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RESEARCH REPORT

Clovis Technology is not Unique to Clovis

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ABSTRACT

We previously showed that stone-tool technological attributes thought to be unique to the Clovis period were present in a radiocarbon and OSL dated middle Holocene-age stratum at Goodson Shelter, Oklahoma (Eren et al. 2018a. "Is Clovis Technology Unique to Clovis?" *PaleoAmerica* 4:202–228). Consequently, we argued that technological attributes alone should not be used to assign assemblages to Clovis times. Huckell, Haynes, and Holliday (2019. "Comments on the Lithic Technology and Geochronology of the Goodson Rock Shelter." *PaleoAmerica* 6:131–134) proposed two alternative hypotheses: that material we identified as Clovis-like was not, or that it was Clovis but had been mixed with younger deposits. They called for more information on the Clovis-like assemblage at Goodson, and additional dating of the site's lowest deposits. We provide that information, which confirms that stone-tool technologies ostensibly unique to Clovis were indeed in use in the middle Holocene.

KEYWORDS

Clovis; technology; caches; blades; evolutionary convergence

1. Introduction

In *PaleoAmerica* in 2018, we argued that attributes routinely attributed to Clovis lithic technology may not be restricted to that time period (Eren et al. 2018a). This was based on our excavations at Goodson Shelter in Oklahoma, where over several field seasons we recovered artifacts displaying attributes strongly suggestive of Clovis lithic technology (Bradley and Collins 2014; Bradley et al. 2010; Collins 2005). The specimens included fluted bifaces (one with a diving flute failure); curved blades and other evidence of prismatic blade production such as blade cores, core tablets and small bladelets; large early-stage biface cores; large bifacial overface flakes (*sensu* Smallwood 2010); and, thinning flakes and overshot flakes possessing both pronounced dorsal flake scars and some combination of ground, faceted, isolated, reduced, projected, and/or released platforms. Also uncovered were "classic" Clovis-like unifacial "tools on flakes" (Collins 2005), such as trianguloid end scrapers and spurs. Several of the blades refit, suggesting there had been in situ blade production.

Yet, we found no finished Clovis fluted projectile points. Even so, we were convinced – as were colleagues who saw the assemblage (Andrews et al. 2015) – that the specimens with attributes suggestive of Clovis lithic technology indicated Goodson Shelter was occupied in Clovis times. We retained that conviction until more than half a dozen radiocarbon and two OSL ages demonstrated that Stratum 1, the depositional unit in which those specimens were found, dated to the middle Holocene.

That finding in turn led us to ask whether attributes thought to be diagnostic of Clovis technology were unique to that time period. The answer to that question goes beyond Goodson Shelter, as it bears on the validity of assigning assemblages to the Clovis period based solely on the presence of those ostensibly Clovis-specific technological attributes, and in the absence of late Pleistocene radiocarbon ages or diagnostic, finished Clovis fluted points. The potential for mistakenly assigning an assemblage to Clovis, as we noted, is particularly pronounced in the case of stone-tool caches. Nearly two-thirds (15/24) of the supposed Clovis caches lack Clovis fluted points, were rarely recovered in situ (or by archaeologists) thus limiting the possibility of radiometric dating, and contain bifaces and blades that are part of a generalized technological strategy shared "by many precontact cultures through time" (Muñiz 2014, 117). As we showed, the morphometric features of those artifacts overlapped with ones from later periods (Eren et al. 2018a). Those 15 caches might indeed be Clovis, but without independent evidence of their age or affiliation, that assignment remains undemonstrated.

In the spirit of Thomas Chamberlin's "multiple working hypotheses," Huckell, Haynes and Holliday (2019) offered "two alternative interpretations" to our

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Goodson Shelter findings. The first is that the Stratum 1 assemblage "is Archaic but is not a Clovis look-alike and use of the term "doppelganger" is not valid." The second alternative is that the assemblage "is Clovis, but mixing introduced sediment, charcoal, and possibly artifacts from younger occupations." We leave aside the logical contradiction between their assertion that the Goodson assemblage "is not a Clovis look-alike at all," while simultaneously accepting that "the assemblage is Clovis, but mixed with [younger] artifacts." The Goodson technology cannot be both insufficiently Clovis-like to support the arguments we have made, while at the same time being so Clovis-like as to possibly be Clovis. Put another way, one cannot accept that the Goodson technology can appear to be both Archaic and Clovis unless, as we have suggested, there is not a significant difference between the technologies.

Regardless, Huckell et al. (2019) suggest the means of evaluating their alternatives: first, by providing additional information on the Stratum 1 lithic assemblage[1] and, second, by undertaking an "all-out OSL investigation" to confirm the dating results we previously obtained for the age of Stratum 1. We have done as they suggested, and are pleased to report our evidence and new findings here, along with our response to a number of their specific arguments and criticisms.

2. From ruling theory to multiple working hypotheses

Since Huckell et al. (2019) began with Thomas Chamberlin,[2] we start here as well, as there is an important but often overlooked element to Chamberlin's call for multiple working hypotheses that is relevant to the issues raised.

Chamberlin's thoughts on multiple working hypotheses were first delivered in a talk in late 1889, then published a few months later in *Science* (Meltzer 2015, 119–120).[3] He laid out what he saw as three approaches to scientific investigation: that of the *ruling theory*, the *working hypothesis*, and of *multiple working hypotheses* (Chamberlin 1890, 92). He took particular aim (and umbrage) at the "*method of the ruling theory*," which he described as resulting when a premature explanation passes into a tentative theory and then becomes the overriding idea, as "the mind lingers with pleasure upon the facts that fall happily into the embrace of the theory, and feels a natural coldness toward those that seem refractory." Under the ruling theory, he warned,

> the search for facts, the observation of phenomena and their interpretation, are all dominated by affection for the favored theory until it appears to its author or its advocate to have been overwhelmingly established. The theory then rapidly rises to the ruling position, and investigation, observation, and interpretation are controlled and directed by it. (Chamberlin 1890, 93)

To guard against the method of the ruling theory, Chamberlin argued, it was not enough to treat an idea as a (single) *working hypothesis*, and seek facts "for the purpose of ultimate induction and demonstration" of the hypothesis. Even then the hypothesis could too easily "degenerate into a ruling theory," as one would be just as tempted to grow fond of the idea (Chamberlin 1890, 93). Instead, he urged the method of *multiple working hypotheses*. It was an approach that, in his words:

> […] is directed against the radical defect of the two other methods; namely, the partiality of intellectual parentage. The effort is to bring up into view every rational explanation of new phenomena, and to develop every tenable hypothesis respecting their cause and history. The investigator thus becomes the parent of a family of hypotheses; and, by his parental relation to all, he is forbidden to fasten his affections unduly upon any one. (Chamberlin 1890, 93)

Chamberlin's advocacy of the method of multiple working hypotheses was thus not only about the importance of considering alternatives, as it is often portrayed (e.g., Huckell et al. 2019). It was just as much about not becoming enamored of a ruling theory – as, for example, the idea Clovis technology is marked by attributes that are unique to Clovis. Thus, it is just as much in the spirit of Chamberlin to question the "ruling theory," as it is to provide alternative hypotheses to it: hence, our 2018 paper that asked if Clovis technology is unique to Clovis.

3. The 'dopplegangers' of Goodson Shelter Stratum 1

In questioning just how closely the Goodson Shelter assemblage resembles a set of Clovis artifacts, Huckell et al. (2019) asked "how many bifaces, blades, unifacial tools, cores and pieces of debitage" comprise the assemblage from which they were drawn, and whether the 19 artifacts we illustrated (Eren et al. 2018a, figures 4–9) were "from an assemblage that numbers in the 10s, 100s or 1000s" (Huckell et al. 2019). There are 7756 specimens in the Stratum 1 assemblage (Table 1, Supplemental Materials). Of these, 7222 specimens (93%) are small waste chips, resharpening flakes, and debitage less than 25 mm in maximum dimension and unidentifiable block shatter. This leaves 534 tools ($n = 107$) and debitage ($n = 427$) from Stratum 1, making this a relatively small lithic assemblage.

Table 1 Tools and debitage from Goodson Shelter, Stratum 1. See also Supplemental Materials.

Artifact class	Count	Collective mass (g)
Debitage		
Debitage specimens < 25 mm in maximum dimension	7154	1310
Biface thinning flake	179	597
Block shatter	68	667
Blades	19	141.84
Blade cores	2	678
Cores	4	860
Bipolar specimens	3	37
Flake specimen	181	854
Flute flake	1	6
Ochre flake	1	9
Overshot flake	34	233
Potlids	2	31
Tools		
Biface specimens	65	1535.53
Hammerstone	2	395
Spur	2	6
Uniface specimens	38	383
Uniface made on overshot flake	1	52
Total	7756	7790.37

Were the 19 specimens we originally reported Clovis fluted projectile points, Huckell et al. (2019) presumably would not have questioned their number or the size of the assemblage from which they were drawn, as Clovis points are unique to and diagnostic of the period. But if bifaces with early-stage flutes, curved prismatic blades, blade cores, blade core tablets, etc., are also unique to and diagnostic of Clovis as they suggest, then why should having 19 of these in an assemblage of tens, hundreds, or thousands be any different than having 19 Clovis points? If tool classes or technological attributes are unique to Clovis, then they are diagnostic of that period. If those same tool classes or technological attributes are not unique to Clovis, and found in assemblages that are demonstrably post-Clovis in age, as we have shown is the case at Goodson Shelter, then they are not diagnostic of Clovis – regardless of their number and no matter how large the assemblage.

Huckell et al. (2019) accept that certain features, such as overshot flaking, occur in post-Clovis age assemblages, but argue that if few of these occur then their "significance is minimal." The reasoning here may be based on Huckell's estimate (the evidentiary basis for which is not explained) that random knapping errors will result in overshot flakes "in frequencies no greater than 5 or at most 10 percent across an assemblage" (Huckell 2014, 140). Yet, overshot flakes occur in percentages just as low in some Clovis assemblages (Eren et al. 2013, 2939). More importantly, they occur in frequencies higher than 5–10 percent in some post-Clovis assemblages, including the Late Prehistoric Easterday II cache (Muñiz 2014). But as we stressed previously, arguments based on the frequency of overshot flakes in an assemblage (whether expected, or deemed insignificant) are moot, since no modal tendency has ever been demonstrated for the production of overshot flakes in Clovis assemblages. Nor, more importantly, has one been demonstrated for post-Clovis assemblages (Eren et al. 2018a, 211; also Eren et al. 2013).

Huckell et al. (2019) further argue that "the larger the assemblage, the greater the likelihood that resemblances are liable to be due to chance." However, in making that argument, they undermine their own position, for in saying so they must assume that there are a finite number of technological processes and products, and thus tool classes or technological attributes found in Clovis assemblages will also be present in post-Clovis assemblages, though perhaps rarer (in which case their tally will increase with larger assemblages). But then that also means those tool classes or technological attributes are not unique to the Clovis period – which was the point of our 2018 paper.

Assemblage size is relevant in one regard they do not mention: if Goodson Shelter was occupied by Clovis groups, and only a limited number of Clovis fluted projectile points were discarded on site, then the volume of our excavation and the resulting size of the recovered assemblage could bear on the likelihood of our finding those rare points (we would note that our excavations were sufficiently extensive that we recovered 332 projectile points from later periods[4]). Of course, we did not find any Clovis points, just what we identified Clovis "dopplegangers."

Huckell et al. (2019) asked if the 19 specimens we discussed were "the only ones identified as sharing similarities with analogous Clovis specimens from secure contexts." They were not: they were just examples. The entire Stratum 1 assemblage is consistent with how lithic technologists identify Clovis technology, as we previously indicated (Eren et al. 2018a, 205), and as we now provide in the details and counts in the Supplemental Materials. To summarize and illustrate some examples and highlights from the Supplemental Materials, of the 247 specimens exhibiting a platform, the majority ($n = 180$, 73%) appear to be carefully prepared through facetting, projecting, isolation, reducing, or grinding (Figures 1–5). In fact, there are more facetted platforms at Goodson Shelter (159 of 224, 71%), than in the Clovis levels at the Welling site, in central Ohio (116 of 281, 41%; Diez-Martin et al. 2021). These platforms were used to frequently remove bifacial thinning flakes, of which at least 35 from Goodson Shelter are easily recognized as overshots, representing 16.1% of the bifacial thinning flakes (Figures 2–6).

Ten of the 65 biface specimens (15.4%) exhibit overshot and/or overface scars, while six of 65 biface

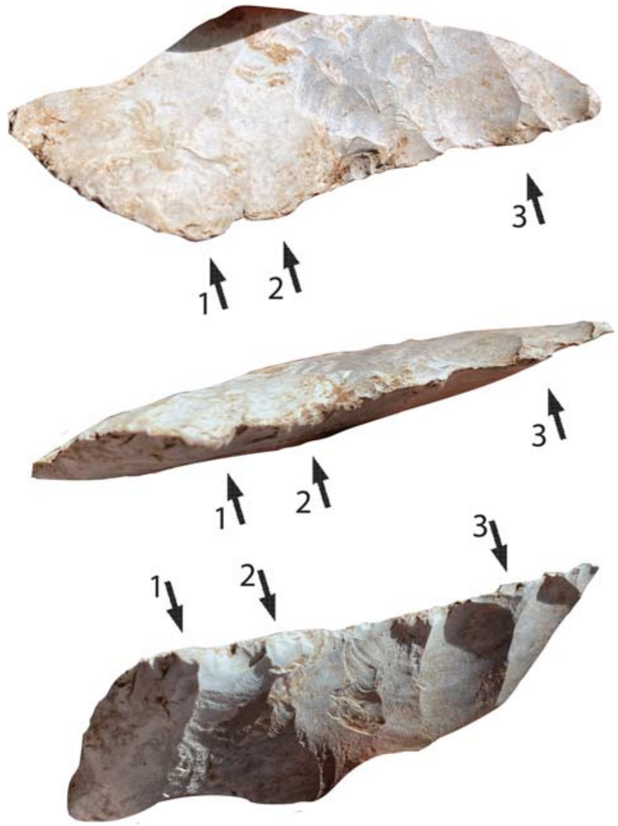

Figure 1 Goodson biface edge fragment with three prepared platforms shown from three different angles (L16-24-151). Numbers specify the same platform from each angle. This specimen is 80.75 mm in maximum length.

specimens exhibit flutes (9%) (Figure 7). However, the overshot and fluted biface percentages are almost certainly underestimates, given that many of the bifaces are small fragments. This inference is supported by the presence of a channel flake,[5] which does not refit to any of the fluted bifaces (Figure 8).

The presence of two spurs with retouch further reinforces the Clovis impression (Figure 9), as do the 19 blades[6] and two blade cores, which we discuss further in the next section. In sum, the proposal by

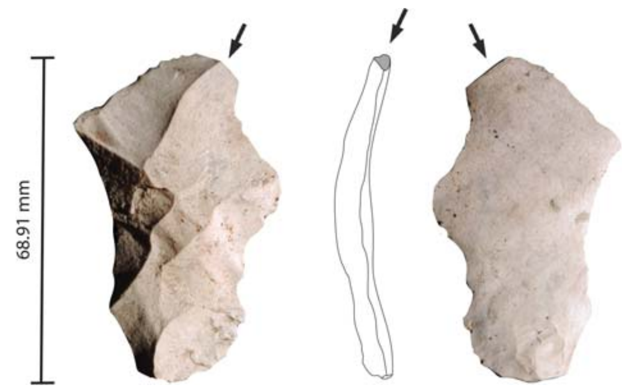

Figure 3 Goodson overshot flake (L16-24-127). The arrows and gray shaded area indicate the opposite biface margin.

Huckell et al – that the Goodson assemblage is not a Clovis look-alike – is not supported by the evidence.

4. Identifying Clovis blades

Huckell et al. (2019) state, and we agree, that the process of blade manufacture produces a range of products and byproducts, and that there are challenges to identifying Clovis-age blades (also Bamforth 2014; Bradley et al. 2010; Waters et al. 2011). (There are few challenges to identifying prismatic blade core tablets, and Goodson Shelter provides a prime example (Eren et al. 2018a, 207, Figure 6)).

Despite the admission of challenges to identifying Clovis-age blades, Huckell et al. (2019) nonetheless assert that the “principal desired product” of Clovis knappers were “true blades,” which they suggest share a series of qualitative attributes that are critical to defining the type (in this they follow Bradley et al. 2010, 11–13). Yet, judging those attributes is inevitably a subjective exercise, relying as it does on ambiguous measures such as “often” faceted and ground platforms, “minimal” ripple marks, “robust” cross-sections, and

Figure 2 Goodson uniface made on a biface thinning flake (L16-13-123). Notice well-spaced flake scars on dorsal face (left).

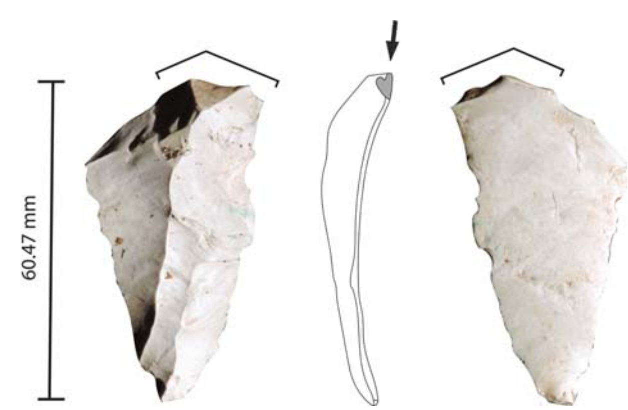

Figure 4 Goodson overshot flake (L16-24-158). The arrows, lines, and gray shaded area indicate the opposite biface margin.

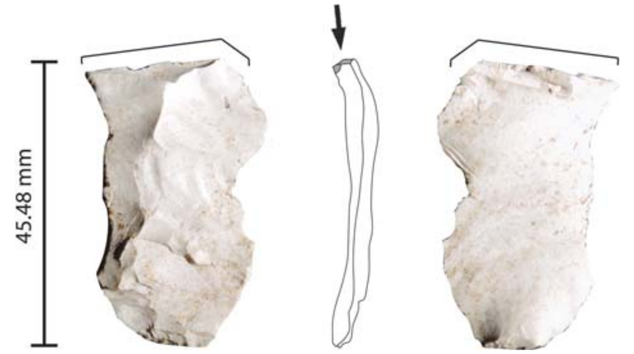

Figure 5 Goodson overshot flake (L16-13-123). The arrows, lines, and gray shaded area indicate the opposite biface margin.

arises "more or less parallel" to the long axis of the blade (Huckell et al. 2019). Vague measures such as "often," "minimal," and "more or less," do little to clarify

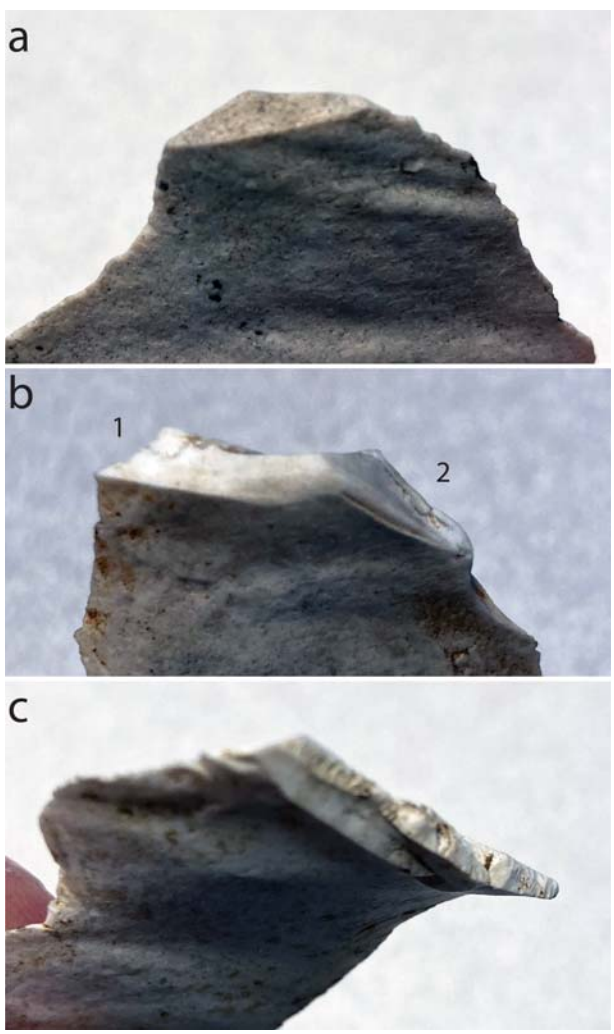

Figure 6 Close up images of the distal overshot specimens from figures 3 (a, L16-24-127), 4 (b, L16-24-158), and 5 (c, L16-13-123). L16-24-127 depicts a natural, squared edge (a). L16-24-158 depicts a bifacial margin where a clear platform and bulb negative are present (b1); this facet is different from the snapped section (b2). L16-13-123 depicts a bifacial margin (c).

Figure 7 Goodson early-stage biface with overshot flake scar (L16-15-156), the latter indicated by the dotted lines.

where and what the differences are between "true" Clovis blades and non-Clovis blades, and whether or how reliably that boundary would be placed by different investigators. Beyond these challenges, Eren and Redmond (2011) show that blade-like flakes can come from bifacial reduction.

To avoid such ambiguity and subjectivity, Collins (Collins 1999; see also Collins and Lohse 2004) identified a series of metric attributes and calculated ratios to identify Clovis blades. Doing so offers the possibility of greater reliability, though whether these provide a valid means of identifying Clovis blades is a separate matter. Following Collins' lead, we used those measures to conduct a discriminant function analysis of 348 blades known to be Clovis or Archaic in age (Eren et al 2018a). There is considerable morphometric variation in blades, which includes:

(1) Variation within blade assemblages of the same age – even when the Gault (Clovis) blades were used to create the discriminant functions, for example, ~12 percent of the blades from that same assemblage were nonetheless identified as Archaic, not Clovis (Eren et al. 2018a, table 3; see also Bamforth 2014, 50; Collins and Lohse 2004);

Figure 8 Goodson channel flake (L16-24-124).

Figure 9 Goodson spur (L16-14-153).

(2) Overlap between blade assemblages of different ages – more than a third of the blades from some Clovis assemblages – e.g., Gault and Pavo Real – were identified as Archaic, just as some of the Archaic-age Goodson Shelter blades were assigned to Clovis – 11/17 of the Goodson Shelter blades in one analysis (Eren et al. 2018a, table 3);
(3) Varying success rates in the correct assignment of blades known to be Clovis, depending on how one defines Clovis blades, whether using the attributes of the large and variable sample of blades from the Gault site, or the smaller and far more homogenous sample of the Green blades from Blackwater Locality 1 (Eren et al. 2018a, 211–212, supplemental materials).

Thus, at both the individual and the assemblage level, blade forms are not exclusive to or always reliably assigned to a specific time period. That is why it is necessary to have independent evidence of what the specimens are found with, such as Clovis points as in the case of the East Wenatchee cache (Gramly 1993), or Archaic points, as at Goodson (Eren et al. 2018a); and/or evidence of the age of the deposits in which the blades are found, as at Gault (Eren et al. 2018a, 213).

Huckell et al. (2019) discount our analyses since we did not use the qualitative attributes of "Clovis true blades," the importance of which is "underscored by studies of the Green and Dickenson Clovis blade caches from Blackwater Draw […] and the Keven Davis blade cache in northeastern Texas" (Huckell et al. 2019).[7] They observe that blades from all three "are remarkably similar to one another" in both metric and non-metric attributes, thus permitting their assignment to Clovis. They suggest this is confirmed by the fact that both the Green and Dickenson caches, were "recovered from sediments of demonstrably Clovis age, and their assignment to Clovis did not rely solely on technology."

Yet, that assertion is not altogether true: the Dickenson cache was not found in situ, nor in primary context (Condon et al. 2014, 36; Montgomery and Dickenson 1992). Condon et al. (2014, 36), whose co-authors include Haynes and Holliday, inferred the "Dickenson cache *probably is Clovis despite the uncertainty in its stratigraphic context*" (Condon et al. 2014, 36, emphasis ours).[8] They assigned the Dickenson cache to Clovis based on "current paradigms that would have blade technology almost singularly linked to the Clovis culture" (Condon et al. 2014, 36–37). Whether blade technology is so "singularly linked" is, of course, the "ruling theory" we question.

It is correct that the blades from those three caches are similar to one another, yet saying so misses a more important point: these blades are not necessarily similar to blades from other Clovis-age sites (Bamforth 2014). This is why when the Green cache blades were used to define the discriminant functions in our analysis, the success rate in assigning the Gault and Pavo Real blades to Clovis – where they should be assigned – declined sharply (compare the results for those sites in Eren et al. 2018a, table 3a versus table 3b).

Here, in fact, is another case where sample size actually matters: small samples – and these three caches are small samples (Dickenson, $n = 5$; Green, $n = 6$; Keven Davis, $n = 9$) – do not convey the full range of variation in the tool class. Moreover, caches are distinctive lithic assemblages in other respects (e.g., in the number and types of tools, their uselife stage, tool richness), and quite unlike those found at residential sites, kill sites, workshops, etc. There is reason to expect, and compelling evidence to show, that cache blades are not representative of Clovis blade production and products (e.g., Waters et al. 2011, 75, figures 42a and 42b).

Consider, for example, the Blackwater Locality 1 cache blades (Condon et al. 2014; Green 1963; Montgomery and Dickenson 1992): they have a pronounced curvature that Green (1963) and others consider one of their defining traits (e.g., Collins and Lohse 2004, 166-167; Bradley et al. 2010, 162). Perhaps because these were the first blades to be found and explicitly linked to Clovis, these are often seen as archetypical. Yet, their distinctive curvature is unusual and unlike the majority of Clovis blades.

The index of curvature (as defined by Collins 1999) for a sample of 208 Clovis blades from multiple Clovis sites ranges from 0.82 (essentially no curvature) to 19.94,[9] with an average index of curvature of 8.92 (1 $\sigma = 4.42$) (data from Eren et al. 2018a; Waters et al. 2011). All blades from the Dickenson, Green, and Keven Davis caches have an index of curvature greater than the mean; in contrast, 101/164 blades from the Gault site (which comprises the bulk of the sample analyzed here) have an index of curvature less than the mean. A histogram of this sample of index values

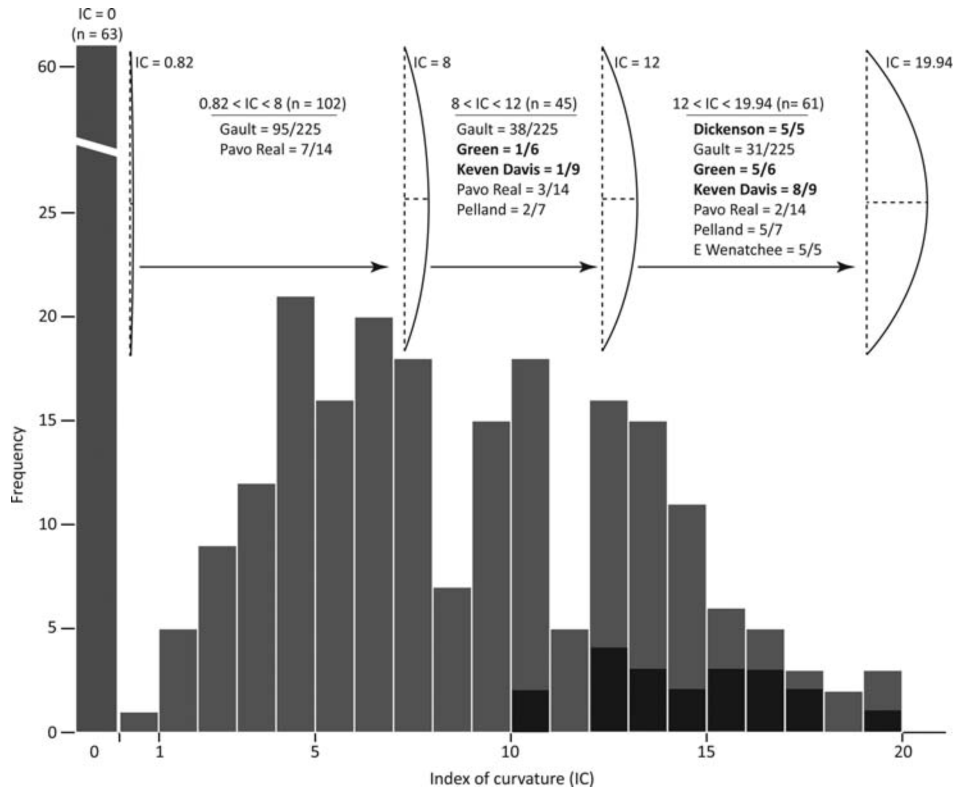

Figure 10 Histogram of the index of curvature of Clovis blades. The histogram includes all blades, with the black portions denoting those from the Dickenson, Green, and Keven Davis caches. The "bow-like" figures above the histogram illustrate the index of curvature values for ∼1, 8, 12 and ∼20. Note the large number of flat blades (IC = 0).

(Figure 10) skews to the right (skewness = 0.308), indicating that the pronounced curvature of the Dickenson, Green, and Keven Davis blades is well beyond that of the majority of Clovis blades in a large assemblage (see also Bradley et al. 2010; Waters et al. 2011).

Finally, the notion of identifying "true blades" in the archaeological record is itself problematic. There is no such thing as a "true blade," any more than there is a "true preferential Levallois flake" or a "true microblade" (see discussion in Eren and Lycett 2016, 380–384). Archaeologists can propose normative ideal, "true," or type specimens, but given the variation that exists in any lithic technology, it is rare indeed that all specimens conform to the ideal or the "true" state. An artifact may more or less closely approximate the ideal or a "true blade" (however subjectively defined), but the difference between "true blades" and bladelike flakes ultimately becomes one of degree, not of kind.

5. Geology and stratigraphy of Goodson Shelter

Although we felt confident that Stratum 1 of Goodson Shelter, in which the Clovis-like material was recovered, was middle Holocene in age (Eren et al. 2018a), Huckell et al. (2019) had concerns about its age and stratigraphic interpretation. They raised several specific issues, along with requesting an "all out" luminescence (OSL) sampling of Stratum 1. They noted:

(1) Stratum 1's reddish color (10YR4/4 and 2.5YR4/6), which suggested to them it "could be the B horizon of a soil," and thus represent a surface of prolonged stability spanning the time from the terminal Pleistocene into the middle Holocene;
(2) That pedogenesis and insect bioturbation could have allowed downward mixing of post-Clovis age charcoal and sediment, resulting in radiocarbon and OSL ages that underestimated the age of the Clovis-like artifacts Stratum 1;
(3) Finally, they questioned whether the depth and relative position of the OSL ages within Stratum 1 accurately and fully bracketed the timing of the deposition of this unit.

We address these matters, then report on newly acquired OSL ages we obtained in response to their request. First, however, we provide a brief summary of the Goodson Shelter stratigraphy and geomorphic history.

Goodson Shelter is located in a narrow (~20–25 m wide) south–north trending valley between two hills that rise relatively steeply (~6–8 m over a horizontal distance of ~50 m) above the valley floor. The shelter extends for a lateral distance of ~18 m, and is relatively shallow, a maximum of ~4 m from the present dripline to the back wall. The floor of the shelter today is ~2.5 m above the small stream that presently flows ~10–12 m east of the shelter.

The shelter is filled with ~2–2.5 m of sediment, divisible into four strata (Stratum 0 – Stratum 3).[10] As the deposits bear on the formation history of the shelter, we discuss the strata from bottom to top. The basal unconsolidated unit (Stratum 0) is a massive bedform of fluvially-deposited tightly packed, rounded, subangular and angular cobbles that range up to at least ~30 cm in maximum length.

Stratum 1 is a relatively clean layer of red sandy loam that rests conformably atop the Stratum 0 cobble bedload. It is massive in structure, comprised largely of medium to fine quartz sand, with lesser amounts of silt and clay between the grains. It varies from ~18 to 28 cm in thickness,[11] generally lacks roots or other debris or clasts (save for the occasional artifacts), and has the shelter's lowest levels of magnetic susceptibility (values < 200), phosphorus, and organic matter.

Both Stratum 1 and the underlying bedload cobbles are fluvial in origin. They indicate that the stream channel was at one time within the shelter, and likely was the mechanism that undercut the valley wall to create the shelter. We surmise that Stratum 1 marks the final time that water flowed through the shelter, and fluvial sediments were deposited or settled out of suspension. There are analogous sand drapes atop cobbles within and alongside the stream today, including where the creek still flows under the overhang of the valley wall upstream of the site.

That the stream no longer flows through the shelter appears to be due to the collapse, ~35 m upstream, of a once-overhanging portion of the valley wall. The collapsed wall extends along a ~30 m stretch of the valley. We surmise that as a result of the collapse, the stream was obstructed and diverted east toward the opposite valley wall, where it then turned to the northeast and north (Figure 11). That diversion redirected the stream so that it flowed east of the shelter, effectively isolating it so that its interior was no longer a water course. With that, fluvial deposition and/or erosion within the shelter ceased. The catchment area in this tributary valley is not extensive, so even during periods of heavy rain the shelter today does not experience significant flooding; nor is there evidence of fluvial deposition in the deposits overlying Stratum 1.

The earliest of the shelter's cultural occupations – notably, the Clovis dopplegangers – occur in the upper centimeters of Stratum 1, which suggests that it took place once water was no longer flowing through the shelter, and atop the then-dry surface. It is conceivable there were earlier occupations within the shelter, but these would have had to take place when the stream was flowing and the shelter floor was underwater, or during seasonal dry spells. Regardless, if there were such occupations, no archaeological traces have been found (had it been occupied, it is likely the traces would have been removed by fluvial erosion, given the energy of the stream as indicated by the size of the bedload cobbles).

Once the shelter was bypassed by the stream, the principal source of deposition became sediment and debris washing down the hillslope above. Colluvial deposition presumably took place while the stream still flowed through the shelter, but (as just noted) fluvial action would have carried away the evidence. Colluvial deposition was supplemented by weathering of the shelter ceiling, including episodic roof fall of large blocks up to 40 cm across, and ranging down to grain-sized material that erodes more or less continuously from the porous sandstone ceiling.

Stratum 2, is a < 10 cm to ~30 cm thick transitional zone of sandy loam that sits conformably atop Stratum 1. Micromorphological evidence indicates that Stratum 2 resulted from the incorporation of sediment brought up from Stratum 1, as well as the mixing and small-scale insect bioturbation of the base of overlying Stratum 3 (Andrews et al., in revision). Rock clasts from weathering and erosion of the shelter ceiling and walls (including large sandstone blocks and innumerable small (< 5 cm) sandstone fragments) are found in this unit, as well as the overlying Stratum 3. Stratum 3, in turn, is comprised of a ~1.4–1.7 m thick, dark reddish gray, massive sandy loam, which is organic rich with abundant roots and charcoal, and produced the vast majority of the artifacts and faunal remains that have come from the site.

With this as background, we turn to the issues raised by Huckell et al. (2019). In regard to their suggestion that the red color of Stratum 1 indicates it "could be the B horizon of a soil," we note that not all red strata are soils or B horizons (for that matter, not all soils are red). Moreover, Stratum 1 is a sediment, not a soil. There is only weak evidence of pedogenesis or pedogenic alterations (indicated in part by the low levels of phosphorus and magnetic susceptibility (Holliday 2004, 89)). Illuvial clay coatings are present in Stratum 1, but are most abundant and thickest in Stratum 1 under or inside of the dripline, a byproduct of the high permeability of the sandstone

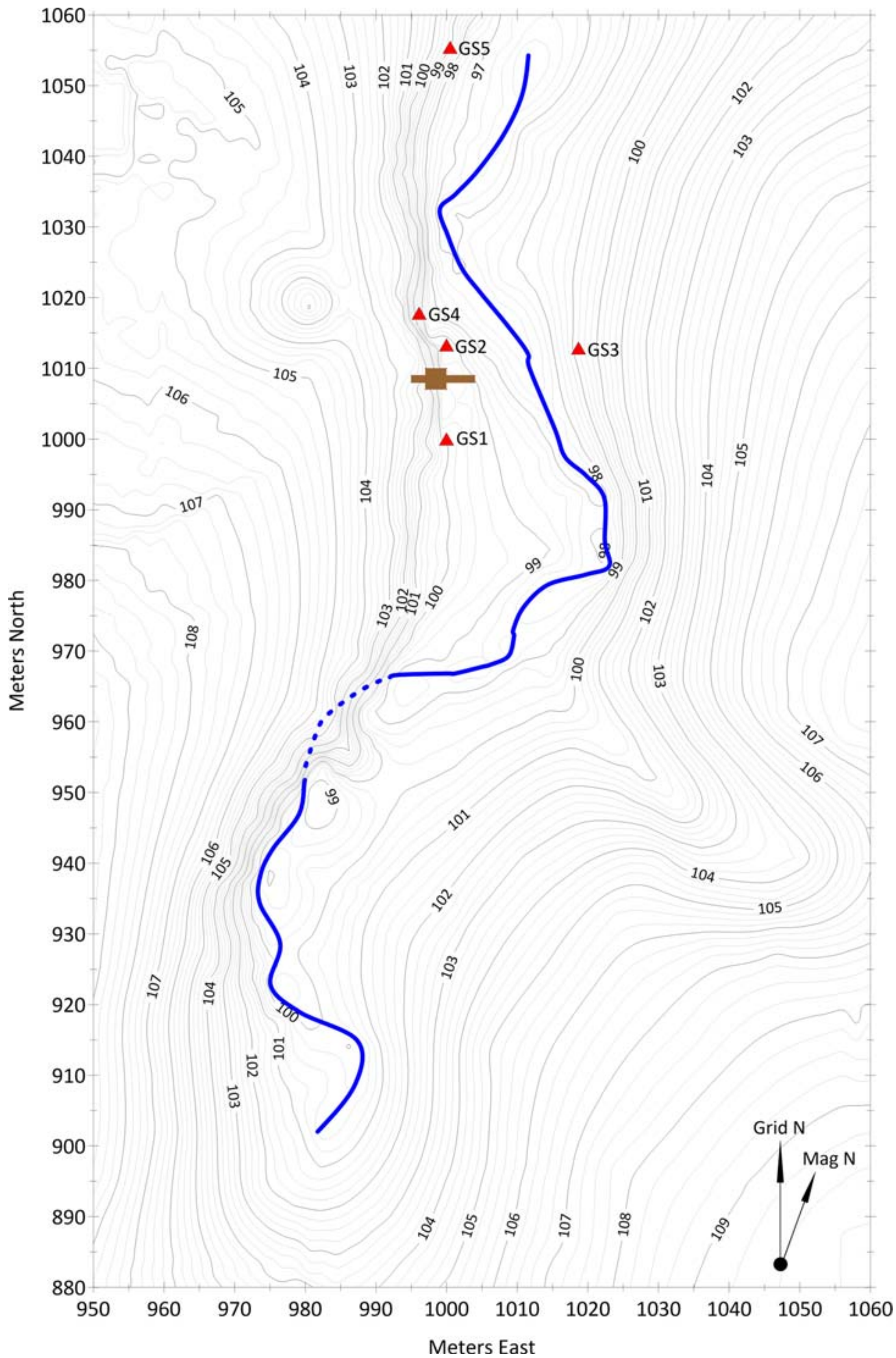

Figure 11 Topographic map of the tributary valley in which Goodson Shelter is located. The shelter is on the west side of the valley, and approximately extends between datums GS1 and GS4 (triangles). The excavation area is the polygon between GS1 and GS2. The stream is shown as a heavy line running south to north in the figure; note the stream bend to the east (dashed line) at around grid N 965.

and the nearly constant dripping of water over the brow of and inside the shelter, along with groundwater flow. Pedogenic iron and manganese oxide nodules are present, though are uncommon and appear from micromorphological evidence to have been re-worked from elsewhere, likely brought in by colluvial action (Andrews et al., in revision). The possibility of prolonged stability of the Stratum 1 surface spanning the time from the terminal Pleistocene into the middle Holocene and resulting in soil formation is undermined by the near overlap of the radiocarbon ages from the top of Stratum 1, and the base of Stratum 2 (see below). Finally, the red color of Stratum 1 (in the range of 2.5YR 4/6 and 10YR 4/4), is attributable to the yellow-to-deep red sandstone bedrock of this area, and which is the parent material for sediment within the shelter as well as the cobbles comprising the stream bedload (drapes of red sand virtually identical in color and texture to Stratum 1 are found on the surface of the valley today).

Post-depositional bioturbation of the sediment by insects, particularly at the upper boundary of Stratum 1, along with illuviation within the shelter, certainly raises the possibility that radiocarbon dates on charcoal from Stratum 1 may not reliably estimate the age of this deposit and its Clovis-like artifacts. Charcoal, in fact, is rare within Stratum 1 and often occurs as sand-sized fragments (Andrews et al., in revision); it is more abundant in Stratum 2 and particularly in Stratum 3. The possibility of charcoal down drift through the profile, in fact, led us to suspect that despite our initial radiocarbon samples returning middle Holocene ages associated with Clovis-like artifacts (Table 2), we nonetheless had a Clovis occupation at Goodson Shelter. Yet, additional charcoal samples from Stratum 1, including from below large roof fall blocks (presumably protected from down drift) also dated to the middle Holocene (Eren et al. 2018a).

Importantly, the radiocarbon ages from Stratum 2 (one of which was associated with Archaic projectile points, the other in a pit feature incised into Stratum 1 and filled with Stratum 2 sediment) yielded median calibrated ages of 4470 and 4721 calendar years ago (cal yr BP)[12] (4020 ± 30 and 4180 ± 30 radiocarbon years ago (^{14}C yr BP), respectively). This is just a few centuries younger than the four radiocarbon ages from Stratum 1, three of which average to a median age of 5169 cal yr BP, and a fourth has a median age of 5506 cal yr BP. All the Stratum 1 samples were from within 10–20 cm of the Stratum 2/Stratum 1 contact.

To assess the reliability of those radiocarbon ages, we submitted for OSL assay two samples: one from the top of Stratum 1, to ascertain whether it replicated the radiocarbon ages, and one at the base of Stratum 1, atop the bedload cobbles of Stratum 0. Owing to the possibility of bioturbation, single-grain OSL analyses were conducted. In the resulting analyses, the "single-grain De distributions were normally distributed, suggesting that the sand was well zeroed at deposition and there wasn't evidence for post-depositional mixing" (T. Rittenour, personal communication, June 15, 2016).

The OSL ages were in correct stratigraphic order within Stratum 1, at 5900 ± 690 yr BP and 6440 ± 800 yr BP (± 2σ), respectively. Of greater significance, the OSL age from the top of Stratum 1 overlaps at two sigma the calibrated radiocarbon ages from the top of Stratum 1, suggesting that the upper surface of that

Table 2 Radiocarbon ages from Goodson Shelter, Stratum 1 and Stratum 2.

Laboratory sample number	^{14}C age	Median probability (cal yr BP)	1 sigma calibrated age (area under the curve)[1]	2 sigma calibrated age (area under the curve)	Field designation	Description
Beta-412027	4020 ± 30	4479	4424–4431 (0.087) 4438–4454 (0.222) 4460–4492 (0.456) 4504–4522 (0.235)	4417–4532 (0.948) 4547–4570 (0.052)	L16-18-148	Charcoal from N1008.302 E997.764 Z97.884, Level 122, from Feature 1, pit feature comprised of Stratum 2 sediments incised into Stratum 1, associated with Archaic projectile points
Beta-347600	4180 ± 30	4721	4648–4674 (0.222) 4697–4757 (0.559) 4802–4828 (0.219)	4583–4597 (0.021) 4615–4767 (0.750) 4784–4835 (0.229)	L16-20-42	Charcoal from N1008.280 E999.370 Z98.100, Level 117, associated with Archaic projectile point, Stratum 2 sediments
Beta-347601	4530 ± 30	5158	5058–5105 (0.349) 5130–5179 (0.393) 5275–5306 (0.258)	5051–5192 (0.667) 5214–5227 (0.026) 5231–5312 (0.307)	L16-20-51	Charcoal from N1008.360 E999.220 Z97.920, Level 121, associated with apparent Clovis biface
Beta-412028	4540 ± 30	5160	5061–5103 (0.314) 5133–5170 (0.344) 5277–5311 (0.342) 5232–5239 (0.031) 5254–5316 (0.307)	5051–5189 (0.647) 5215–5225 (0.015)	L16-20-75	Charcoal from N1008.750 E999.250 Z97.950, Level 120, from Stratum 1 below large roof fall block, limiting possibility of downward movement of charcoal
Beta-412029	4580 ± 30	5304	5143–5158 (0.122) 5286–5322 (0.723) 5420–5436 (0.155)	5055–5108 (0.109) 5127–5183 (0.170) 5272–5326 (0.559) 5403–5444 (0.163)	L16-20-80	Charcoal from N1008.750 E999.250 Z97.850, Level 122, from Stratum 1 below large roof fall blocks
-	4550 ± 20	5169	5088–5096 (0.066) 5139–5162 (0.335) 5283–5312 (0.600)	5056–5107 (0.211) 5128–5182 (0.324) 5273–5316 (0.466)		Average of Beta-347601, Beta-412028, Beta-412029, all from within a vertical span of 15 cm and statistically indistinguishable as determined by chi-square test
Beta-347602	4740 ± 30	5506	5334–5342 (0.052) 5363–5371 (0.059) 5464–5483 (0.206) 5509–5576 (0.683)	5328–5384 (0.232) 5447–5581 (0.768)	L16-20-52	Charcoal from N1008.490 E999.210 Z97.910, Level 121, associated with apparent Clovis biface

[1]Calibrations done with CALIB 8.2, IntCal20 (Reimer et al. 2020).

unit and the initial human occupation that took place atop it dated to ∼5500 cal yr BP.

Although the placement of our two OSL samples bracket the deposition of Stratum 1, and reinforce the radiocarbon results indicating this unit is middle Holocene in age, Huckell et al. (2019) were nonetheless skeptical of their reliability.[13] To ascertain whether Stratum 1 could be Clovis in age, they called for an "all-out OSL investigation of Stratum 1." We have done so.

6. Additional OSL sampling and dating of Goodson Shelter

In October 2019, we returned to Goodson Shelter to take additional samples for OSL dating. The excavation block had been left open since fieldwork was completed in 2015, but it was protected both by an artificial cover and the shelter overhang. After cleaning a thin mud slip from a portion of the south wall and an adjacent area of the floor – the same area illustrated in Eren et al. 2018a, figure 3 – the excavation unit looked much the same as it had four years previously (Figure 12). A test pit ∼60 × 40 cm was then taken down an additional ∼50 cm below the 2015 floor, with all material water-screened for artifacts – none were recovered. This was done to fully expose the base of Stratum 1 in the wall, and to reach as far as possible into Stratum 0 (note the pickaxes in Figure 12, necessary for digging through the densely-packed cobble bedload of Stratum 0).

Unfortunately, the water table was encountered before we reached the base of Stratum 0 (and, presumably, consolidated bedrock). From that lowest depth, a probe was pushed down an additional 25 cm, but still did not encounter consolidated bedrock. These results indicate that the cobble bedload of Stratum 0 is at least 70 cm thick. The measured elevation of consolidated bedrock visible on the creek floor indicates that it is still at least ∼45 cm higher in elevation than the lowest point we reached within Stratum 0 in the shelter. This indicates that the deepest part of the stream channel was at one time within the shelter, and, as we surmise, served to incise the shelter overhang.

After cleaning back the face of the profile, six samples were taken for OSL dating using opaque steel tubes. Five of the samples were taken at ∼5.5-cm intervals from the top (OSL 2019-1) to the bottom (OSL 2019-5) of Stratum 1 (Figure 13), a vertical span of 27.6 cm. The sixth sample (OSL 2019-6) was taken from well within Stratum 0, 35.5 cm below the base of Stratum 1 at this spot.

The samples were submitted to the Sheffield Luminescence Laboratory at the University of Sheffield (UK), for analysis at the single grain level, which allowed for more reliable calculation of OSL ages. Once prepared,[14] samples responded well to OSL measurement. None of the samples from Stratum 1 (OSL 2019-1 through 2019-5) appeared to have been pedoturbated, and the paleodose results are within what would be expected for well-bleached undisturbed samples (Table 3). Ages for these five Stratum 1 samples

Figure 12 Left: The south wall (N 1007 grid line) of the Goodson Shelter excavations in 2015, looking south (Goodson Project image 2015:4044). This is the same image as shown in Eren et al. 2018a, figure 3. Note that the prism pole is divided into 12 inch (30.48 cm) increments. Right: A portion of the same excavation wall in 2019, showing the location of five of the six OSL sampling tubes prepared for samples OSL 2019–1 to 2019-5, numbered from top to bottom (Goodson Project image 2019:6585). The black rectangle in the left image shows the approximate area shown in the image on the right; the smaller white rectangle shows the corresponding position of the OSL sampling shown in close-up in Figure 12.

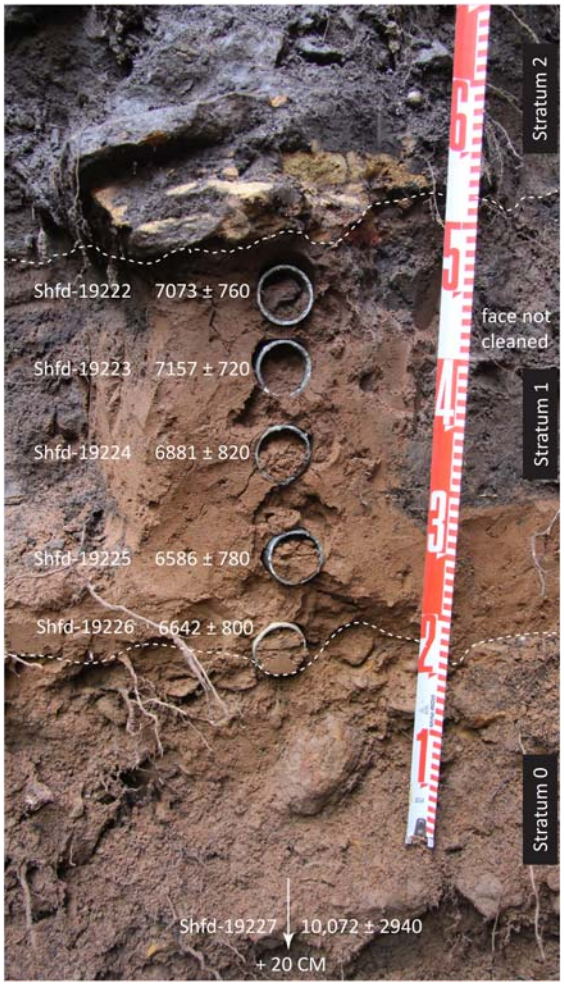

Figure 13 Close-up of the sampling tubes for samples OSL 2019–1 through OSL 2019-5. Sample OSL 2019–6 is in Stratum 0, 40.7 cm below OSL 2019-5, and is not visible in the image. (Goodson Project image 2019:6586).

were calculated using the Central Age Model (Galbraith and Green 1990).

In contrast, the Stratum 0 sample (OSL 2019-6) had a skewed paleodose distribution, indicating it was only partially bleached prior to burial. That it did not receive sufficient sunlight for full bleaching may be a consequence of rapid movement and burial of the sediment and cobbles in that fluvial setting. The paleodose value for this sample was therefore calculated using the Finite Mixture Model (Galbraith and Green 1990), which returned two paleodose components. These resulted in two very different calculated ages, one of which is younger than the overlying Stratum 1. Given the partial bleaching of the sample, and a potentially inaccurate background dose rate for Stratum 0 (the cobbles in the unit were not assessed for their radioactivity), we accept the older of the two OSL ages, as these fit with the stratigraphy.

As is apparent, Stratum 1 is middle Holocene in age. Although the dates within it are not in clear stratigraphic order (likely due to small-scale single grain bioturbation), they are nonetheless statistically contemporaneous, as determined by chi-square, whether calculated at one or two standard deviations. Stratum 1 OSL ages average to 6880 yr BP. The two OSL ages on Stratum 1 previously reported in Eren et al. (2018a, and above) were taken from a different spot in the shelter excavation, but are consistent with these new Stratum 1 ages, and are likewise statistically contemporaneous. When all the OSL ages from Stratum 1 are averaged, they yield an age of 6650 yr BP. The Stratum 1 deposit appears to represent a more or less singular depositional event, as the sedimentary evidence suggests.

Huckell et al. (2019), in proposing that the artifacts in Stratum 1 "are in fact Clovis and that the "problem" at the site is related to stratigraphic interpretations and dating," hypothesized that if "this scenario is valid, mineral grains from the deeper, least disturbed, portions of Stratum 1 should yield OSL ages in excess of 13,000 yr BP or at least of pre-Clovis age."

They do not. The OSL ages and radiocarbon ages from Stratum 1 confirm that this deposit dates to the middle Holocene. It is not pre-Clovis, let alone Clovis in age. Even using the older of the two Stratum 0 OSL ages, the deposits within Goodson Shelter are still within the early Holocene, and not the late Pleistocene.

The Stratum 1 radiocarbon and OSL ages are informative in another respect: they likely date the last time

Table 3 OSL ages from Goodson Shelter (USU = Utah State University Luminescence laboratory; Shfd = Sheffield Luminescence Laboratory). In years before 1950, to be consistent with calibrated ^{14}C ages.

Lab code	Field reference	Stratum	Depth (m below surface/grid elevation)	Dose (Gy)	Dose rate (μGy/a^{-1})	FMM (%)	Age ± 2σ
USU-2048	GS-OSL2	1	1.27/97.827	8.84 ± 0.42	1500 ± 100	n/a	5910 ± 690
Shfd19222	OSL 2019–1	1	1.31/97.805	11.00 ± 0.33	1540 ± 68	n/a	7073 ± 760
Shfd19223	OSL 2019–2	1	1.37/97.752	11.18 ± 0.27	1547 ± 68	n/a	7157 ± 720
Shfd19224	OSL 2019–3	1	1.43/97.691	10.74 ± 0.42	1545 ± 68	n/a	6881 ± 820
USU-2047	GS-OSL1	1	1.45/97.652	8.86 ± 0.59	1370 ± 90	n/a	6440 ± 800
Shfd19225	OSL 2019–4	1	1.52/97.604	10.27 ± 0.39	1543 ± 68	n/a	6586 ± 780
Shfd19226	OSL 2019–5	1	1.59/97.528	10.35 ± 0.42	1542 ± 68	n/a	6642 ± 800
Shfd19227	OSL 2019–6	0	2.00/97.121	8.70 ± 1.04	1616 ± 75	50	5314 ± 1400
				16.39 ± 2.28	1616 ± 75	45	10,072 ± 2940

the stream flowed through Goodson Shelter itself. If we are correct that it was an upstream collapse of an overhang that diverted the creek to the east and thus led it to bypass the shelter, then this collapse occurred sometime around 6000 years ago – based on the youngest of the OSL ages on the Stratum 1 sands. It was soon thereafter, ~5500 years ago, that people began to occupy the shelter, based on the oldest of the charcoal samples recovered in association with artifacts within Stratum 1.

As stated earlier, we cannot preclude the possibility that Goodson Shelter earlier may have been occupied before ~6000 years ago when the stream still flowed through the shelter. However, there is no extant archaeological evidence to support that possibility (Stratum 0 appears barren of artifacts), and all indications are that the occupation of Goodson Shelter began in the middle Holocene.

7. Discussion

Goodson Shelter has yielded a lithic assemblage that technologically and morphologically looks like Clovis, but is demonstrably not late Pleistocene in age (Eren et al. 2018a). At first glance this conclusion may seem surprising, anomalous, or, as Huckell et al (2019) suggest, invalid – either because the Stratum 1 assemblage is not a Clovis look-alike and/or because the original dating of that stratum was in error. Given that we have confirmed Stratum 1 dates to the middle Holocene, and that the artifacts display attributes and elements of Clovis technology, our conclusion that Goodson Shelter provides an Archaic-age Clovis look-alike remains valid. We are left to consider whether our conclusion should be considered surprising or anomalous.

It should not be considered surprising. If an organ as complex as the eye can independently emerge at least 49 times (McGhee 2011, 67), there is no reason to be surprised by the independent invention of stone-tool technologies that are themselves severely limited by intrinsic developmental and functional constraints (Eren et al. 2018b; Groucutt 2020, 2). Indeed, convergent evolution is now understood to be a frequent and widespread occurrence in lithic technology around the world (e.g., Groucutt 2020; O'Brien et al. 2018; see also Adler et al. 2014; Boulanger and Eren 2015; Lycett 2009, 2011; Maguire et al. 2018; Straus et al. 2005; Wang et al. 2012; Will et al. 2015). Moreover, this applies not just to single attributes, but to similarities across assemblages (McLaughlin and Lemaitre 1997).

With respect to Clovis technology, Goodson Shelter is not the only site to provide an example of shared features and convergences. Jennings and Smallwood (2018) demonstrated that despite differences in production routes, there is convergence in the occurrence of blade technologies in Clovis and Late Prehistoric Toyah; likewise, Crassard et al. (2020) documented fluting in the Neolithic of Arabian peninsula, though via a different process and for an apparently different purpose; and Eren et al. (2013, 2014) established that the presence of overshot flaking between Clovis and Solutrean are merely convergent mistakes.

The above comments assume that Goodson Shelter's stone-tool assemblage represents an instance of convergence with Clovis, but there is an alternative possibility: its assemblage may simply be part of a shared historical technological tradition that extends from the Pleistocene to the mid-Holocene (Eren et al. 2018a, 214). We cannot currently state which possibility is more likely – convergence or shared tradition – because we simply do not know the intervening early Holocene lithic technologies of northeastern Oklahoma in the same way and detail that we know Clovis technologies.

In fact, across the North American continent, we are still far from describing, analyzing, and understanding post-Paleoindian lithic technologies in the same way as we describe, analyze, and understand Clovis and other Paleoindian technology. Perhaps not surprisingly, when those sorts of studies do occur, we find similarities (e.g., Muñiz 2014; Norris et al. 2019; Sellet 2015) between Clovis and later technologies, and in this sense our conclusions should not be considered anomalous either.

Thus, in the absence of finished Clovis points or absolute dates, we cannot assume that a technology or specific attributes are unique to and diagnostic of Clovis – especially not until we have comparable knowledge of the technology of later periods, and can demonstrate that that same technology is absent from post-Clovis age assemblages.

Notes

1. These and other matters are in our detailed report of the excavations at the site, which we had hoped would be completed in time to refer to it in our 2018 article, which would have addressed a number of the questions raised by Huckell et al. (2019). Unfortunately, it was not. That manuscript is completed and being revised for publication (Andrews et al., in revision).
2. Although perhaps less widely known today than in his time, Chamberlin was America's preeminent glacial geologist of the late 19th/early 20th century. In addition to successive academic appointments (including at the Universities of Wisconsin and Chicago), he was the decades-long Chief of the USGS Glacial Division. Among his many substantial contributions was his extensive mapping in the early 1880s of what he referred to as

the "Kettle Moraine," which he identified as the terminal moraine of "the Second Glacial Epoch" (Chamberlin 1883 – that 'epoch' was soon to be known as the Wisconsin period). This was the definitive demonstration that the North American Pleistocene involved multiple glacial episodes (for additional biographic information on Chamberlin, see Meltzer 2015, 88–92).

3. Chamberlin published another version of the paper in the *Journal of Geology* in 1897, which was reprinted on a couple of occasions. The original (1890) version was reprinted in *Science* in 1965.
4. We previously (Eren et al. 2018a) reported there were ~600 projectile points from the site. That was an error in our preliminary tallying.
5. Based on our initial examination, we suspected this might be a crested blade; after further study, we now interpret it as a channel flake. Either way, it is a Clovis look-alike.
6. Two of the blades we originally identified came from levels 106 and 109. They were made of the same lithic raw material as seen in Stratum 1.
7. Huckell et al. (2019) neglect to acknowledge that our discriminant function analyses assigned the Green and Keven Davis blades, and two-thirds of the Dickenson blades, to Clovis (Eren et al. 2018a, table 3), and did so regardless of whether the discriminant functions were based on the Gault or the Green blades (Eren et al. 2018a, table 3).
8. Although their inference as to the age of the Dickenson cache seems reasonable, it is nonetheless just an inference that may or may not be correct.
9. The index of curvature is based on two measures: the length of the plane connecting the proximal and distal end points of a blade, and the maximum perpendicular distance between that plane and the blade's interior surface of the blade. The index is calculated by taking the ratio of the latter to the former, and multiplying by 100 (Collins 1999, 86–87). Although the index can be 0, we excluded all 0 values from our sample, since it was not always evident in the data we compiled that a cell left blank in the index of curvature column was intended to convey a 0 or missing data.
10. We previously did not separate the basal red sands and underlying cobble bed load into two units. We do so here, as it helps clarify the shelter's origins and geomorphic history (also, Andrews et al., in revision).
11. Huckell et al. (2019) surmised that Stratum 1 must be thicker than the measured value we stated, on the basis of their assumption that the intervals on the prism pole shown in our Figure 3 (Eren et al. 2018a) were in 50 cm increments. That is wrong: the prism pole increments are in the English system, so each is 12 in. or 30.48 cm. Also, they apparently did not realize that the floor of the excavation shown in the photograph was just atop the basal gravels, so virtually all of Stratum 1 was indeed visible, contra Huckell et al. (2019). Stratum 1, as we stated previously and again here, is ~18-28 cm in thickness.
12. Ages calibrated in Calib 8.20, based on the IntCal20 calibration curve. Consequently, these calibrated ages differ slightly from what we published in 2018, since those were calibrated based on the IntCal13 calibration curve.
13. That Huckell et al (2019) were skeptical was not unreasonable, since our 2018 paper had not provided sufficient details on the provenience of the OSL samples.
14. Bateman (2020) provides the full details of the analysis and results. Briefly summarizing that report, quartz grains were extracted and cleaned following the procedure in Bateman and Catt (1996). Samples were measured with a Risø DA-15 luminescence reader. Paleodose values were determined using the single-aliquot regenerative (SAR) approach (Murray and Wintle 2000) in which an interpolative growth curve is constructed using data derived from repeated measurements (five) of a single aliquot which has been given various laboratory irradiations. Values from individual grains were only accepted if they exhibited an OSL signal measurable above background and showed good growth with dose, among other criteria (Bateman et al. 2007). Up to 1200 grains were measured for each sample; ~5% of the grains per sample passed the acceptance criteria. All samples possessed generally good luminescence characteristics with a rapid decay of OSL with stimulation and OSL signals dominated by a fast component and OSL signal that grew well with laboratory dose. Concentrations of naturally occurring potassium, thorium, uranium, and rubidium, the main contributors of dose to sedimentary quartz, were determined by inductively coupled plasma mass spectrometry. These elemental concentrations were converted to annual dose rates using data from Guerin et al. (2011). Calculations took into account sediment grain sizes used, density and paleo-moisture (with present-day moisture applied as the average paleo-moisture level with an uncertainty of ± 5%). The contribution to dose rates from cosmic sources was calculated following Prescott and Hutton (1994, table 2). The calculated dose rates are based on analyses of corresponding bulk sediment samples (one sample for OSL 2019-1 through 2019-5; one for OSL 2019-6). It is assumed that the present-day values reflect those since burial.

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Disclosure statement

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

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