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Assessing the proposed pre-last glacial maximum human occupation of North America at Coats-Hines-Litchy, Tennessee, and other sites

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ABSTRACT

Genomic studies indicate that the first Pleistocene foragers who entered North America diverged from ancestral populations in Beringia sometime after the Last Glacial Maximum (LGM); however, several archaeological sites in North America have been proposed to predate the LGM. We present the results of our excavation and analysis of one such site, Coats-Hines-Litchy, Tennessee, which show that this site is a paleontological locality containing a geofact assemblage that pre-dates the LGM. Other sites in North America that purportedly predate the LGM occur in geomorphic contexts that are also conducive to the formation of geofact assemblages. As such, we propose that the reported artifacts from these sites were created by natural processes. No sites in North America currently provide credible evidence of a pre-LGM occupation.

1. Introduction

The Americas were the last continents to be explored and settled by modern humans. Genomic evidence suggests an initial human arrival, or at least genetic divergence, approximately 15,000 to 16,000 years ago (Llamas et al., 2016; Raghavan et al., 2015; Schurr, 2015). While many aspects of that migration are still debated, the overwhelming evidence supports a population expansion out of eastern Beringia and into the Americas after the Last Glacial Maximum (LGM; ca. 19,000-26,000 cal yr B·P.) (Nielsen et al., 2017; Rasmussen et al., 2014; Reich et al., 2012; Tackney et al., 2015).

However, archaeological sites pre-dating the LGM have been proposed for both North and South America (e.g., Boëda et al., 2016; Collins et al., 2003; Holen et al., 2017; Madsen, 2015). These sites largely consist of non-diagnostic lithic assemblages and supposedly modified bones. As such, these proposed archaeological sites are in conflict with current genomic data. To address this incongruence, we examine the archaeological evidence for proposed pre-LGM sites in North America. We present the results of our investigation of the Coats-Hines-Litchy (CHL) site, Tennessee, and assess two other proposed North American pre-LGM sites with similar site formation processes (Fig. 1C).

1.1. Site setting and previous research

CHL is located near the head of a small stream channel that is surrounded by rolling hills (Fig. 1A). Outcrops of Fort Payne and Bigby-Canon limestones, which contain seams of chert, occur upslope of the site (Wilson and Miller, 1963). A series of excavations from 1994 to 1995 focused in Area B of the site and exposed a bone bed containing the disarticulated remains of a mastodon (*Mammut americanum*) along with highly fragmented remains of horse (*Equus*), deer (*Odocoileus*), muskrat (*Ondatra zibethicus*), canid (*Canis*), turkey (*Meleagris gallopavo*), frog (*Rana*), and painted turtle (*Chrysemys*) (Fig. 2) (Breitburg et al., 1996). Lithic and osseous artifacts were found during the excavations and potential cutmarks made by stone tools were identified on one vertebrae fragment

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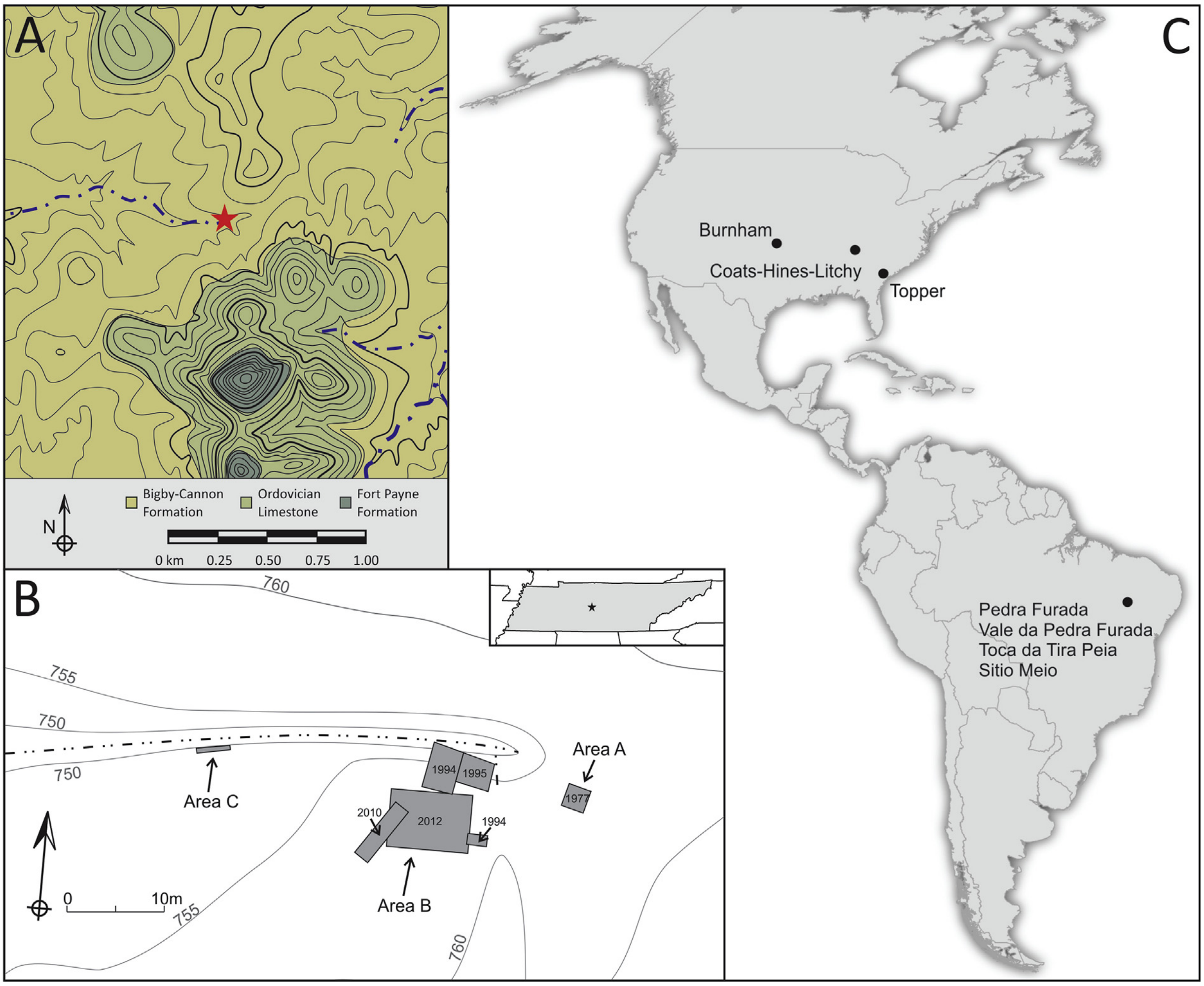

Fig. 1. Locations of sites mentioned in text. (A) Geomorphic and geologic setting of Coats-Hines-Litchy. (B) Site detail map of Coats-Hines-Litchy indicating areas and years of excavations. (C) Hemispheric perspective of all sites discussed in text.

(Breitburg et al., 1996). A single radiocarbon age on charcoal yielded an age of 27,050 ± 200 ^{14}C yr B.P. (Beta-80169), or ~31,000 cal yr B.P. (Table 1), though younger ages were obtained on organic sediments (Breitburg et al., 1996). In 2010, a trench was excavated and yielded additional faunal remains, more chert fragments, and a new radiocarbon age of 29,120 ± 150 ^{14}C yr B.P. (Beta-288802), or ~33,200 cal yr B.P. (Table 1) (Deter-Wolf et al., 2011). Both studies concluded that artifacts were directly associated with mastodon remains, resulting in CHL being often cited as a potential pre-Clovis site in the mid-continent (e.g., Anderson et al., 2015; Cannon and Meltzer, 2004; Grayson and Meltzer, 2015; Haynes, 2015; Haynes and Hutson, 2013).

2. Materials and methods

The 2012 excavation of CHL was conducted by the Center of the Study of the First Americans, Texas A&M University. A total of 43 contiguous 1 × 1 m units were excavated in Area B that intersected all previous excavations (Fig. 1B). This enabled the correlation of the previous geological and archaeological studies with the 2012 excavation, and the evaluation of site stratigraphy, site formation processes, and site geochronology. All 1 × 1 m excavation units were dug in 5 cm arbitrary levels within stratigraphic units, and all sediment water screened through 1/4" and 1/8" wire mesh. All bones and rocks larger than 2 cm, unit elevations and boundaries, and stratigraphic boundaries were recorded with a Sokkia total station. Radiocarbon samples were collected during excavations in 2012 and additional geomorphic studies in 2014. All radiocarbon measurements were determined at the W. M. Keck Carbon Cycle Accelerator Mass Spectrometry Laboratory. Geoarchaeological analyses were conducted at the Center for the Study of the First Americans, Texas A&M University.

Faunal analysis was undertaken at the DeSantis DREAM Laboratory at Vanderbilt University. Rare Earth Element (REE) analyses were conducted at the Department of Geological Sciences, University of Florida. Geochemical analysis of the late Pleistocene faunal remains was conducted to further investigate the contextual association between the faunal remains excavated in 1994–1995 and those excavated in 2012. Approximately 5–10 mg of cortical bone or turtle carapace was sampled using a Dremel™ rotary drill with carbide burs. The sample powders were placed in clean Savillex™ vials, and dissolved overnight on a hot plate with 3 ml of 8M HNO_3. After dissolution, samples were opened and dried on the hotplate. Four ml of 0.8M HNO_3, spiked with 8 ppb Re, was added to the samples by weight to re-dissolve the dry residue. A small aliquot of the resultant solution was removed and diluted with additional 0.8M HNO_3, spiked with 8 ppb Re, so that the final dilution was around 2,000×. The final dilution for trace element analyses was determined by weight for each sample. REE analyses were performed on a Thermo Finnigan ELEMENT2 Inductively

Fig. 2. Photograph from the March 1995 Coats-Hines-Litchy excavation looking south. The mastodon bone bed can be seen in the foreground. Photograph courtesy of the Tennessee Division of Archaeology.

Table 1
Radiocarbon ages from Coats-Hines-Litchy.

Laboratory Number	Northing/Easting	Elevation	Material Dated	Age ^{14}C yr B.P. (±1 sigma)	Geologic Unit	Remarks
1994/1995 radiocarbon measurements[a] [b]						
Beta-80169			Charcoal	27,050 ± 200	Base of 3 (estimated)	Base of 1994, associated with horse teeth
Beta-75403			Organic Sediment	6530 ± 70	Unit 3 (estimated)	Within dental cusps of mastodon tooth
Beta-125351			Organic Sediment	10,260 ± 240	Unit 3 (estimated)	Above mastodon humerus
Beta-125350			Organic Sediment	12,030 ± 40	Unit 3 (estimated)	Below mastodon rib fragment
Beta-125352			Organic Sediment	14,750 ± 220	Unit 3 (estimated)	Below mastodon humerus
2010 radiocarbon measurements[b]						
Beta-288801		260 cmbs	Charcoal	12,300 ± 60[c]	Units 2-4	Estimated provenience
Beta-288802		302 cmbs	Charcoal	29,120 ± 150	Units 2-4	Estimated provenience
Beta-290990		289 cmbs	Organic Sediment	1960 ± 30	Units 2-4	Estimated provenience
Beta-290991		290 cmbs	Organic Sediment	23,490 ± 110	Units 2-4	Estimated provenience
2012 radiocarbon measurements						
UCIAMS-149780		215 cmbs	Charcoal	33,220 ± 440	Base of Unit 5	Recovered from cutbank profile
UCIAMS-149781		200 cmbs	Charcoal	30,900 ± 180	Base of Unit 5	Recovered from cutbank profile
UCIAMS-120329	N1000/E1010.5	98.000–97.950	Charcoal	22,490 ± 100	Unit 4	Recovered during 2012 excavation
UCIAMS-120330	N998/E1008	97.900–97.850	Charcoal	26,290 ± 150	Unit 3	Recovered during 2012 excavation
UCIAMS-120331	N1000/E1010	97.750–97.700	Charcoal	36,120 ± 480	Unit 3	Recovered during 2012 excavation
UCIAMS-121950	N1000/E1010	97.750–97.700	Charcoal	36,590 ± 650	Unit 3	Recovered during 2012 excavation
UCIAMS-120332	N999/E1005	97.650–97.600	Charcoal	31,140 ± 270	Base of Unit 3	Recovered during 2012 excavation
UCIAMS-121951	N999/E1005	97.650–97.600	Charcoal	30,910 ± 320	Base of Unit 3	Recovered during 2012 excavation
UCIAMS-120333	N995/E1005	97.550–97.500	Charcoal	30,740 ± 240	Unit 2	Recovered during 2012 excavation
UCIAMS-120334	N1000/E1006	97.550–97.500	Charcoal	26,310 ± 150	Unit 2	Recovered during 2012 excavation
UCIAMS-120335	N1000/E1008	97.850–97.800	Charcoal	30,620 ± 240	Unit 1	Recovered during 2012 excavation
UCIAMS-120336	N996/E1007	97.400–97.350	Charcoal	>26,400	Unit 1	Recovered during 2012 excavation

[a] Breitburg et al., 1996.
[b] Deter-Wolf et al., 2011.
[c] Previously this age was reported without the delta 13C correction as 12,050 ± 60 (Deter-Wolf et al., 2011).

Coupled Plasma Mass Spectrometer (ICP-MS) in the University of Florida Department of Geological Sciences. All measurements were performed in medium resolution with Re used as internal standard. Quantification of results was done by external calibration using a set of gravimetrically prepared REE standards. All REE concentrations were normalized to PAAS (Post-Archean Australian Shale) (McLennan, 1989). The REEs analyzed range from La (Z = 57) to Lu (Z = 71). We excluded europium (Eu) from the analysis *post hoc*, due to anomalous Eu enrichment and depletion spikes (see DeSantis and Wallace, 2008; Trueman et al., 2004).

The CHL site was then compared to other proposed archaeological sites generally contemporary with, or older than the LGM. The Topper and Burnham sites were chosen for this comparison due to the similarities in assemblages and site formation processes. Moreover, these sites represent some of the most thoroughly reported sites possibly dating to the LGM.

3. Results

3.1. Late quaternary geology

Nine stratigraphic units were defined in the 2012 excavation block (Schmalle, 2013). These units are grouped into four disconformity-bound packages; Units 1-5, 6-7, 8, and 9 (Fig. 3). Units 1-5 are the product of episodes of coarse-grained colluvial deposition from the hillslopes and fine-grained alluvial deposition from the stream (Schmalle, 2013). These sediments fine-upward from a clayey gravel (Unit 1), to gravelly silty clay (Units 2-4), and silty clay (Unit 5). Unit 5 was altered by pedogenesis and contains distinct redoximorphic features (Schmalle, 2013). Units 1-5 are truncated by channel erosion, with interbedded gravels and clay (Unit 6) filling the channel west of Area B. In Area B, Unit 6 is not present; rather, Unit 7 directly overlies Unit 5 and consists of alluvial silty clay. Pedogenic processes altered the upper portion of Unit 7. Unit 8 is a silty clay that overlies Unit 7. Unit 9 is historic-period fill.

During our investigation, we obtained 12 new radiocarbon ages from Units 1-5 on pieces of dispersed charcoal (Fig. 3; Table 1). While there are some internal date reversals and two older ages within this sequence, as a group, Units 1-5 date between 22,490 ± 100 ^{14}C yr B.P. (UCIAMS-12329) and 30,620 ±240 ^{14}C yr B.P. (UCIAMS-120335) or ~27,000 to 34,500 cal yr B.P. Correlation of our stratigraphy to the geological sequence recorded during the 1994-1995 excavations shows that the mastodon and reported artifacts came from the base of our Unit 3. The radiocarbon age of 27,050 ± 200 ^{14}C yr B.P. (Beta-80169) obtained from the bone bed correlates with the late Pleistocene ages we obtained from this unit. Units 6-8 were not directly dated.

3.2. Faunal assemblage

A total of 1122 bone fragments were recovered from late Pleistocene Units 1-4 in 2012. These remains were heavily weathered and highly fragmented, which prevented identification of most specimens. Turtle fragments were the most abundant specimens (*Chrysemus* cf. *picta*), greater than 95% of all identifiable fossil fragments. However, fragmentary material was also collected from the American mastodon (*Mammut americanum*), including post-cranial elements and identifiable enamel fragments. Enamel fragments of horse teeth (*Equus* sp.), and deer antler (*Odocoileus* sp.) were also recovered. Most notably, the faunal list was expanded by one new taxon, a giant ground sloth (*Paramylodon* sp.) from the family Mylodontidae. Presence of the giant ground sloth is based on several tooth fragments, including a nearly complete caniniform (canine-like) tooth.

Of all the faunal material examined from the site, only the mastodon remains excavated in 1994–1995 have previously been suggested to provide evidence of human interaction. Breitburg et al. (1996) reported cutmarks on a thoracic vertebra based on an apparent V-shaped cross-section of the linear incision. Other researchers have questioned this interpretation (Cannon and Meltzer, 2004; Grayson and Meltzer, 2015; Haynes, 2015). Specifically, it is unclear how the purported cutmarks were originally identified from the numerous scratches that are present on the fragmented specimen in question. While a detailed study of the purported cutmarks has not been published, some information can be gleaned from photographic evidence. The marks in question consist of three incisions of varying depth, approximately one-to-four cm in length (Fig. 4). Natural processes have been demonstrated to produce V-shaped incisions on bones (Haynes and Krasinski, 2010; Krasinski, 2010). Thus, the presence of incisions alone does not unequivocally prove modifications to the bones were culturally-produced.

In sum, the CHL faunal assemblage represents a secondary accumulation of disarticulated remains of many animals redeposited in a small stream channel. Individual elements occurred in isolation, showed evidence of tumbling and transport breakage, and were scattered vertically throughout the late Pleistocene geological units indicating a secondary accumulation. The high-energy alluvial environment, as indicated by channel deposits, likely fractured and damaged the bones in the process of redepositing them. Angular gravels, including the non-culturally produced

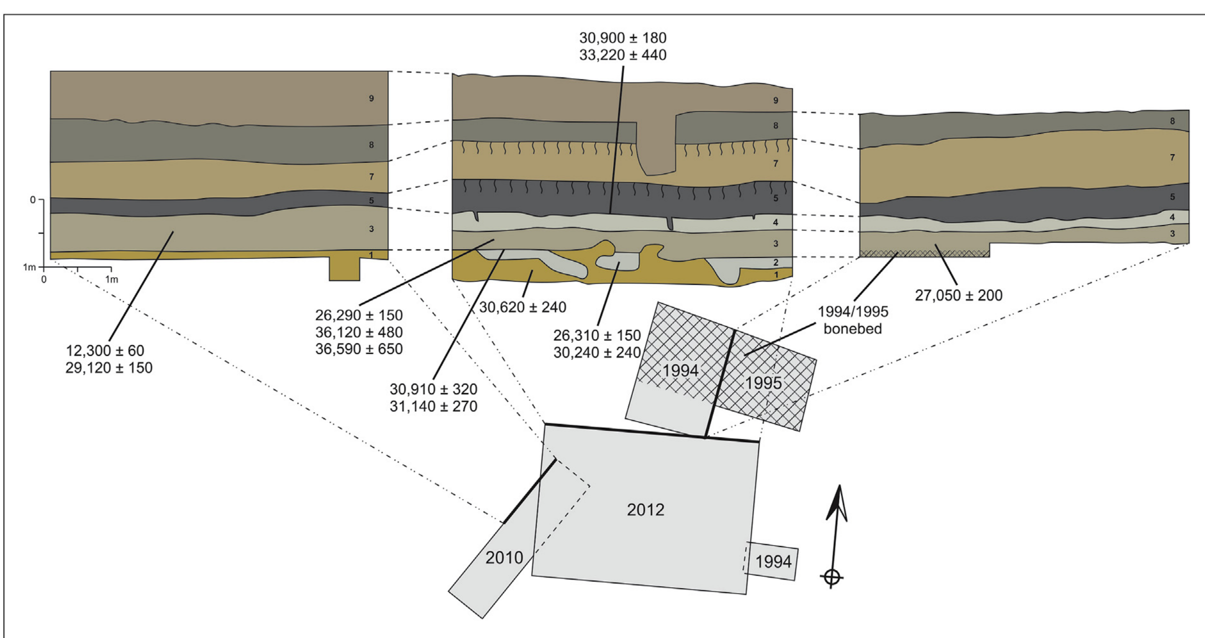

Fig. 3. Excavations and stratigraphy of Area B at Coats-Hines-Litchy. Geological units are identified and correlated. Radiocarbon ages on charcoal are presented. Location of 1994/1995 mastodon bone bed is noted in profile. Adapted with permission from Schmalle (2013) and Tune (2015).

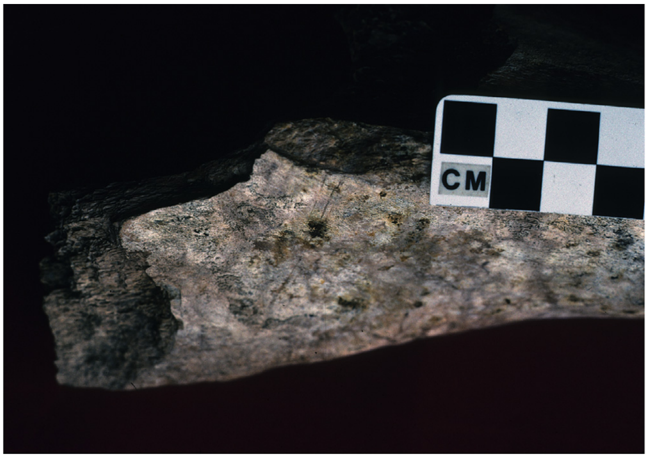

Fig. 4. Photograph of the purported cutmarks on the thoracic vertebra recovered in the 1994/1995 excavations. Previously reported in Breitburg et al. (1996). Photograph courtesy of the Tennessee Division of Archaeology.

lithic flakes, occurring in the stream channel could have easily produced V-shaped, linear incisions on the bones. Furthermore, the fragmentary nature of the bone bed and presence of linear incisions also suggest post-depositional disturbance. Animals scavenging and moving bones in coarse-grained sediments can also disperse, fragment, and modify bones (Haynes and Krasinski, 2010).

3.3. Rare earth element analysis

Based on geological correlations, the mastodon remains reported in 1994–1995 (Breitburg et al., 1996) correlate to our Unit 3 (Figs. 5–6). REEs from the humerus of the 1994-1995 mastodon and mastodon and turtle bones excavated in 2012 were measured and compared to evaluate the stratigraphic assignment of the 1994-1995 mastodon to Unit 3.

Normalized REE patterns from the mastodon humerus (1994-1995) are parallel to those of turtle shell and mastodon bones (2012) (Table 2, Fig. 7). While absolute concentrations of each element vary in each sample (which can also be driven by the porosity of the material taking up REEs; MacFadden DeSantis. 2010), the REE patterns are largely similar between samples and reflect comparable depositional environments (MacFadden et al., 2007; Trueman, 1999). For example, all samples have ratios within one standard deviation of the mean when looking at Sm to Gd, Nd to Sm, or Yb to Lu, with the exception of the mastodon specimen 329 which may have been slightly older or younger in age than the rest of the specimens, or even transported from an area with slightly different poor water chemistry. While the sediments and faunal materials at CHL are in secondary alluvial deposits, the similar REE patterns indicate that the majority of animals died and were buried in close proximity to one another and/or most bones were exposed to pore water with similar chemistry. The similar REE patterns of the faunal samples, therefore, reaffirm the stratigraphic correlations between the excavations.

3.4. Artifact assemblage, composition, and context

Thirty-eight artifacts were reported from the 1994-1995 excavation and 11 artifacts from the 2010 testing; a total of 49 specimens (Figs. 8–9). These included one biface fragment, one angular scraper, two gravers, one piece of fire-cracked chert debris, 42 flakes and flake fragments, and two osseous artifacts (Breitburg et al., 1996; Deter-Wolf et al., 2011). Breitburg et al. (1996) reported that 12 lithic specimens were found *in situ* within the bone, including a single macrodebitage flake. The remaining specimens were microdebitage or flake fragments, and either recovered out of context or during the processing of bulk sediment samples in the lab. Notably, all purported lithic artifacts are made of Fort Payne or Bigby-Cannon chert. The 2012 excavation yielded 11 additional flake-like chert pieces. Additional lithic artifacts and faunal remains, including a biface, core, and antler fragment were found out of context in the modern stream channel adjacent to the site and are not included in the CHL assemblage (Deter-Wolf et al., 2011).

Fig. 5. The east wall profile of the 2012 Coats-Hines-Litchy excavation.

Fig. 6. Photograph from the 1994 Coats-Hines-Litchy excavation showing the disarticulated mastodon remains in relation to the geologic units identified in 2012. Photograph courtesy of the Tennessee Division of Archaeology.

Table 2
REE data for faunal remains from Coats-Hines-Litchy.

Element	2012 Turtle (T416)	2012 Turtle (T676)	1994-1995 Mastodon (M1994.1)	2012 Mastodon (M653.2)	2012 Mastodon (M625.1)	2012 Mastodon (M382.2)	2012 Mastodon (M329.4)
La	6.09	6.08	1.28	3.12	2.71	1.35	4.44
Ce	24.93	22.03	2.45	6.84	6.35	2.45	11.36
Pr	4.79	4.17	0.38	1.13	0.91	0.31	2.52
Nd	32.17	26.70	1.74	5.75	4.72	1.17	14.37
Sm	10.90	8.71	0.47	1.59	1.34	0.26	4.68
Eu	3.26	2.62	0.18	0.46	0.39	0.13	1.38
Gd	21.16	16.94	0.73	2.56	2.57	0.34	8.08
Tb	3.49	2.82	0.12	0.41	0.43	0.05	1.37
Dy	24.73	20.00	0.73	2.73	3.04	0.29	9.83
Ho	5.98	4.89	0.19	0.67	0.80	0.09	2.48
Er	18.13	14.85	0.55	2.04	2.52	0.22	7.67
Tm	2.36	1.93	0.08	0.28	0.35	0.04	1.06
Yb	14.12	11.54	0.44	1.66	2.12	0.23	6.80
Lu	2.15	1.77	0.07	0.27	0.35	0.03	1.09

Lithic artifacts have been recovered from three Archaic and Woodland surface sites 200 m upslope of CHL according to site file records.

As previously reported, the lithic artifact assemblage from CHL appears to be associated with mastodon remains (Breitburg et al., 1996; Deter-Wolf et al., 2011). However, upon closer examination of the evidence, two issues arise. First, the human origin of some of the reported artifacts is equivocal, and second, the reported location and association of the artifacts is questionable. Analysis of the lithic assemblage and review of excavation records show that the biface fragment (Fig. 8ag) and angular scraper (Fig. 8aj) were recovered out of context; thus, their association to the bone-bearing deposits cannot be unequivocally determined. The biface was recovered from the area of the bone bed initially excavated in May 1994; however, according to original field notes the biface was not actually discovered until the third stage of the original excavation in March 1995 (Fig. 9). At that time, the area where it was discovered had already been excavated and the bones removed. The location where the biface was recovered was exposed for approximately 10 months in the bottom of the modern channel before its discovery. Therefore, the association of the biface to the bone-bearing deposits cannot be unequivocally determined. Likewise, the angular scraper was recovered after it had eroded into the stream channel; thus, direct association with the mastodon bone bed cannot be verified. Examination of the two purported gravers show that they are fortuitously shaped natural chert debris and lack any evidence of intentional flaking or usewear. One specimen (Fig. 8ad) has three large flat facets on the dorsal surface, there is no systematic pattern to the flaking that indicates intentional modification. The other specimen (Fig. 8ae) does not possess any facets from flake removals and both faces are covered in weathered, natural cortex. Both of these lithic fragments lack evidence of microchipping or other indicators of usewear. The single thermally altered chert fragment (Fig. 8ai) from 1994-1995 cannot be unequivocally attributed to human activities, and pot lidding may have been the result of natural fires. The two osseous specimens do not exhibit any evidence of intentional modification or use. The purported pressure flaker (Fig. 8v) is a 15.1 mm long fragment of

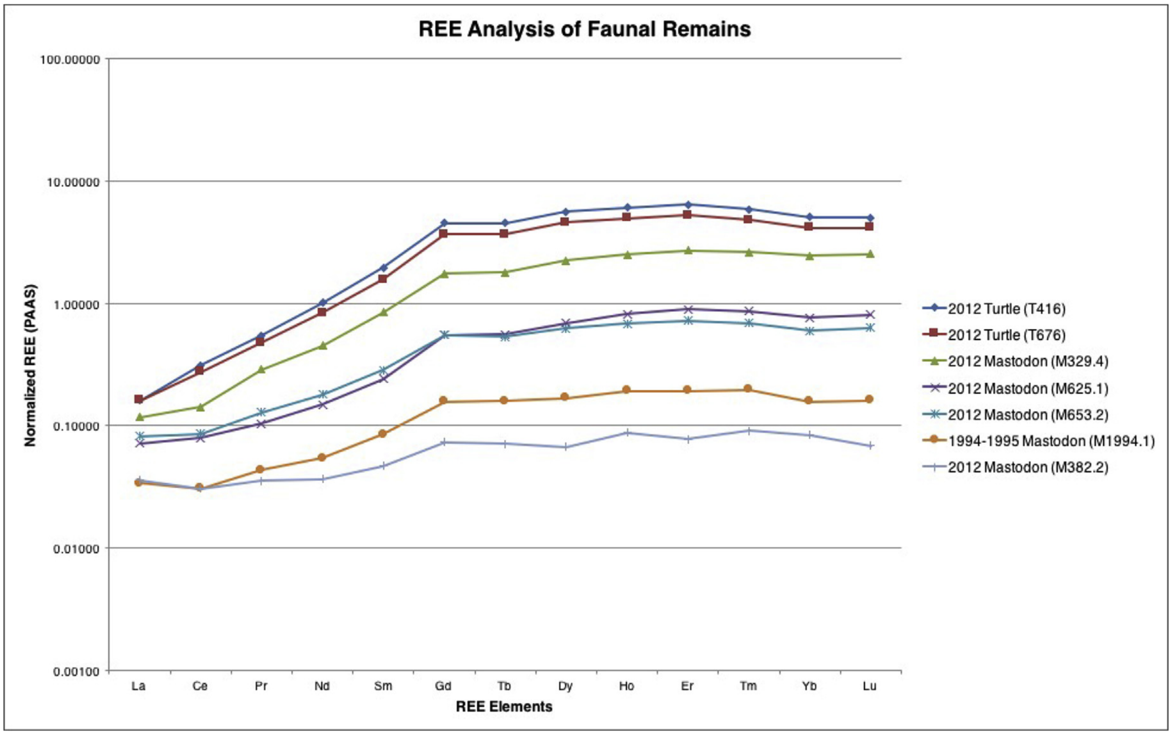

Fig. 7. Normalized to PAAS rare earth elements for mastodon and turtle bone from Coats-Hines-Litchy.

antler that is heavily weathered and lacks evidence of usewear. The purported bone point (Fig. 8w) is a naturally splintered bone fragment with three flat, angular sides and no unequivocal evidence of intentional modification.

There are 53 pieces of chert debris that resemble flakes and flake fragments, including 19 pieces of microdebitage (smaller than 1.25 cm) in the combined 1994/1995, 2010, and 2012 CHL lithic assemblage (Figs. 8 and 10). Microdebitage was deemed as too small to conclusively discern specific characteristics that can be unequivocally attributed to human production (King, 2016; Lubinski et al., 2014; Waters et al., 2011). As such, only macrodebitage that was documented *in situ* is described here based on morphological and technological attributes. Nine specimens resemble flake-like fragments lacking striking platforms, and 24 specimens resemble proximal flakes with apparent striking platforms. The largest flake-like fragment exhibits systematic, unifacial flaking on its dorsal face (Fig. 8ah); however, this specimen is from a different, unrelated archaeological site that was originally inadvertently catalogued with the CHL assemblage. An additional 13 flake-like specimens lack unequivocal association with the bone-bearing deposits and were either recovered from the modern stream channel, or were recovered in general bulk sediment samples in the laboratory.

Of the 53 total pieces of flake-like debris, our analysis primarily focuses on the 11 pieces of macrodebitage (1 from 1994-1995 and 10 from 2012) with verifiable provenience from the bone-bearing deposits. All macrodebitage specimens are relatively small (Table 3) with an average width of 14.98 mm, length of 13.78 mm, and width:length ratio of 1.08. The average thickness (4.19 mm) and weight (1.01 g) are slightly greater than most of the pieces because of two unusually large chert fragments (specimens 491-2 and 94-24-81). Overall, the CHL assemblage has very little variation in flake size.

Following previous attribute-based studies (Lubinski et al., 2014; Peacock, 1991; Staley, 2006; Wisniewski et al., 2014), each potential macro-flake and flake fragment was assessed based on the presence or absence of technological attributes typically associated with culturally produced lithic assemblages (Table 4). This method does not definitively identify a cultural versus natural origin of flakes, but rather characterizes flakes and flake-like pieces in a comparable way. The flake-like assemblage from CHL scored low on the presence of technological attributes. The assemblage is dominated by flat, non-cortical platforms. Half of the specimens have eraillure scars, but only four exhibit distinct bulbs of percussion. Four specimens have more than three dorsal scars, but only one has flake scars demonstrating directional orientation. Two specimens appear to have negative bulbs of percussion on their dorsal sides, and three completely lack dorsal cortex.

The flake-like chert pieces recovered in 2012 were vertically dispersed over 50 cm in geologic Units 2 and 3, corresponding to excavation levels 52-61 (Fig. 11). To assess the relationship of the sediment matrix and the lithic assemblage, the gravel content was characterized for 12 excavation units. A total of 351.89 kg of angular limestone gravel and 4.78 kg ($n = 427$) of angular chert debris was recovered from excavation levels 52-61. This showed that the flake-like chert debris was most abundant in levels with substantial amounts of chert gravel.

Based on the absence of formal tools associated with the bone bed, absence of intentional modification to flakes, equivocal characteristics of the debitage, and the absence of a clear occupation surface, we interpret the lithic debris from CHL to be a naturally-produced geofact assemblage. The entire lithic assemblage consists of chert that naturally occurs in outcrops upslope of the site where it is highly fractured and small fragments are spalling from the outcrop. Additionally, the angular chert debris along with chert-gravel were transported to Area B by high-energy fluvial processes. This combination of physical weathering and transport likely led to the creation of geofacts. While unequivocal formal tools and lithic debitage were found in close proximity to the bone bed, the excavation records indicate these materials were not excavated from the bone bed, but were found out of context in the modern streambed and were likely redeposited from surrounding

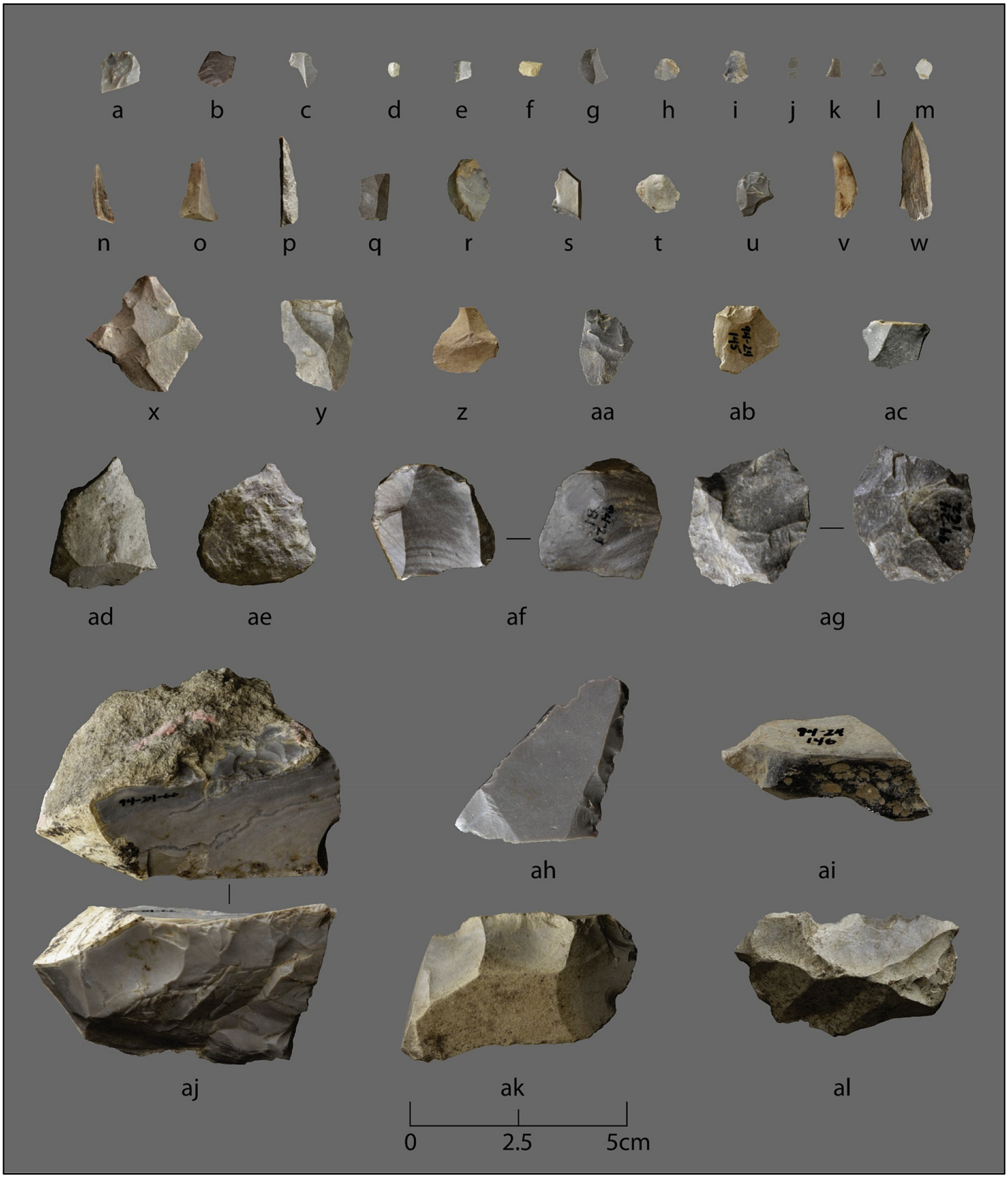

Fig. 8. The 1994-1995 lithic and osseous assemblage from Coats-Hines-Litchy. a-q, s-u, microdebitage; r, x-ac, ak-al, macrodebitage; v, antler fragment; w, bone fragment; ad-ae, natural chert previously identified as gravers; af, macrodebitage found *in situ*; ag, biface fragment; ah, not from Coats-Hines-Litchy; ai, thermally fractured chert; aj, angular scraper.

archaeological sites. Finally, the cutmarks reported on the single bone cannot unequivocally be determined to have been produced by humans and are consistent with post-depositional damage – most likely caused by abrasion from colluvial gravels.

3.5. Patterns at proposed pre-LGM sites

Discerning culturally-produced lithic artifacts from naturally-fractured stone is a generally straightforward task when large, diverse lithic assemblages exist in undisturbed contexts. However, making a distinction between artifacts and geofacts at sites with small assemblages of unmodified flakes is more problematic (Lubinski et al., 2014). This problem is exacerbated in high-energy geomorphic settings, especially if toolstone quality materials outcrop nearby. The CHL site is not unique in this regard. Other proposed pre-LGM sites have remarkably similar lithic assemblages and geomorphic contexts. Here we examine the Burnham site, Oklahoma, and Topper site, South Carolina (Fig. 1C).

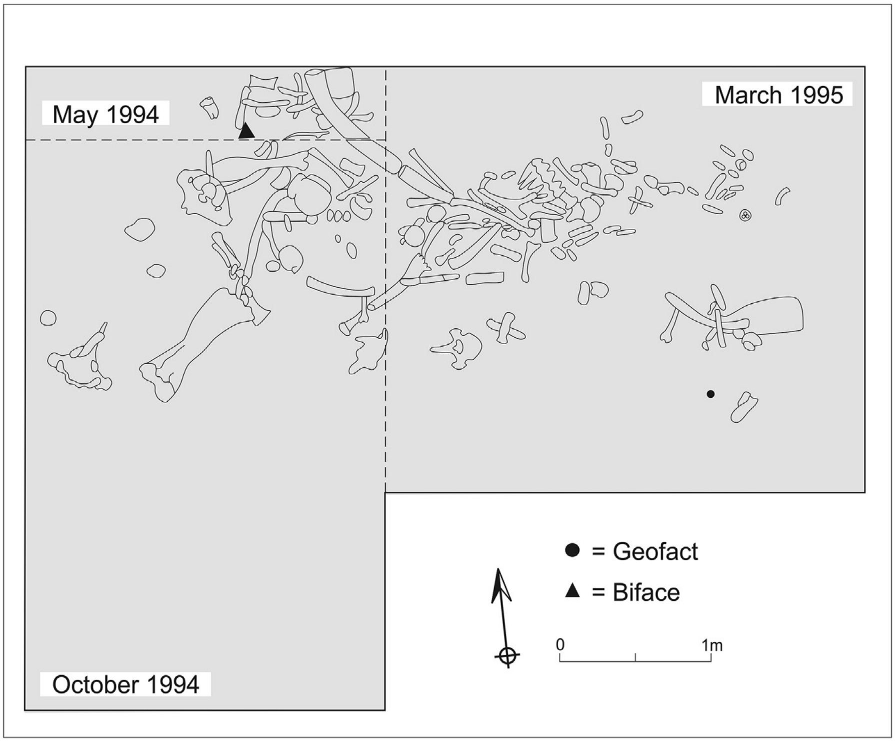

Fig. 9. 1994/1995 bone bed and distribution of macro artifacts with verifiable provenience at Coats-Hines-Litchy.

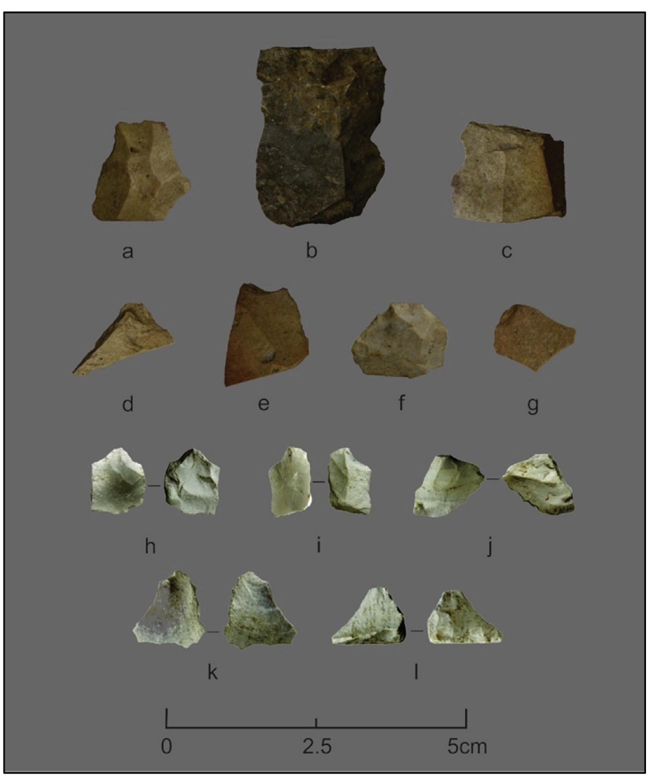

Fig. 10. The 2010, 2012 macrodebitage assemblages from Coats-Hines-Litchy. a-g, 2010 assemblage from Units 2-3 (exact provenience unknown); h-i, k, 2012 assemblage from Unit 2; j, l, 2012 assemblage from Unit 3.

3.6. Burnham site, Oklahoma

The Burnham site is a single-component site located along an erosional drainage associated with a tributary of West Mocassin Creek in Woods County, Oklahoma (Dort and Martin, 2003). The partial remains of extinct bison (*Bison chaneyi*) and many other late Pleistocene mammals were recovered in a deposit that dated to ~35,000-36,000 cal yr B·P. and also contained possible lithic artifacts (Wyckoff and Carter, 2003). The bison remains and reported artifacts occurred in pond and alluvial sediments in a secondary context (Carter, 2003; Todd, 2003).

The reported lithic assemblage includes chert flakes and flake fragments, a crude bifacially flaked chert fragment, and a chert cobble. A study of the flake scars along the unbroken margin of the biface indicated this specimen was naturally produced, as there is no unequivocal evidence of intentional flaking (Buehler, 2003). The Burnham flake assemblage consists of four pieces (8%) of macrodebitage and 47 pieces (92%) of microdebitage. All of the macroflakes are either distal or medial fragments. Macrodebitage at Burnham averages 15.26 mm wide and 14.66 mm long, with an average width:length ratio of 1.8. While the flakes at Burnham are predominately microdebitage, the overall assemblage size and morphology is remarkably similar to CHL. The lithic assemblages at both Burnham and CHL exhibit relatively little variation in flake size, and nearly all flakes from these assemblages are smaller than 2.5 cm.

The lithic artifacts and bison remains from Burnham were dispersed vertically in a zone 90 cm thick. Further, the majority of the reported lithic artifacts and bison bones co-occurred, both horizontally and vertically, with natural chert gravels deposited by fluvial processes. There is a significant spike in the frequency of natural chert gravel that directly corresponds to the vertical

Table 3
Metric attributes of the macrodebitage assemblage from Coats-Hines-Litchy.

Specimen	Condition	Weight (g)	Length (mm)	Width (mm)	Thickness (mm)	W:L
94-24-81	complete	4.51	24.3	27.4	5.9	1.13
FS#530	complete	0.67	15.0	18.1	3.4	1.21
FS#652	complete	1.31	16.5	17.1	5.8	1.04
FS#357	complete	0.38	9.6	13.0	4.7	1.35
FS#203	complete	0.49	11.8	10.0	5.2	0.85
FS#630	complete	0.30	10.4	13.2	2.5	1.27
FS#491-2	complete	2.96	18.0	23.7	10.5	1.32
FS#424	complete	0.40	11.7	13.5	2.5	1.15
FS#538	complete	0.28	11.8	10.2	2.1	0.86
FS#182	complete	0.31	13.6	12.5	2.0	0.92
FS#459	complete	0.32	10.5	13.7	2.9	1.30
FS#514	complete	0.24	12.2	7.4	2.8	0.61
Average		1.01	13.78	14.98	4.19	1.08

Table 4
Technological attributes of the macrodebitage assemblage from Coats-Hines-Litchy.

Specimen Number	Faceted Platform	Non-Cortical Platform	Bulb of Percussion	Eraillure Scar	3+ Dorsal Flake Scars	Flake Scar Orientation	Negative Dorsal Bulb	Absence of Dorsal Cortex	Total
94-24-81	0	0	1	1	1	0	1	0	4
FS#530	0	1	0	0	0	0	0	0	1
FS#652	0	0	1	0	0	0	0	0	1
FS#357	0	1	0	0	0	0	0	0	1
FS#203	0	1	1	0	0	0	0	0	2
FS#630	1	1	0	0	0	0	0	0	2
FS#491-2	0	1	0	0	1	0	1	0	3
FS#424	0	1	0	1	0	0	0	1	3
FS#538	0	1	0	1	0	0	0	1	3
FS#182	0	1	0	1	0	0	0	1	3
FS#459	0	1	1	1	1	0	0	0	4
FS#514	1	1	0	1	1	1	0	0	5
Total Attribute Score (%)	**2 (16.67%)**	**10 (83.33%)**	**4 (33.33%)**	**6 (50.00%)**	**4 (33.33%)**	**1 (8.33%)**	**2 (16.67%)**	**3 (25.00%)**	

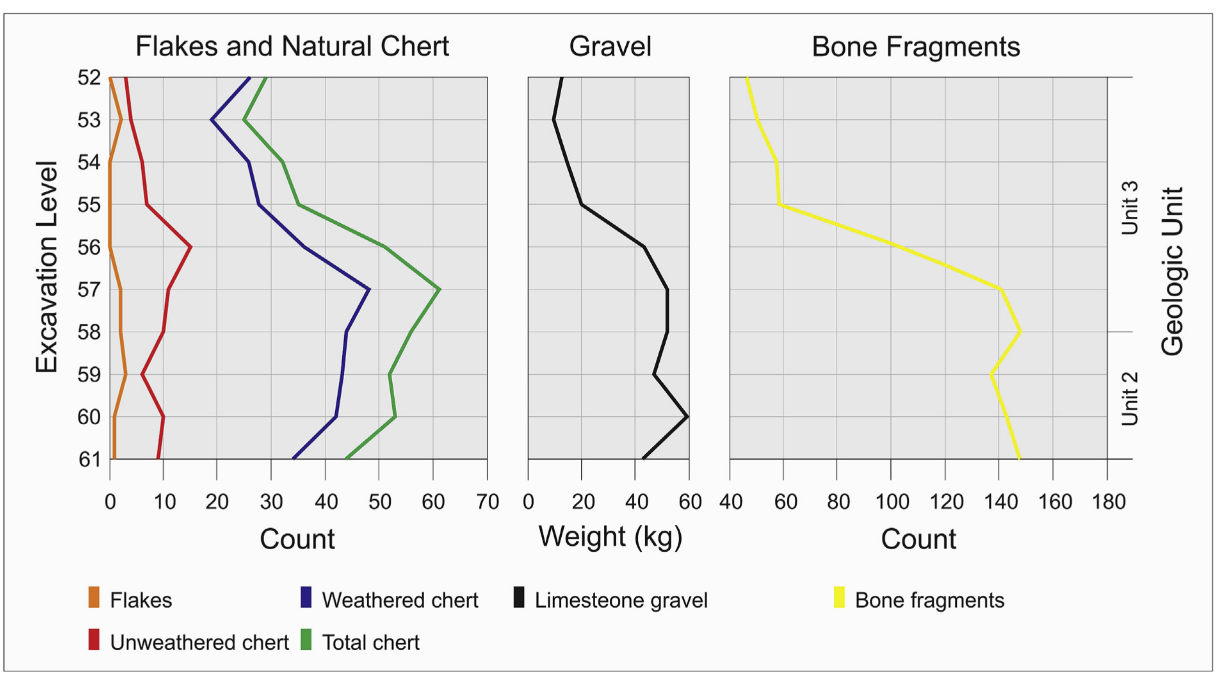

Fig. 11. Vertical distribution of chert flakes, chert and limestone gravel, and bone fragments at Coats-Hines-Litchy.

distribution of the lithic flakes (Buehler, 2003). A Fisher's Exact Test (n = 24, $p = 0.001$) demonstrates that there is a significant correlation between the distribution of potential flakes (n = 52) and natural chert gravel (n = 116). The increase in gravel content and displaced bison remains indicate deposition occurred under a relatively high energy regime.

As at CHL, formal tools or modified flakes are absent from the Burnham site assemblage. Only unmodified flakes of roughly the same size were found scattered over a vertical distance of 90 cm with no discrete occupation surfaces. Further, the flakes were found exclusively associated with gravel lenses deposited in a high-energy fluvial environment. Taken together, the Burnham site appears to be a naturally produced geofact assemblage.

3.7. *Topper site, South Carolina*

The Topper site is a multi-component site located adjacent to an outcrop of Coastal Plain chert on a terrace of the central Savannah River in South Carolina (Goodyear, 2005). Goodyear (2005) has proposed that artifacts pre-dating the LGM were found in what he called the "Pleistocene Sands" and "Pleistocene Terrace" – stratigraphic Units 1 and 2 (Waters et al., 2009).

Sain (2015) and King (2016) studied the Clovis and potentially pre-Clovis assemblages. Both noted that the Clovis assemblage is characterized by a formal biface and blade lithic technology, while the proposed pre-Clovis tool assemblage is dominated by informal and unmodified bend-break tools associated with bipolar lithic technology. Further, they found that the debitage differed between the Clovis and pre-Clovis assemblages, suggesting distinct technological differences between the two. The Clovis assemblage is comprised of flakes, broken flakes, and flake fragments, while the potential pre-Clovis assemblage consists mainly of angular, amorphous debris and cortical pebbles (Sain, 2015).

While there are no significant differences in the individual attributes of macrodebitage from the Clovis and potential pre-Clovis deposits (King, 2016; Sain, 2015), lithic debris in the potential pre-Clovis assemblage has significantly more dorsal cortex than debitage in the Clovis assemblage. Further, debitage from the pre-Clovis assemblage is characterized as smaller and highly fragmented in comparison to debitage from the Clovis assemblage (King, 2016; Sain, 2015). When comparing flake fragments between the Clovis and pre-Clovis levels, there is a significant difference in the size and distribution of debitage ($X^2 = 79.919$, df $= 2$, $p = <0.001$) (King, 2016). Sain (2015) noted that the size of flakes is heavily skewed towards larger flakes in the Clovis levels, while flakes from the "Pleistocene Sands" and "Pleistocene Terrace" are more evenly distributed across the size classes.

Moreover, lithic debris is increasingly fragmented in lower deposits associated with the potential pre-Clovis assemblage. Over 50% of macro-flakes in the Clovis deposits were complete, whereas only 26% in the potential pre-Clovis deposits were complete (King, 2016). Sain (2015:245, Tables 7-3) also noted a significant increase in broken flakes in the potential pre-Clovis deposits ($X^2 = 498.800$, df $= 10$, $p = <0.001$). This suggests high-energy transport of chert debris in the potential pre-Clovis deposit, which increases the likelihood of lithic debris fracturing under natural processes. Waters et al. (2009) noted that the pre-Clovis materials were recovered from sediments deposited in high-energy braided stream (Unit 3) and meandering stream (Unit 2) environments, while Clovis artifacts were buried by low-energy colluvial processes. King (2016) noted that natural pebbles are more common in the pre-Clovis compared to the Clovis horizons at the site. Finally, the pre-Clovis materials are scattered over a vertical distance of 115 cm and no discrete occupation surfaces are identified.

Again, as at CHL and Burnham, the pre-Clovis assemblage at Topper lacks formal tools, is mostly cortical debitage of similar size, occurs scattered in sediments that were deposited in high-energy fluvial settings, and is all locally derived. The proposed pre-Clovis artifacts appear to be a geofact assemblage.

4. Discussion

Assemblage composition, context, and site formation processes are critical factors when interpreting Pleistocene-aged lithic assemblages, especially those that may pre-date Clovis. Because cryptocrystalline silicate materials fracture in a predictable conchoidal way, some fracture patterns can be produced by natural processes and mimic human-made lithic assemblages (Andrefsky, 2013; Cotterell and Kamminga, 1987). This is particularly true when there is physical weathering of chert outcrops and transport of the resulting debris in high-energy depositional settings. Experimental studies of artifact taphonomy have demonstrated how sediment composition and depositional processes can potentially produce lithic debris that mimics culturally produced artifact assemblages (Andrefsky, 2013; Eren et al., 2011; Pevny, 2012; Rasic, 2004). Furthermore, depositional factors influencing the creation of naturally-produced lithic assemblages have been previously documented at other Pleistocene-age sites (Gillespie et al., 2004; Lubinski et al., 2014; King, 2016; Wisniewski et al., 2014).

The CHL, Topper, and Burnham sites are currently some of the most thoroughly investigated and reported sites that pre-date the LGM in North America. Here we have shown that a pattern exists at these sites. In all of these cases geofact assemblages originate from chert outcrops in the drainage basin. This toolstone is weathered and fractured at the outcrop, and then deposited downstream in high-energy geomorphic contexts containing coarse-grained sediment matrices. When comparing overall assemblages from potential pre-LGM sites, formal tools are absent and there is generally very little variation in flake size and morphology. Moreover, flake-like debris typically occurs in a secondary context with substantial vertical dispersion and lacks discrete occupation surfaces.

Artifacts dating to the pre-LGM are also reported from multiple archaeological sites in South America (Fig. 1C). However, problems of assemblage composition, context, and site formation processes exist at these sites (Borrero, 2016). At Pedra Furada, Brazil, simple split pebble tools that date back to ~50,000 cal yr B.P. are suggested to be the oldest artifacts in the western hemisphere (Guidon and Delibrias, 1986; Santos et al., 2003). However, the artifacts from this site appear to be geofacts that were produced by natural processes (Meltzer et al., 1994). Additional assemblages similar to those from Pedra Furada have been reported from several other pre-LGM sites in Brazil (Vale da Pedra Furada, Toca da Tira Peia, Sitio do Meio) (Boëda et al. 2014, 2016; Lahaye et al., 2013). Recently, it was shown that the capuchin monkeys of Brazil produce small split pebble tools that are similar to those found at all the proposed pre-LGM Brazilian sites (Proffitt et al., 2016). Thus, non-human primates may be responsible for the split pebble assemblages from these sites (Fiedel, 2017), with human-made artifacts showing up later in the stratigraphic sequences.

Even more problematic than sites with geofact assemblages and bones, are proposed LGM and pre-LGM sites where flaked-stone tools are absent and the entire case for human occupation is based on the taphonomy of faunal assemblages. Recent claims of pre-LGM occupation at the Cerutti Mastodon site, California (Holen et al., 2017), as well as the La Sena site, Nebraska, the Lovewell site, Colorado, and others, have been based primarily on bone breakage patterns and the position of faunal elements (Holen et al., 2017; Holen, 2006, 2007). Because both human and natural processes can create cut marks, spiral fractures, and percussion marks on bone (Haynes and Krasinski, 2010; Krasinski, 2010), the evidence reported from these sites remains equivocal at best.

A critical evaluation of assemblage composition, context, and site formation processes at reported archaeological sites do not support a pre-LGM human presence in the Americas. Rather, these sites appear to be produced through natural processes unrelated to human activities. Interpretations of late Pleistocene archaeological sites should be made at the assemblage level, rather than based on individual artifacts, and must consider the potential for natural processes to produce geofact assemblages. Furthermore, the archaeological record for the early occupation of the Americas must be consistent with the genomic evidence of human evolution and the global dispersal of modern humans.

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