angiosperm) associated

Table 1
Stratigraphic descriptions designated during 2019 fieldwork.

Stratum	Thickness (cm)	Description
O horizon	7–15	Moss, heaths, etc.
1	3–9	Modern A horizon rich in organics, silt, and tephra
2	1–4	Modern B horizon with gleyed silt
3	0.5–10	1Ab, silt with charcoal and weak humification
4	1.5–6	1Bb, silt with fine sand
5	1–6.5	2Ab, charcoal layer with weak humification
6a	4–11	2Bb, weakly oxidized silt
6b	4–21	2Bg, silt with green-gray gleying stains
6c	0.5–4	2Bg, silt with strong green-gray gleying stains
7a	2.5–10	Possible 3Bbg, gleyed silt
7b	0.5–6	Thin sandy silt layer, comparatively unweathered
8a	1–6.5	Strong brown silty sand
8b	0.75–6	Dark brown-gray sand
8c	0.25–3	Thin layer of reddish-brown silt
9a	0.5–4	Gray silty sand with gravels
9b	3.5–19	Gray coarse sand with gravels

Table 2
Radiocarbon dates from samples recovered during the 2017, 2018, and 2019 field seasons. Beta dates previously reported by Reininghaus (2019). All age estimates were calibrated using the IntCal20 curve (Reimer et al., 2020). Component 4 age estimate comes from Stratum 5, and thus represents a lower-limiting date not associated with any cultural materials.

	Locus A				Locus B			
	Lab number	Material dated	^{14}C age	2σ calendar range (cal BP)	Lab number	Material dated	^{14}C age	2σ calendar range (cal BP)
Component 4	UGAMS-44754	*Picea/Larix* Charcoal	1440 ± 35	1380–1295				
Stratum 4 (5)								
Component 3					Beta-478468	Unidentified bone	2880 ± 30	3080–2920
Stratum 6a-Locus B								
					Beta-478467	Unidentified bone	3070 ± 30	3365–3210
					Beta-504783	Unidentified charcoal	3970 ± 30	4525–4395
Component 2	UGAMS-43874	*Picea/Larix* Charcoal	5090 ± 25	5830–5750				
Stratum 6a								
	UGAMS-44756	*Pinaceae* Charcoal	7700 ± 30	8545–8410				
Stratum 6b (top)	UGAMS-44755	*Salix* (type) Charcoal	8640 ± 30	9680–9540				
Stratum 6b (base)	Beta-480080	Unidentified charcoal	9870 ± 30	11,330–11,210				
	UGAMS-44757	Angiosperm Charcoal	10,070 ± 30	11,755–11,400				
	Beta-446231	Unidentified charcoal	10,110 ± 30	11,835–11,600				
	Beta-504784	Unidentified charcoal	10,130 ± 30	11,880–11,610				
	Beta-504787	Unidentified charcoal	10,130 ± 30	11,880–11,610				
	Beta-504782	Unidentified charcoal	10,160 ± 30	11,935–11,700				
	Beta-480081	Unidentified charcoal	10,300 ± 30	12,190–11,930				
	Beta-504786	Unidentified charcoal	10,300 ± 30	12,190–11,930				
Component 1	UGAMS-44758	Unidentifiable charcoal	11,100 ± 30	13,100–12,925				
Stratum 8c								
	UGAMS-43875	Unidentified charcoal	11,120 ± 30	13,105–12,960				

with Component 2's combustion feature, situated near the base of Stratum 6b, yielded an age of 10,070 ± 30 ^{14}C BP (UGAMS-44757). This conforms with ages previously reported by Reininghaus (2019:33), which are shown in Table 2 (i.e., the Beta-run dates). A dispersed piece of *Salix* charcoal recovered from above the combustion feature, in the upper part of Stratum 6b, yielded an age of 8640 ± 30 ^{14}C BP (UGAMS-44755). Two pieces of dispersed charcoal from Stratum 6a (stratigraphically above the combustion feature and the majority of Component 2), identified as Pinaceae and *Picea/Larix* respectively, yielded ages of 7700 ± 30 (UGAMS-44756) and 5090 ± 25 (UGAMS-43874) ^{14}C BP. They suggest that the upper part of Stratum 6 represents loess deposition during the Early-Middle Holocene. Finally, we report an age of 1440 ± 35 (UGAMS-44754) ^{14}C BP on *Picea/Larix* charcoal from Stratum 5, the upper, charcoal-rich paleosol. Although no artifacts were recovered from this stratum, it provides a lower-limiting age for Component 4, found primarily in Stratum 4b. Calibrated age ranges (Fig. 5; Table 2) suggest that Component 1 dates to ~13,000 cal BP, Component 2 to ~12,000 cal BP, Component 3–~3000 cal BP, and Component 4 to later than ~1300 cal BP.

4.2. Site formation processes

Component 1 does not appear to have been disturbed by animal burrowing; however, the presence of solifluction lobes and small ice-wedge casts indicates significant cryoturbation (Fig. 4). Nonetheless, the component's artifacts occur only in Stratum 8c, suggesting stratigraphic integrity. Importantly, none of the artifacts were found in the area directly below the combustion feature of Component 2 and its associated artifact concentration. One of the Component 1 artifacts (a piece of flake shatter) was recovered in direct contact with dated charcoal sample UGAMS-44758. Despite the obvious deformation of this artifact-bearing stratum, we are confident that it represents an earlier sealed context stratigraphically below and not mixed with Component 2.

Component 2 is tightly clustered around the combustion feature reported by Reininghaus (2019). Significantly, 28.6% of its lithic assemblage came from two of the seven 50×50-cm quadrants that contained portions of the combustion feature (NPS TU1 and the northeast quad of N97E99; Fig. 6), while only 22.7% of the assemblage was recovered from the 3.5 m^2 of the excavation that did not contain portions of the combustion feature. Component 2's assemblage was recovered from a wide elevational range within Stratum 6, in association with charcoal dating ~12,000 cal BP (Fig. 7). The artifact concentration in Stratum 6b, however, was more than twice as dense as that in 6a. Reininghaus (2019:32) reported encountering a large rodent-burrow cast in our Stratum 8a in the southern portion of the NPS excavations, though this did not extend below the base of Stratum 8a (i.e., into Stratum 8c and Component 1). We did not recognize this in our adjacent excavation unit, though we did encounter an area of complex overlapping stratigraphy (Fig. 4) in that unit, which we interpret as having resulted from solifluction. Whatever the nature of this disturbance, given that it does not impact Stratum 8c, there is no evidence to suggest that it has compromised the integrity of Component 1.

Component 4 artifacts were few in number and almost entirely recovered directly above the densest artifact concentration of Component 2 (Fig. 7). They could represent artifacts displaced upward from Stratum 6 by rodent burrowing or fire-related tree throw; however, two observations suggest to us that this is not the case. First, we identified several small rodent-burrow casts in Stratum 4, but none appeared to continue downward into Stratum 5, let alone Stratum 6. Second, none of the artifacts in Component 4 were found on the surface of Stratum 5, suggesting that they were deposited after the natural fire (i.e., during the deposition of Stratum 4). Although we were able to successfully rearticulate only a few artifacts within components (Fig. 6), it is important to note that we identified no refits between the components. Additionally, Stratum 5 forms a clear and intact layer across the excavation (Fig. 4). Given the thickness of Stratum 5 and its distinct appearance, we are

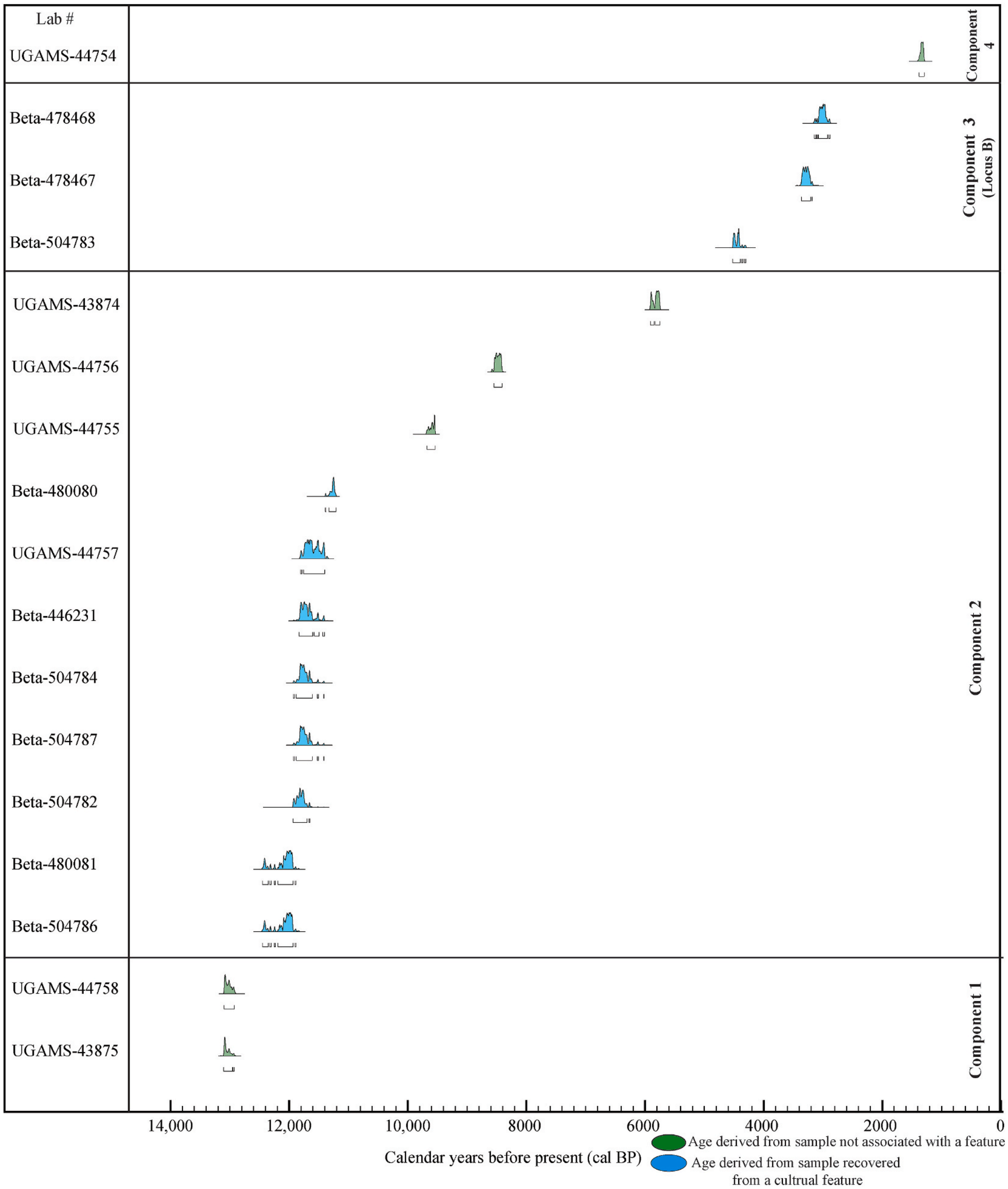

Fig. 5. Calibrated radiocarbon age estimates for *Natael Na'*. All dates calibrated using the IntCal20 curve (Reimer et al., 2020). "Beta" dates (including all Component 3 dates, from Locus B) from Reininghaus 2019, recalibrated using IntCal20.

confident that any bioturbation mixing sediments from Stratum 6 with higher strata would be clearly visible. All signs suggest that Component 4 is an intact (but ephemeral) Late Holocene component situated stratigraphically above Component 2.

Given the obvious signs of site deformation in the lower strata (Fig. 4), we sought to determine the impact of solifluction and ice wedging on the site's geological deposits and cultural components. For Component 2, most artifacts measured for trend and plunge were oriented northeast or southwest. Given that Locus A's natural slope trends toward the southwest (i.e., ~180–270°), this pattern is unsurprising. About 35% of measured artifacts, however, plunge toward the northeast, opposite the site's natural slope, likely the result of post-depositional involution of Stratum 6 during solifluction downslope. As shown in Fig. 4, the natural slope of the site's surface and buried stratigraphic contacts range from nearly horizontal up to approximately 20°; however, more than half of the measured artifacts have plunge values greater than this (Fig. 8). These data clearly suggest that the orientations of the artifacts in Component 2 have been significantly altered by solifluction and possibly small ice-wedge formation, providing evidence that some of its contents have been removed from their initial positions and depositional contexts. This likely explains why we recovered artifacts from both sub-strata of Stratum 6. We successfully measured only a single artifact in Component 1 for trend and plunge. It was oriented generally south and had a plunge of 30°. Combined with the undulating surface formed by Stratum 8c (Fig. 4), we believe that this demonstrates that artifacts in this component were also affected by cryoturbation. However, their exclusive occurrence within the thin layer of Stratum 8c reinforces the interpretation that, though heavily soliflucted, these artifacts remain in their original sedimentary context.

We performed refit analysis to determine if significant artifact mixing had occurred between components (see López-Ortega et al., 2019), rearticulating four pairs of artifacts from Component 2 (Fig. 6A). Two pairs are basalt flakes and flake fragments, one of which was recovered from the initial NPS shovel test pit and lacks precise provenience. Two

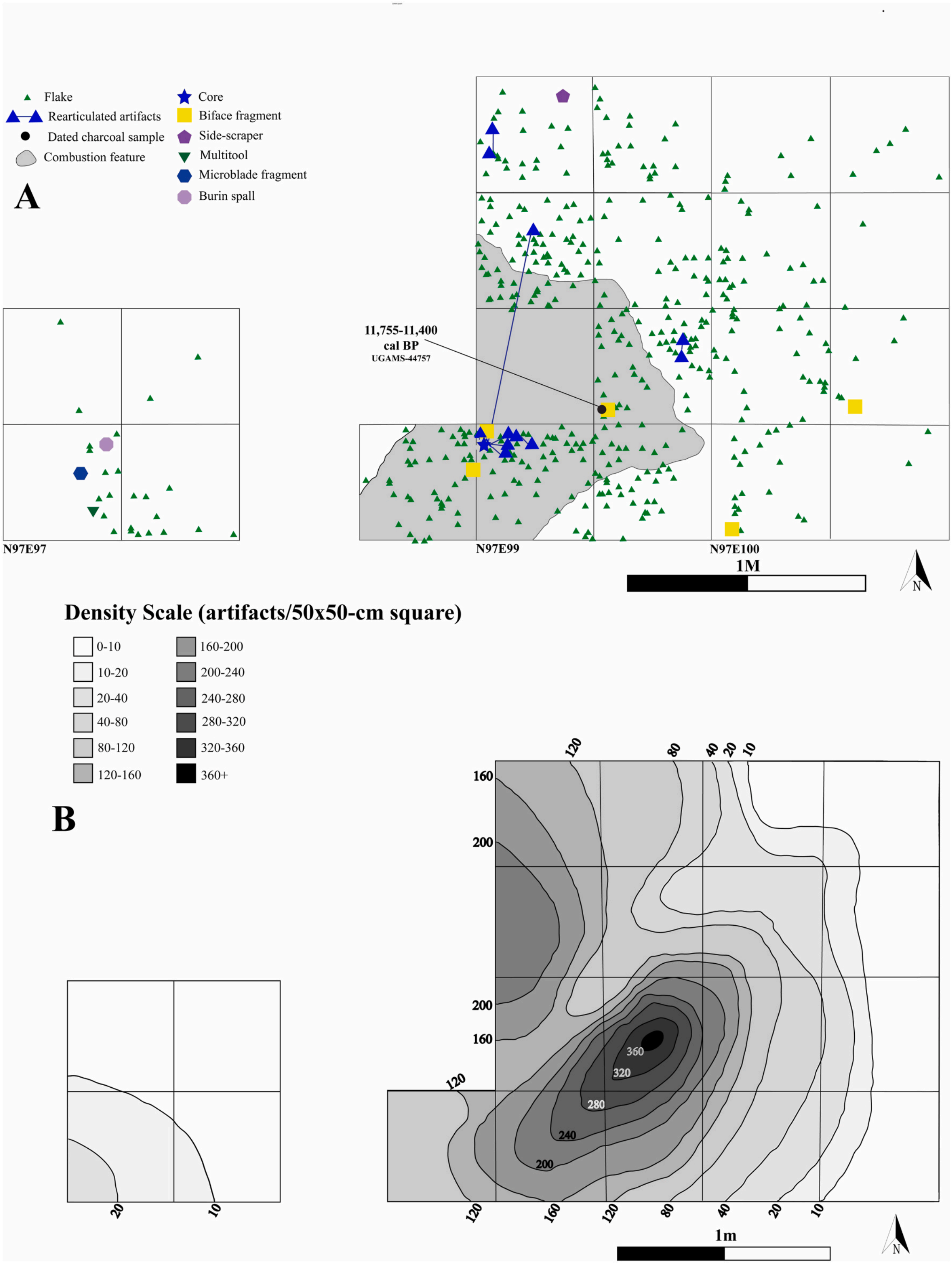

Fig. 6. (A) Planview of *Natael Na'* Component 2. Artifacts recovered from the initial NPS test unit were not piece-plotted with horizontal position, resulting in the gap in distribution. Only artifacts with definite three-point provenience are included. (B) Density contours of *Natael Na'* Component 2.

other pairs are rough, granitic stone with uneven broken surfaces, dark staining, and moderate oxidation; these represent stones broken in the combustion feature. Additionally, we rearticulated five basalt cortical spalls to a flake core, all of which were recovered in close proximity to the core, except one large cortical spall recovered 83 cm to the north (Fig. 6A). All of these refits were confined within Stratum 6. For Component 1 we rearticulated a pair of basalt flake fragments, again suggesting stratigraphic integrity of this assemblage (see López-Ortega et al., 2019). Despite searching, we identified no refits between components.

4.3. Lithic artifact assemblages

The artifact assemblage recovered from Component 1 (Fig. 9A r-w,

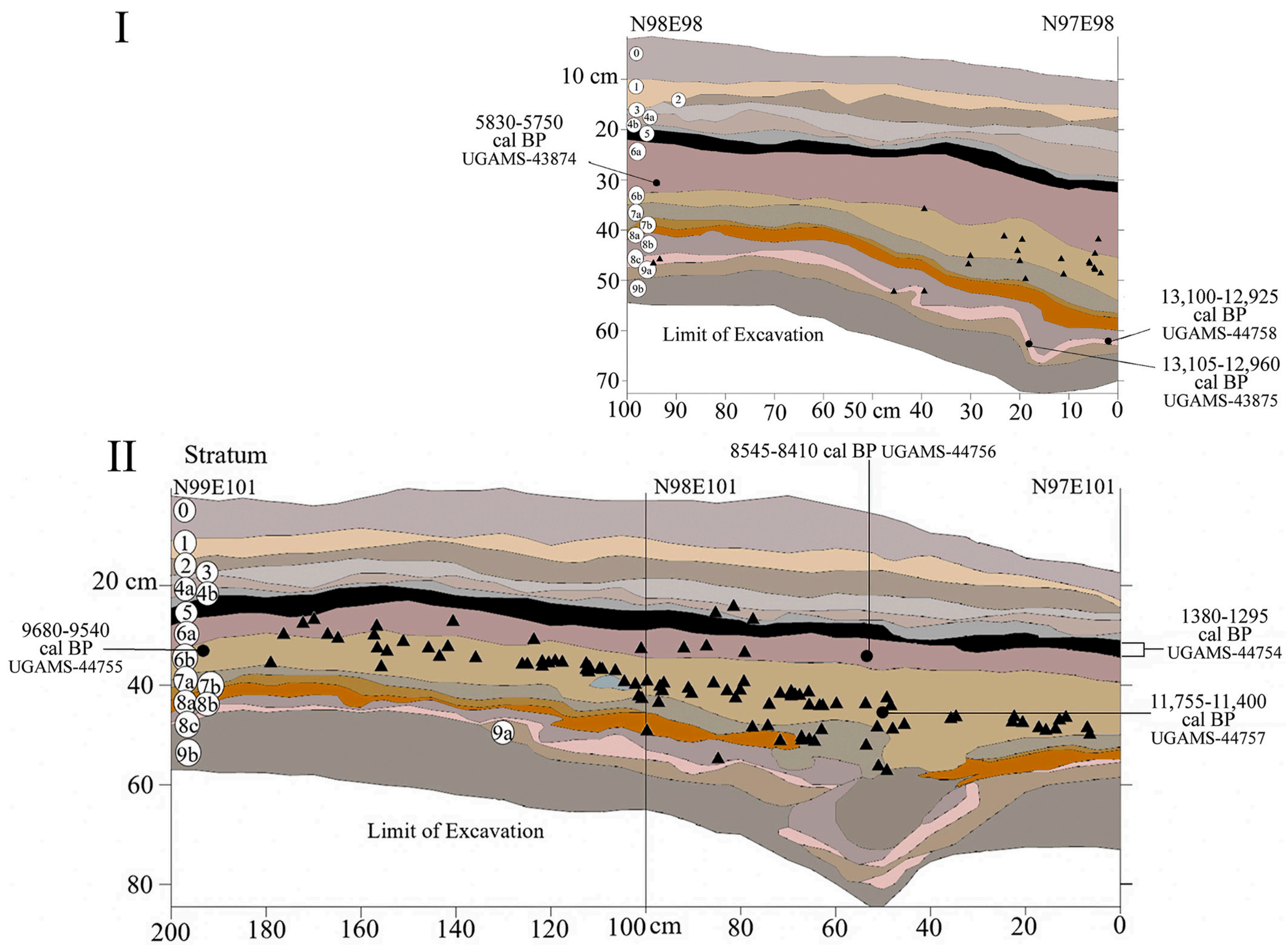

Fig. 7. (A) Vertical distribution of artifacts from all components recovered within 1 m of the 2x2-m excavations block's eastern wall (E101 line). (B) Vertical distribution of artifacts recovered from N97E97, within 1 m of profile. In both profiles, triangles represent artifacts and circles represent charcoal samples with associated age estimates.

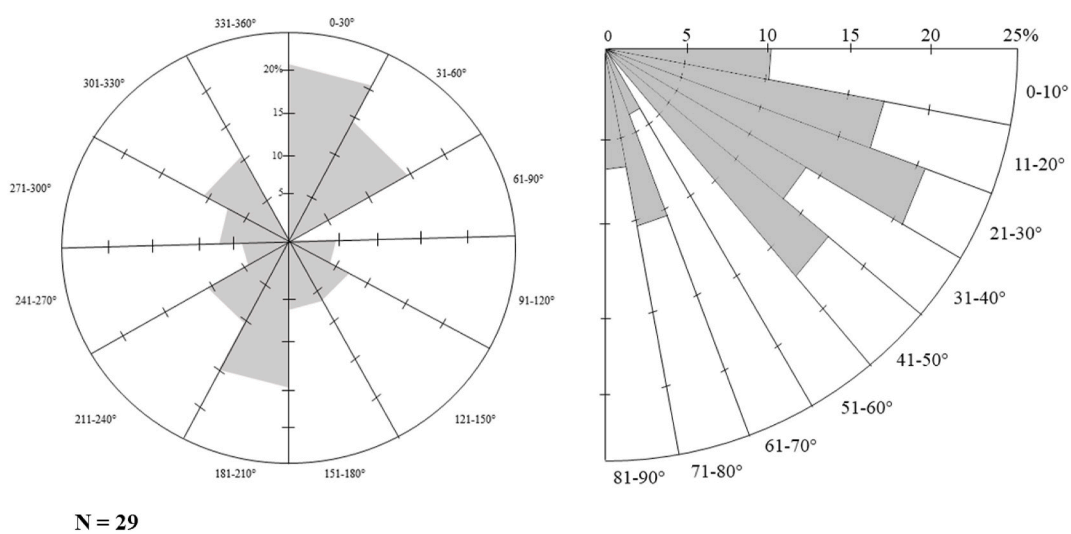

Fig. 8. Percentages of trend and plunge measures of artifacts recovered from Component 2.

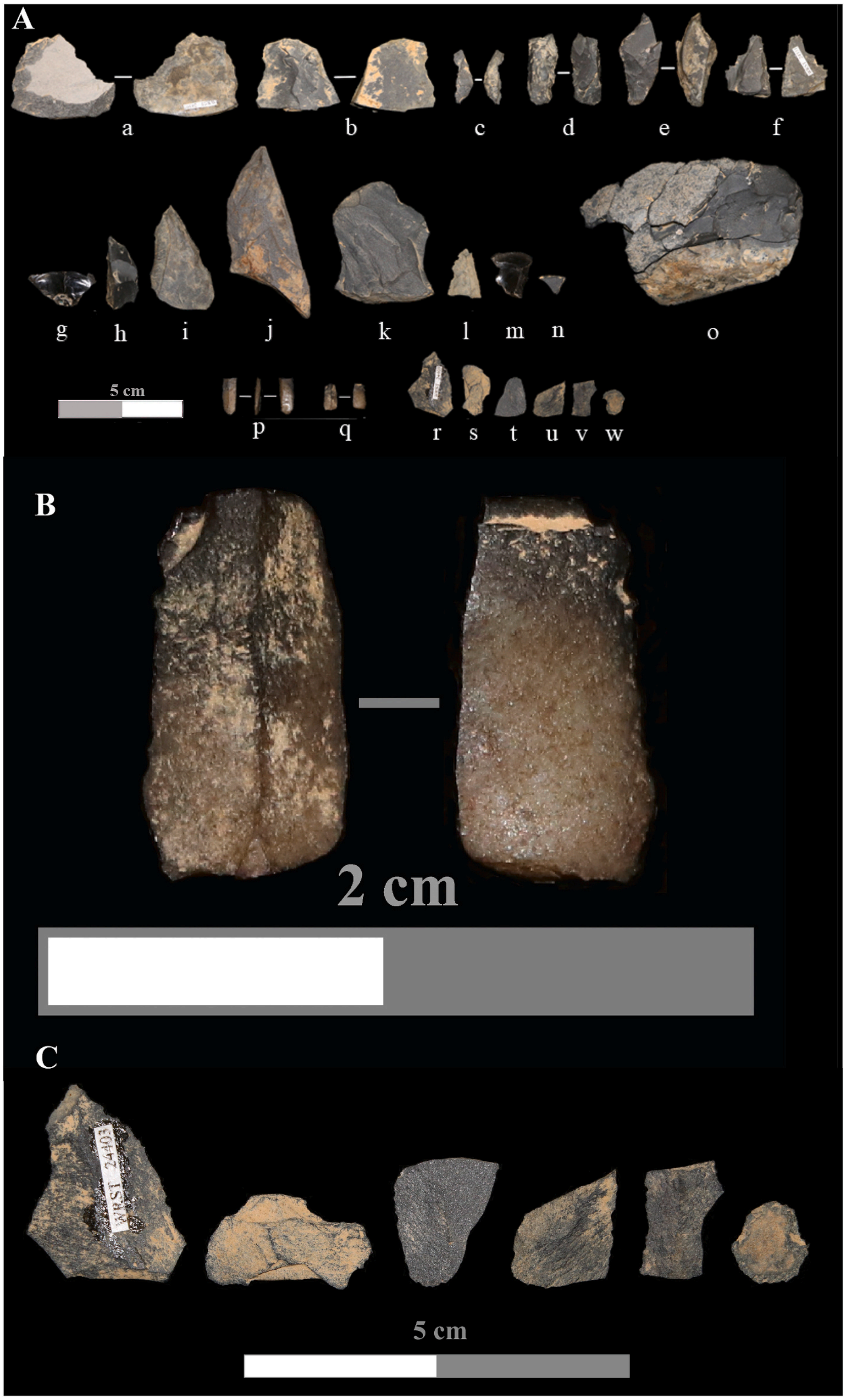

Fig. 9. (A). Lithic artifacts from Component 2 (a, c-q) and Component 1 (r–w): (a) early-stage biface fragment, (b) early-stage biface fragment recovered from rodent-burrow cast, (c) indeterminant-stage biface fragment, (d) mid-stage biface fragment, (e–f) late-stage biface fragments, (g) graver/notch, (h) scraper/adze fragment, (i–j) side scraper fragments, (k) retouched flake, (l, n) utilized flake fragments, (m) utilized flake, (o) reconstructed flake core with spalls refit, (p) burin spall, (q) retouched microblade fragment, (r) cortical spall, (s, v-w) biface-reduction flakes, (t–u) flake shatter. 8A r-w are from Component 1. (B) Microblade fragment. Retouch is visible along the left lateral margin of the ventral surface. (C) Detailed view of Component 1 debitage sample (8A r-w).

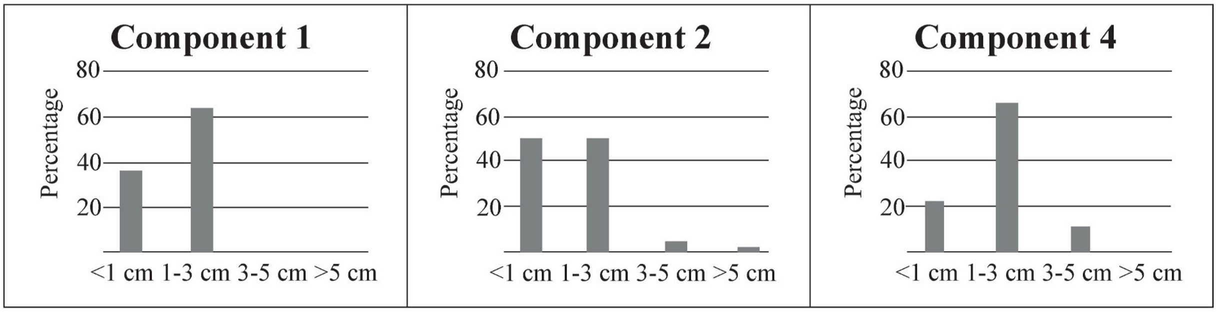

Fig. 10. Proportions of lithic debitage recovered from each cultural component by size category (Component 3 is not included because it is present only at Locus B and this study did not include any Locus B materials).

Table 3
Lithic debitage recovered from *Nataeł Na'* Component 2.

	Andesite	Basalt	CCS	Diorite	Obsidian	Quartzite	Rhyolite	Total
Cortical spall		91		1	1		1	94
Angular shatter	1	45		1		1		48
Bipolar flake					2			2
Core-reduction flake		51			4			55
Biface-reduction flake		629	1		1	1		632
Retouch chip		61	1					62
Burin spall			1					1
Flake shatter								
Cortical flake shatter		37		1	1			39
Non-cortical flake shatter		737			2	3		742
Bipolar flake shatter					1			1
Total	1	1651	3	3	12	5	1	**1676**

Fig. 9C) is small (n = 23). Aside from nine fragments of flake shatter, there are eight biface-reduction flakes, three cortical spalls, one core-reduction flake (i.e., smooth-platformed flake), a piece of cortical shatter, and a single rough pebble larger than others found in the surrounding matrix. All 23 are manufactured on basalt. Most of the complete or proximal flakes in the assemblage (63.6%) fall between 1 and 3 cm in diameter, with a smaller proportion (36%) being less than 1 cm (Fig. 10).

Component 2 yielded a lithic assemblage of 1744 artifacts[2] (see Table 3 for lithic debitage assemblage; Table 4 for lithic tool assemblage). Basalt is the dominant lithic raw material in the assemblage, representing ~98% of the recovered artifacts, though a few cases of obsidian, quartzite, diorite, crypto-crystalline silicate (CCS), andesite, and rhyolite also occur. The single artifact interpreted to represent a core is a basalt flake-core fragment with re-articulated cortical spalls (shown reconstructed in Fig. 9A o). Among 15 artifacts displaying evidence of deliberate manufacture, retouch, or use (i.e., the 15 tools recovered from Component 2), 12 are manufactured on basalt (Fig. 9A a-f, h-l, and n-o), two on obsidian (Fig. 9A g, m), and one on tan-gray CCS (Fig. 9A q). Additionally, we recovered one CCS burin spall (Fig. 9A p) which, while not itself a tool, is diagnostic of a specific lithic reduction strategy.

Table 4
Lithic cores and tools recovered from *Nataeł Na'* Component 2 (Locus A).

	Basalt	CCS	Obsidian	Total
Microblade fragment		1		**1**
Scraper fragment	3			**3**
Graver/notch			1	**1**
Flake core	1			**1**
Utilized flake	2		1	**3**
Retouched flake	1			**1**
Biface fragments				
Early-stage	2			2
Mid-stage	1			**1**
Late-stage	2			**2**
Indeterminate-stage	1			**1**
Total	**13**	**1**	**2**	**16**

Besides the technical debitage, we recovered 41 small unmodified pebbles and one large cobble which preserve no evidence of cultural modification and appear of similar composition to natural stones present in Stratum 6. Additionally, we recovered eight shattered cobbles that were likely thermally altered in the combustion feature associated with Component 2 based on their breakage pattern and level of oxidation. We also recovered one smooth, possibly polished, green-tan stone of unknown origin, with a maximum diameter of 17 mm. No similar objects were observed in any strata during excavation, or anywhere on the surrounding landform in an area with a diameter of at least 20 m. We have been unable to determine the composition of the stone, though we tentatively identify it as metamorphic. This may represent a manuport, though its purpose is unclear.

[2] Seventy-one artifacts were recovered without sufficient associated spatial data to confidently assign them to a component. We are hesitant to assign these artifacts to Component 2 because they were recovered either during the first positive shovel probe at locus A in 2016 (NPS TU1), when site stratigraphy was not yet established, or from a screen bag from 2019 labeled with multiple strata and an elevation range straddling a stratigraphic transition. These artifacts are most likely derived from Component 2, but without the spatial data to confirm this assumption, they have been excluded from the description above. This assemblage contains mostly secondary reduction debitage, with limited primary and tertiary reduction debitage and fire-affected rock (FAR). These artifacts were all manufactured on basalt, except for one CCS biface-thinning flake and the FAR, which is granite but for one fine-grained volcanic rock tentatively identified as oxidized rhyolite. Seven basalt flakes were recovered from the rodent-burrow cast that Reininghaus (2019) identified in the southern portion of the excavation. Excavation records show that these artifacts were associated with Stratum 8a sediments, but the artifacts were described as part of Component 2. Given the recorded elevation for these artifacts, it is possible that these sediments were translocated upward and that this natural feature intrudes into and through strata 7 and 6c. We cannot, however, be certain of the origin of these flakes and so they have not been included in the descriptions of either Component 1 or Component 2.

Table 5
Results of geochemical analysis of the *Natael Na'* Component 2 obsidian artifacts (values in ppm).

Catalog Number	K	Mn	Fe	Zn	Ga	Th	Rb	Sr	Y	Zr	Nb	Source Name	Quantitative Assignment
WRST 24115	29449	346	8817	33	17	10	105	85	16	147	10	Wiki Peak	Yes
WRST 24116	32279	410	9705	35	18	12	115	95	18	157	11	Wiki Peak	Yes
WRST 24118	29127	356	8722	34	17	10	102	82	15	141	8	Wiki Peak	Yes
WRST 24121	32749	386	9273	37	18	10	115	89	19	158	10	Wiki Peak	Yes
WRST 24165	30312	358	9032	33	17	10	103	81	16	143	9	Wiki Peak	Yes
WRST 24243	35909	420	10405	40	18	10	121	91	18	152	9	Wiki Peak	No
WRST 24288	34040	370	9307	33	18	10	109	87	17	152	10	Wiki Peak	Yes
WRST 24290	30705	367	8720	29	18	10	104	85	16	147	9	Wiki Peak	Yes
WRST 24291	33044	388	9499	32	18	11	113	90	18	149	10	Wiki Peak	No
WRST 24292	29184	341	8466	34	17	10	96	78	15	138	7	Wiki Peak	No
WRST 24293	32588	378	9668	34	18	12	113	92	18	156	10	Wiki Peak	Yes
WRST 24295	31681	352	8646	29	18	8	104	83	16	144	10	Wiki Peak	Yes
WRST 24294.1	33938	399	10046	45	18	10	115	89	17	150	10	Wiki Peak	No
WRST 24294.2	32522	375	9386	34	18	11	114	89	18	154	11	Wiki Peak	Yes
WRST 24294.3	32301	377	9162	31	18	11	112	90	18	152	9	Wiki Peak	No
WRST 24294.4	31727	365	9333	40	17	10	103	83	16	140	8	Wiki Peak	No

Table 6
Summary statistics of analyzed basalt artifacts from *Natael Na'* Locus A (values in ppm).

	Rb	Sr	Y	Zr	Nb
Basalt 1					
Mean	52.59673	508.6963	31.57876	266.8037	12.15681
Standard Deviation	11.61013	34.07593	3.205512	44.79694	1.853797
Basalt 2					
Mean	27.82429	136.7857	28.22429	171.9714	8.894286
Standard Deviation	29.80644	54.74547	12.91379	154.1222	7.871572
Basalt 3					
Mean	62.23081	398.6186	40.52919	320.8384	14.51676
Standard Deviation	16.69618	50.73013	7.995362	74.08131	2.82372
Basalt 4					
Mean	48.81611	428.7408	29.3708	259.7663	11.32009
Standard Deviation	7.187949	35.56401	4.458226	33.92186	1.798494

Excluding 782 fragments of flake, cortical, or bipolar shatter (i.e., medial or distal fragments of flakes or spalls lacking platforms, following Andrefsky (2005), which are excluded because the platform is critical to identifying debitage as resulting from specific reduction strategies), the debitage assemblage (98.2% of which is basalt) is dominated by biface-reduction flakes (70.7%) and small unifacial-retouch chips (6.9%), clear evidence of secondary reduction (Table 3). The presence of cortical spalls (10.5%), core-reduction flakes (6.2%), and angular shatter (5.4%) indicates that primary reduction also occurred on site. The assemblage of tools and proximal debitage from Component 2 is dominated by small, unmodified pieces, with 48.8% falling below 1 cm in diameter and another 48.4% between 1 and 3 cm (Fig. 10), while the remaining 2.1% of the assemblage is between 3 and 5 cm. Clearly, the basalt assemblage represents the full spectrum of reduction activities, from cobble decortication and production of flakes from simply-prepared cores to production of bifaces from early- through late-stage. Two obsidian bipolar flakes and one piece of obsidian bipolar flake shatter indicate that bipolar reduction also occurred on site, and the single CCS microblade fragment indicates at least the presence of that technology, as well.

The Component 4 assemblage includes 20 lithic artifacts, all manufactured on basalt and mostly representing secondary reduction. No tools were recovered from this component. Aside from eight fragments of flake shatter and two small pebbles (likely of natural origin), this assemblage contains two cortical spalls, a core-reduction flake, six biface-reduction flakes, and a tiny unifacial-retouch chip interpreted as a pressure flake. Just over 22% of the complete or proximal debitage from Component 4 are artifacts smaller than 1 cm in diameter, while 67% fall between 1 and 3 cm, and the remaining 11% (n = 1) is 3–5 cm in diameter (Fig. 10).

Despite the abundance of basalt in central Alaskan archaeology, thus far little attempt has been made to geochemically characterize and source this lithic raw material. During our refit analysis, however, we visually identified at least four potentially distinct basalts based on crystal size, structure, and weathering (i.e., cortical) characteristics (following Larson and Kornfeld, 1997). Seeking to better understand variation in the basalt sub-assemblages, we geochemically characterized a subsample (n = 270) of the basalt artifacts from *Natael Na'* with the Bruker Tracer portable x-ray fluorescence device at the Center for the Study of the First Americans. Our subsample included artifacts from all three components, though Component 2 was represented by the most robust sub-assemblage (Component 1, n = 4; Component 2, n = 271; Component 4, n = 1) (Supplementary Table S1 in SOM), and thus the only sub-assemblage we analyzed statistically. Through principal component and cluster analyses of the resulting compositional data, we identified four separate geochemical signals (Supplementary Figs. S1–S3, Supplementary Table S2 in SOM). Between-group comparisons of the abundance of variable reduction debitage and tools using chi-square analysis ($p = 0.0002743$) and a Kruskal-Wallis test ($p = 0.0001131$) demonstrated significant differences in the geochemically distinct basalt sub-assemblages at the 95% confidence interval.

Basalt groups 2 and 3 are represented in the Component 2 assemblage by few analyzed artifacts (n = 7 and 33, respectively), while basalt groups 1 and 4 are well represented (n = 119 and 112, respectively). Basalt 1 is represented almost exclusively by biface-reduction flakes. Basalt 2, though represented by only a few artifacts, includes evidence of primary, secondary, and tertiary reduction though none of the recovered lithic tools were manufactured on this material. Such tools could have been manufactured elsewhere on the site but not recovered during our excavations, however. Basalt 3 and Basalt 4 are represented by the full spectrum of lithic reduction from decortication to discard, and both include lithic tools (respectively, 6.1% and 5.5% of the group sub-assemblages) (see Supplementary Table S1 in SOM).

Geochemical analysis of the small obsidian sub-assemblage suggests that this raw material originated entirely from a single source near Wiki Peak, located ~130 km Euclidean distance east-southeast of *Natael Na'* (Patterson, 2008, 2010). We do not know, however, whether this obsidian was quarried from the primary Wiki Peak 'flow', or if it came from secondary sources glacio-fluvially transported to some location closer to the site (Cook, 1995; Reuther et al., 2011). Finally, we observe that the entire obsidian sub-assemblage as well as six of seven pieces of CCS (including the microblade fragment and burin spall) were recovered from the western outlying excavation unit, N97E97 (Fig. 3; Fig. 6). This horizontal variation in toolstone representation suggests that additional activity areas of Component 2 may exist along the low ridge continuing southwest of our small excavation area.

5. Discussion

5.1. Regional paleoecology

The central, low-elevation valley of the Copper River basin is believed to have remained largely free of glacial ice throughout the LGM (Briner and Kaufman, 2008; Dyke, 2004; Dyke et al., 2003), making it a region of particular interest to scientists investigating the peopling of Beringia and the Americas. The presence of extensive montane glaciation blocking many of the passes through the region's mountain ranges, however, caused the formation of Glacial Lake Atna, the extent of which, while still debated, is now becoming increasingly clear (Smith, 2019; Wygal and Krasinski, 2019). *Nataeł Na'* sits directly adjacent to a reconstructed shoreline of the lake (Fig. 2). During the earliest identified occupation, represented by Component 1 at ~13,100 cal BP, the lake was likely filled to the 777-m shoreline or a slightly lower shoreline, while by the time of the Younger Dryas-aged occupation (Component 2), the lake may have receded as far as the 762-m level or somewhat lower (Smith, 2019). Regardless, Glacial Lake Atna and its dynamic margins would have been the most prominent feature of the local Late Pleistocene landscape. During both Pleistocene occupations *Nataeł Na'* was likely situated along a narrow peninsula (Fig. 2B) that would have provided easy access to the lake. Based on extant modern topography, we hypothesize that the lake along the Copper River arm may have been ~10 m deep during the Allerød occupation, while the Tanada Creek arm would have been much shallower, perhaps forming a marsh. During the Younger Dryas occupation Glacial Lake Atna may have receded to create a broad, shallow estuarian marsh along the Copper River arm adjacent to *Nataeł Na'*. Given that we are not currently able to estimate the rate of subsequent downcutting that occurred along the Copper River during the Holocene, however, we offer these characterizations of the site's local environment as hypotheses to be tested with more extensive paleoenvironmental and archaeological research.

Proximity to the shore of Glacial Lake Atna, especially when it was shallower and therefore more productive near shore, suggests that lacustrine resources played an important (if seasonal) role in the subsistence strategies of the early inhabitants of *Nataeł Na'*. Importantly, marsh, lacustrine, and riverine resources often characterize faunal assemblages from Nenana and Denali sites in the Tanana valley, for example at Broken Mammoth (Dixon, 1999; Potter et al., 2014a; Yesner et al., 1992), Mead (Potter et al., 2014a; Yesner et al., 1992), Swan Point (Holmes, 2011; Potter et al., 2014a), and Upward Sun River (Potter et al., 2011, 2014a). The location of additional early sites like Healy Lake Village, Linda's Point (Bowman, 2017; Cook, 1969; Younie and Gillispie, 2016), and the Keystone Dune site (Lanoë et al., 2018) further suggest a close connection to lacustrine and riverine settings. Traditional Athabaskan subsistence relied heavily on aquatic resources as well, for example at nearby Mentasta Lake, Tetlin Lake and its extensive wetlands, and throughout the Copper River basin (Grinev, 1993; Haynes et al., 1984; Shinkwin, 1979; Strong, 1972).

The surrounding biotic landscape would have been largely devoid of trees when late-glacial humans inhabited *Nataeł Na'*, with the predominant ecosystem being an open shrub tundra (Ager, 1989; Ager and Sims, 1981) similar to reconstructions of much of Beringia at the time (Bigelow and Edwards, 2001; Edwards et al., 2000; Guthrie, 2001; Hoffecker and Elias, 2007; Hopkins et al., 1982). In this unique mosaic landscape wetlands and marshes, favoring the growth of ligneous plants such as willow, would doubtless have been a critical determinant in the procurement of firewood and potentially even plant foods by ancient populations. Though vegetation communities may have shifted somewhat from the Allerød through the Younger Dryas and into the Early Holocene, major vegetational change did not occur until establishment of the boreal-forest ecosystem ~9000 cal yr BP (Ager, 1989:91). This regional vegetation history is supported by our analysis of the charcoal recovered from *Nataeł Na'* (Table 2; see also Supplementary Text S6, Supplementary Fig. S6, Supplementary Tables S4–S6 in SOM). Coniferous species have not been identified in the charcoal record of strata 9–7 and appear only in the middle and upper portions of Stratum 6a, with the earliest identification of conifer being ~8500 cal BP (UGAMS-44756).

5.2. Chronology of cultural occupations

At ~13,100–13,000 cal BP, Component 1 at *Nataeł Na'* represents the earliest known human occupation of the Copper River basin, and indeed the oldest occupation in eastern Beringia south of the Alaska Range identified to date. Currently, however, the limited excavation area and resulting small size of the assemblage prevent further interpretation. Here we present our understanding of the site's occupation history, based on extant data from Locus A.

The only current evidence of potentially intensive site use at *Nataeł Na'* dates to the late Younger Dryas, specifically ~12,000 cal BP, when human populations are known to have inhabited the nearby Susitna valley (Blong, 2019; Wygal and Goebel, 2011, 2012; Wygal and Krasinski, 2019) though the possibility of a more robust occupation during the Allerød associated with Component 1 may exist outside the limited area of our excavations. Charcoal samples recovered from higher in Stratum 6 than the combustion feature and above the densest lithic artifact concentration of Component 2 yielded successively younger dates (Fig. 5); we believe these to have resulted from natural fire events as the age estimates are in stratigraphic order. Given that post-depositional movement of materials through solifluction has certainly obscured the spatial distribution, it is not currently possible to accurately estimate the number of occupation episodes that may be represented by Component 2. Although the majority of artifacts from Component 2 came from sub-Stratum 6b, those from underlying Stratum 7 occurred directly beneath the densest artifact concentration around the combustion feature (Fig. 7A), suggesting that they, too, relate to this feature and activities surrounding it. Their re-deposition could be the result of rodent burrowing, periodic cleaning-out of the hearth, or cryoturbation such as solifluction. The overlying materials in sub-Stratum 6a are more widely distributed (Fig. 7), most likely the result of solifluction.

Based on our charcoal analysis (see Supplementary Text S6, Supplementary Fig. S6, and Supplementary Tables S5 and S6 in SOM) and radiocarbon dating (Supplementary Table S4; see also Reininghaus, 2019:33–34) Component 3 at Locus B, dating somewhere between 3000 and 4500 cal BP (Table 2), is currently the earliest evidence of human occupation at *Nataeł Na'* after establishment of the boreal-forest ecosystem. Component 4, post-dating 1300 cal BP (Supplementary Table S4), is the youngest known occupation of *Nataeł Na'* but appears to predate the historic period because all Component 4 artifacts were recovered stratigraphically above charcoal-rich Stratum 5 but below the tephra pockets which resulted from eruptions within the last millennium (Supplementary Fig. S7, Supplementary Table S7; see also Zander et al., 2013).

5.3. Lithic raw-material procurement & technological organization

At first glance, the lithic artifact assemblage recovered from *Nataeł Na'* appears to be primarily derived from relatively homogeneous raw-material sources, likely locally procured. Our analyses, however, have revealed additional levels of complexity in technological organization practiced by the site's early inhabitants. The small Wiki Peak obsidian sub-assemblage from Component 2 preserves cortex on even very small spalls and contains the only identified evidence of bipolar reduction at the site. This may suggest that the inhabitants of *Nataeł Na'* procured Wiki Peak obsidian in the form of small cobbles or pebbles from secondary glacial or fluvial deposits distant from the primary geologic source where larger nodules are available, though no such secondary deposits of Wiki Peak obsidian are known in the site vicinity. While it is possible that this intensive use of small packages of Wiki Peak obsidian represents efforts to conserve a scarce and useful lithic raw material in response to mobility or scheduling constraints (*sensu* Goodyear, 1993), the presence of cortex in relatively high proportions in the obsidian assemblage leads us to suspect that these flakes were manufactured on site from small cobbles and pebbles carried from unknown secondary geologic deposits elsewhere rather than being derived from exhausted formal tools. The limited CCS sub-assemblage, lacking any cortex and primarily resulting from late stages of tool shaping and maintenance, likewise suggests transport from a considerable distance but possibly reliant on larger lithic raw-material packages than the Wiki Peak obsidian which were initially reduced elsewhere.

Basalt, however, appears to represent a more local toolstone. Our attempt to characterize intrasite basalt variability at *Natael Na'* represents one of the first systematic efforts to geochemically characterize culturally modified basalt in Alaska (see Rains, 2014). Regionally, such geochemical studies have met with broad success when applied to obsidian (Goebel et al., 2008b; Rasic, 2016; Reuther et al., 2011), rhyolite (Coffman and Rasic, 2015), and dacite (Gore, 2021), but the abundance of basalt in the Alaskan lithic landscape and the geochemical similarity between distinct flows (especially compared to obsidian) have thus far prevented a comprehensive study of this lithic raw material (but see Handley and Easton, 2022 for a study similar to our own in the Yukon). Undoubtedly, basalt was a critically important resource, utilized heavily by Pleistocene peoples at *Natael Na'* and across the Alaska Range uplands (Blong, 2018; Bowers and Reuther, 2008; Goebel, 2011; Gore, 2019; Graf et al., 2015). Our preliminary results validate further study of basalt geochemistry to expand our understanding of the geologic distribution of knappable volcanics and their accessibility to ancient peoples. Future research should attempt to compare archaeological specimens and naturally occurring basalt cobbles, as well as identifying and characterizing local primary geologic sources, to determine if the basalts used by the site's early inhabitants are consistent with those dispersed by the Copper River, Tanada Creek, and other regional waterways. This in turn may allow us to determine if the inhabitants of *Natael Na'* procured their lithic raw materials from nearby secondary deposits, local basalt flows, or more distant sources in the Alaska Range, for example the Nenana Valley where Gore (2019) is currently investigating basalt variability.

The lithic raw materials recovered from *Natael Na'* appear to represent a variety of technological activities; components 1 and 4, however, yielded assemblages too small to allow for comprehensive characterization. Our analysis of the lithic artifacts from Component 2 suggests variable technological activities by raw material. Obsidian represents a tiny fraction of the assemblage (<1%) but preserves the only evidence in the assemblage of bipolar reduction as well as a relatively high proportion (~18%) of artifacts retaining cortex. Combined with the fact that ~14% of the recovered lithic tools are manufactured on obsidian (see Table 4), this suggests a need for expedient tools with reliably sharp edges during the Younger Dryas occupation, hence the procurement and possible curation of this important toolstone. The lack of cortex in the small CCS sub-assemblage and the presence of retouch along the lateral edge of the sole microblade (Fig. 9B) is indicative of curation rather than expedient, on-site manufacture. The extensive basalt assemblage allows for more robust interpretation.

Upon initial examination we recognized the presence of the full reduction sequence from cobble to finished tool; the sub-division of the assemblage based on our geochemical analysis, however, provides a more nuanced understanding of basalt use. Basalt group 1 contains almost no cortical spalls and is composed almost exclusively of biface-reduction flakes, which suggests that primary reduction of this material occurred elsewhere. We did not identify any lithic tools made of Basalt 1, though they may exist in unexcavated areas of the site. Basalt group 2 likewise contains no tools, but includes primary, secondary, and tertiary reduction debitage. Despite the small sample size, this suggests local procurement and on-site tool production, with possible subsequent transport away from *Natael Na'*. Basalt groups 3 and 4 contain significant proportions of primary reduction debitage as well as extensive secondary debitage and lithic tools, expedient as well as formal. Taken together, these patterns suggest that Basalts 2, 3, and 4 were directly procured from local sources, while Basalt 1 may have been procured at a more distant location and transported to *Natael Na'* after cortex removal. These observations suggest that during the occupation of Component 2, the inhabitants of *Natael Na'* curated, transported, and used raw-material packages of obsidian, CCS, and possibly basalt (group 1), while simultaneously replacing the products of these lithic raw materials with new tools created on local basalt (groups 2–4). Scrapers represent 20% of the recovered tools (Table 4), while the prevalence of bifacial reduction may result from production of bifacial knives and projectile points, though none of the biface fragments recovered to date can be identified as such. Although subsistence remains are lacking, we hypothesize that the toolkit utilized by the Younger Dryas inhabitants of *Natael Na'* may have been associated with hunting-related activities.

5.4. Chrono-cultural attribution

The age estimate for Component 1 (Table 2) closely corresponds to the accepted age of the Nenana Complex in Alaska (Graf and Buvit, 2017; Graf et al., 2015; Hoffecker and Elias, 2007), but the paucity of diagnostic artifacts makes definitive cultural assignment difficult. Component 2, however, contains a single microblade and one burin spall, along with extensive evidence of biface production, suggesting assignment to the Denali Complex (e.g. Dixon, 1985, 2013; West, 1967, 1975). Wygal (2018) has observed that the composition of Denali Complex assemblages differs depending on their elevation, with lowland sites characterized by microblades, upland sites by bifacial projectile points, and the intermediate montane zone including both technologies. *Natael Na*'s elevation places it in the montane zone of the Alaska Range, not high enough to preclude the presence of microblades in a Denali assemblage (Wygal, 2018). While the evidence for assigning the occupation to the Denali Complex is meager, this proximity to the uplands may explain the paucity of microblades in the Component 2 assemblage (although we acknowledge that the site may contain additional microblades in unexcavated areas). Component 3 at Locus B dates to the period of the Northern Archaic Tradition (Esdale, 2008), though the assemblage does not contain any diagnostic artifacts (Reininghaus, 2019). Likewise, Component 4 did not yield any diagnostic artifacts, but its presumed age suggests that it represents a Late Holocene Athabaskan Tradition occupation (e.g. Dixon, 1985; Potter, 2016).

6. Conclusions

The results presented here represent an exciting new discovery that demonstrates the potential of the Copper River basin for the study of early Beringian archaeology and paleoecology. Moreover, the existence of an Allerød-aged occupation at *Natael Na'* has significant implications for our understanding of the early Alaskan archaeological record, as it raises questions regarding the potential relationship of the Copper River basin's earliest human inhabitants to the well-established Nenana Complex to the north. Though Component 1 is only some 500 years older than the oldest identified cultural component in the adjacent Susitna valley (Wygal and Krasinski, 2019), the apparent occupation of *Natael Na'* prior to the onset of the Younger Dryas suggests that the climatic changes occurring during that period were not the initial motivator for human populations to move into and south of the Alaska Range (see Graf and Bigelow, 2011). Further investigation of this region will clarify the nature of this connection, most importantly whether the distinctive technologies of the Nenana Complex are present in the archaeological record of the north Pacific watershed.

Previously, obsidian sourcing studies of late-glacial sites in the Tanana River basin suggested a strong connection with Wiki Peak (Goebel et al. 2008; Rasic, 2016; Reuther et al., 2011), located near the present-day northeastern corner of Wrangell-St. Elias National Park and Preserve (Fig. 1), but obsidian from a few unknown sources also occurs in early lithic assemblages. Thus far only Wiki Peak obsidian has been identified in the Younger Dryas assemblage at *Natael Na'* (i.e., Component 2), while the unknown sources documented from Alaska have not been identified at the site to date. Though future investigations at *Natael Na'* will likely provide additional information regarding Younger Dryas obsidian use, the exclusive (or primary) reliance on Wiki Peak obsidian at *Natael Na'* would not be entirely surprising, given the proximity of Wiki Peak to the site. Additionally, only ~5% of Late Pleistocene-aged culturally modified obsidian from Alaska has been connected to unknown sources (Reuther et al., 2011) including unknown Group A', which likely comes from primary geologic sources in the Wrangell Mountains. Expanding archaeological investigation of the Copper River basin will not only increase our understanding of the local lithic landscape and regional identification of obsidian sources (including mapping the primary and secondary distribution of Wiki Peak obsidian), but more generally it may clarify the timing of initial human dispersal into the region and whether this event was an outgrowth of the known Allerød settlement of the Tanana River basin.

Interestingly, the Copper River basin forms an important geographic connection between the Alaskan interior and the southern coast which may have allowed Paleoindian peoples to access the latter while the interior Ice-Free Corridor remained closed or inimical to human habitation (Froese et al., 2019; Heintzman et al., 2016; Margold et al., 2019). Though the presence of ice dams (Fig. 2) preventing final draining of Glacial Lake Atna south through the lower Copper River valley may suggest that the lake and constraining ice presented a significant ecological barrier to early human populations, the archaeological distribution of Wiki Peak obsidian (Reuther et al., 2011) suggests that humans navigated the high passes of the Alaska Range by the Allerød interstadial. Early hunter-gatherers may likewise have been able to find passable routes to the south through the Chugach Mountains to reach the Pacific coast. The first humans to colonize a region, however, do not have specific end goals in mind (see Cannon and Meltzer, 2022; Meltzer, 2003) and we must remember that there is no *a priori* reason to assume that the Allerød inhabitants of *Natael Na'* would have sought such passages to the coast if they originated from north of the Alaska Range. With the increasing interest in the coastal migration theory (Fig. 1) (Braje et al., 2020; Davis and Madsen, 2020), it will become ever more important that we investigate the possibility of human dispersal into and beyond the Copper River basin both from the north and from the south. Efforts must also be redoubled to locate earlier occupations of adjacent regions. The archaeological record of the Susitna River valley currently contains more robust evidence of Younger Dryas and Early Holocene occupation (Blong, 2019; Reuther et al., 2018; Smith, 2019; Wygal and Goebel, 2012; Wygal and Krasinski, 2019) than is known from the Copper River basin, including the oldest cultural dates south of the Alaska Range prior to our identification of Component 1 at *Natael Na'*, and may contain older occupations that have yet to be identified. The Susitna valley also has potential to connect the interior to the southern coast via Cook Inlet where the age of the earliest coastal occupation remains unclear (Reger and Wygal, 2016), though whether such a connection relates to initial waves of human dispersal has yet to be assessed.

The occupations at *Natael Na'* provide an exciting new glimpse into the peopling of eastern Beringia. The position of this site adjacent to the ancient shores of Glacial Lake Atna suggests that identifying the shorelines of Pleistocene-aged proglacial lakes will be an important step in locating evidence of early occupations south of the Alaska Range, especially in ancient estuarine settings. Lake-level fluctuations have been demonstrated to affect the distribution of archaeological sites in other regions (e.g., Adams et al., 2008), and our increased understanding of the dynamics of proglacial lakes in eastern Beringia during the Late Pleistocene (Smith, 2019) suggests that such a pattern may exist here as well. This possibility also warrants further study to elucidate the subsistence and mobility patterns of Pleistocene hunter-gatherer groups.

While much about the nature of the early human occupation at *Natael Na'* remains unclear, our test excavation of the site has provided the first evidence of an Allerød-aged human occupation in a region hypothesized to offer a connection between the oldest interior sites in eastern Beringia and the Pacific coastal regions to the south. Though this phase of investigation is concluded, we believe that the earliest occupation at *Natael Na'* needs to be investigated further, while respecting the wishes of the Ahtna community and preserving the important heritage represented at *Natael Na'*. We hope that we, or other dedicated archaeologists, will be able to return to the site and the surrounding area in the future for this purpose. Further research in the Copper and Susitna River valleys may facilitate greater understanding of the process of adaptation to riverine, lacustrine, and maritime and coastal subsistence and mobility strategies by ancient peoples. Only through studying the regions south of the Alaska Range will we determine if the first Americans entered the coastal fringe of western North America by dispersing from interior Alaska from the north or along the south coast of Beringia. At the least, our results confirm that hunter-gatherer populations were actively occupying the upper Copper River basin by the terminal Pleistocene, dramatically extending the occupation history of this important regional watershed and providing the first direct evidence of human habitation south of the Alaska Range predating the Younger Dryas.

Data availability

Data associated with the 2016–2018 excavations are housed at Wrangell-Saint Elias National Park and Preserve, and full accession catalogue data are stored by the NPS. All data associated with the 2019 excavations and subsequent analyses of the collection are housed at Texas A&M University in College Station, Texas.

CRediT authorship contribution statement

John T. White: Conceptualization, Methodology, Formal analysis, Investigation, Data curation, Writing – original draft, Visualization, Project administration, Funding acquisition. **Auréade Henry:** Formal analysis, Writing – review & editing, Visualization. **Stephen Kuehn:** Formal analysis, Data curation, Writing – review & editing, Visualization. **Michael G. Loso:** Formal analysis, Writing – review & editing, Visualization. **Jeffrey T. Rasic:** Formal analysis, Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

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