Supplementary Materials for

Evidence of an early projectile point technology in North America at the Gault Site, Texas, USA

Thomas J. Williams*, Michael B. Collins*, Kathleen Rodrigues*, William Jack Rink, Nancy Velchoff, Amanda Keen-Zebert, Anastasia Gilmer, Charles D. Frederick, Sergio J. Ayala, Elton R. Prewitt

*Corresponding author. Email: tjw69@txstate.edu (T.J.W.); mc82@txstate.edu (M.B.C.); kathleen.rodrigues@dri.edu (K.R.)

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This PDF file includes:

Table S1. Sample OSL ages and dose rate data.
Table S2. Radon loss effects on each Gault OSL sample.
Table S3. Summary of the Gault Assemblage.
Table S4. Summary counts of the Gault biface assemblage.
Fig. S1. A representative decay curve (upper), growth curve (middle), and plot showing sensitivity changes through the SAR cycle (lower) for Gault 11-18.
Fig. S2. Equivalent dose ($D_e$) distributions for all samples displayed in a histogram (left) and radial plot (right).
Fig. S3. Location of the Area 15 excavation block and the excavation grid and profile.
Fig. S4. Relationship between the stratigraphy and cultural components in Area 15.
Fig. S5. Results of the geoarchaeological analysis of the sediments in Area 15.
Fig. S6. Andice projectile point (left) with representative diagnostic notching flakes (right).
Fig. S7. Backplots of northing (blue) and easting (red) profiles showing the elevation of diagnostic Andice notching flakes and the cultural components discussed in the text.
Fig. S8. Limestone bedrock of Area 15, with three sets of flutes scoured into the limestone (discussed in the text).
Fig. S9. Pollen data from Boriack Bog and the NGRIP and GRIP ice core record as compared to stratigraphic units at Area 15.
Fig. S10. Gault Assemblage stone tool types and frequency (see table S2).
Fig. S11. Gault Assemblage projectile points.
Fig. S12. Principal components analysis of the Gault Assemblage stemmed projectile points and the Gower and Uvalde types.
Section S1. Area 15 stratigraphy
Section S2. Context of early dates in North America
Section S3. Gault Assemblage in Area 15
References (43–85)
Materials and Methods figures

Table S1. Sample OSL ages and dose rate data.

| Sample Name | Elevation (m) | Overdispersion (%) | ²³⁸U (ppm) | ²³²Th (ppm) | K (%) | Measured Water Content (%) | Externally alpha dose rate (µGy/a) | Externally Beta dose rate (µGy/a) | Externally Gamma dose rate (in situ) (µGy/a) | Cosmic dose rate (µGy/a) | Total dose rate (µGy/a) | D_E (Gy) | Age (ka) |
|--------------|---------------|-------------------|------------|------------|-------|---------------------------|------------------------------------|-----------------------------------|-----------------------------------------------|--------------------------|----------------------|-----------|---------|
| 11-05b       | 92.41         | 8.5               | 2.11 ± 0.1 | 8.08 ± 0.51| 0.69 ± 0.02 | 15                                           | 104.5 ± 8.6                       | 818.3 ± 18.6                     | 656.0                                           | 173 ± 17                     | 1758.3 ± 20.6           | 32.8 ± 0.5 | 18.7 ± 1.2 |
| 11-20        | 92.23         | 1.3               | 2.29 ± 0.1 | 8.95 ± 0.57| 0.79 ± 0.02 | 29                                           | 114.7 ± 9.4                       | 916.4 ± 20.4                     | 709.7                                           | 171 ± 17                     | 1918.3 ± 22.5           | 32.0 ± 0.2 | 16.7 ± 1.1 |
| 11-18        | 92.22         | 0                 | 2.48 ± 0.1 | 10.11 ±0.63| 0.94 ± 0.02 | 19                                           | 127.3 ± 10.4                      | 1052.5 ± 22.5                    | 707.3                                           | 171 ± 17                     | 2064.6 ± 24.9           | 34.8 ± 0.3 | 16.9 ± 1.1 |
| 11-06        | 92.16         | 4.9               | 2.13 ± 0.1 | 6.64 ± 0.41| 0.55 ± 0.01 | 23                                           | 93.0 ± 7.5                        | 712.3 ± 15.0                     | 567.3                                           | 170 ± 17                     | 1549.1 ± 16.9           | 33.6 ± 0.3 | 21.7 ± 1.4 |

1. U, Th and K values determined by NAA and DNC at the Nuclear Reactor facility of McMaster University.
2. Cosmic dose rate value calculated using an overburden density of 2 g/cm³, accounting for depth of sample. The cosmic dose rate assumes linear sediment accumulation.
3. All annual dose rates include an internal alpha and beta dose in quartz of 6.5 µGy/a (43) and assume secular equilibrium for the dose rate from all radionuclides in the ²³⁸U and ²³²Th decay chains.
4. All burial doses were modeled from the population of individual aliquot equivalent doses using the central age model (CAM) (21), All CAM D_E calculations for 0.5 mm aliquots were made using o_b = 0.045 which was determined based on results of dose recovery experiments. Ages are calculated assuming a 20% moisture content over the burial history.
5. Based on the arbitrary site datum set at 100 m
Table S2. Radon loss effects on each Gault OSL sample.

| Sample: 11-05b | U-only dose rate (µGy/a) | Total annual dose rate (µGy/a) | Age (ka) |
|----------------|--------------------------|--------------------------------|----------|
| 100% Rn loss   | 111.5                    | 1389.1 ± 30.3                  | 23.6 ± 1.6 |
| 50% Rn loss    | 292.6                    | 1566.2 ± 30.3                  | 20.9 ± 1.4 |
| 25% Rn loss    | 382.3                    | 1655.9 ± 30.3                  | 19.8 ± 1.2 |

| Sample: 11-20  | U-only dose rate (µGy/a) | Total annual dose rate (µGy/a) | Age (ka) |
|----------------|--------------------------|--------------------------------|----------|
| 100% Rn loss   | 125.4                    | 1535.7 ± 32.4                  | 20.8 ± 1.4 |
| 50% Rn loss    | 317.6                    | 1727.9 ± 32.4                  | 18.5 ± 1.2 |
| 25% Rn loss    | 414.9                    | 1825.2 ± 32.4                  | 17.5 ± 1.1 |

| Sample: 11-18  | U-only dose rate (µGy/a) | Total annual dose rate (µGy/a) | Age (ka) |
|----------------|--------------------------|--------------------------------|----------|
| 100% Rn loss   | 135.9                    | 1744.7 ± 34.7                  | 19.9 ± 1.3 |
| 50% Rn loss    | 343.9                    | 1952.7 ± 34.7                  | 17.8 ± 1.2 |
| 25% Rn loss    | 449.3                    | 2058.1 ± 34.7                  | 16.9 ± 1.1 |

| Sample: 11-06  | U-only dose rate (µGy/a) | Total annual dose rate (µGy/a) | Age (ka) |
|----------------|--------------------------|--------------------------------|----------|
| 100% Rn loss   | 116.6                    | 1178.3 ± 24.6                  | 28.5 ± 1.9 |
| 50% Rn loss    | 295.4                    | 1357.1 ± 24.6                  | 24.8 ± 1.6 |
| 25% Rn loss    | 385.9                    | 1447.6 ± 24.6                  | 23.2 ± 1.5 |
Fig. S1. A representative decay curve (upper), growth curve (middle), and plot showing sensitivity changes through the SAR cycle (lower) for Gault 11-18.
Fig. S2. Equivalent dose ($D_e$) distributions for all samples displayed in a histogram (left) and radial plot (right).
Section S1. Area 15 stratigraphy

Site Setting
The Gault Site is located on the eastern margin of the Edwards Plateau within the Balcones Canyonlands ecotype and borders the Blackland Prairie physiographic region. Locally, it is situated on Buttermilk Creek, a spring-fed first- and second-order stream valley. In general, Buttermilk Creek has a low sinuosity (1.26) and a moderately steep gradient of 8.5 m/km. Buttermilk Creek is predominantly a straight channel, but with sections that switch to either a meandering or braided channel at those sections with a lower gradient. These meandering sections exhibit point-bar formations. The outer bends of the meanders are confined by bedrock bluffs or colluvial slopes. The braided sections split into two or more channels that are separated by mid-channel bars.

The local topography ranges from the flat floodplain of the valley to relatively prominent uplands characterized by sedimentary rock outcrops of the Edwards Plateau (Cretaceous Limestone). The bedrock in the valley is Comanche Peak formation, which is overlain by the Edwards formation exposures of the valley walls. Excavation block Area 15 is situated near the intersection of the floodplain and the colluvial toe slope of the valley walls. The soils within the vicinity of the site consist of Georgetown clay loam in the uplands and Lewisville silty clay in the floodplain deposits. The Lewisville series is classified as fine-silty, mixed, active, thermic Udic Calciustolls. Lewisville soils are well-drained, moderately permeable soils formed in ancient loamy and calcareous sediments and are typically located on nearly level to rolling landscapes that have plane to convex surfaces with slopes ranging from 0 to 10 percent. While the Lewisville series is classified as a Mollisol by the Soil Survey Staff, the clay-rich sediments have developed into a weakly expressed Vertisol. Cracks, slickensides, and micro high/micro low topography have been observed at Gault.

To date, scientific excavations at the Gault site consisted of fifteen major excavation areas. This report focuses only on excavation block 15. Excavation block Area 15 was 7 m (N-S) by 8 m (E-W). This block was excavated to step in and down twice with each step being about 1 m high (fig. S3) to expose a 12 m² (N1159-N1162, E1080-E1084) block at bedrock. A complete stratified sequence of Archaic, Late Paleoindian, Clovis, and the Gault Assemblage was found across the entire Area 15 excavation area. Clovis points and Clovis-age artifacts have also been recovered from excavations areas 4, 5, 7, 8, 10, 11, 12, and 13. The Clovis assemblage from Area 8 has been previously reported.
Fig. S3. Location of the Area 15 excavation block and the excavation grid and profile. The other numbered excavations areas referred to locations where Clovis deposits have been recovered (not discussed in text).
Geoarchaeological Analyses
Area 15 consists predominantly of alluvial sediments overlying limestone bedrock. Minor components of colluvial and aeolian sediments are also present. These sediments have been subject to diagenesis, pedogenesis, and erosion, in addition to being heavily overprinted by anthropic processes, especially during the Archaic and Late Prehistoric periods when a midden formed and during the Historic period when the site was extensively vandalized. The deposits of Area 15 are considerably thicker than most, similar aged deposits at the Gault Site, owing to the fact that this sequence is situated within an abandoned channel complex.

The sedimentary contacts and pedogenic boundaries throughout the depositional sequence in Area 15 are presented in fig. S4. Ten sedimentary stratigraphic units and two paleosols were identified (50). A column of bulk sediment samples was collected from the limestone bedrock (at 92.00 m) to the surface (at 94.70 m). Particle-size (sieve-hydrometer), magnetic susceptibility (conducted ex-situ), organic carbon (Walkley-Black), organic matter (Loss-on-Ignition), and calcium carbonate (Chittick; Loss-on-Ignition) were determined along this witness column (fig. S5). A number of micromorphological samples were collected as well.
Fig. S4. Relationship between the stratigraphy and cultural components in Area 15. Stratigraphic unit numbers are shown in the stratigraphic interpretation and the cultural horizons are highlighted in gray.

Fig. S5. Results of the geoarcheological analysis of the sediments in Area 15. Stratigraphic unit numbers are shown in the stratigraphic interpretation and the cultural horizons are highlighted in gray.
Results

Lithostratigraphy and Soils

Saprolite. The lowest soil sample in the column was collected from saprolitic limestone, which is fine-grained and high in calcium carbonate.

Stratum 1. This unit is comprised of chert and limestone cobbles deposited by a stream. These clast-supported cobbles have a clay loam to sandy clay matrix. The cobbles are poorly sorted, angular to sub-rounded, and are generally less than 15 cm in diameter. A seismic reflection line (49), which ran near Area 15, revealed a paleochannel that cut into the bedrock of the valley and was overlain by gravels and clay. Hildebrand et al. (49) observed that the topographic contours of the valley suggest the course of Buttermilk Creek, or one of its tributaries, once ran north of the creek’s current position.

There is a strong decrease in the percentage of calcium carbonate at the base of Stratum 1. This decrease is likely the result of the flow of the water table (48).

Strata 2 and 3. These strata have a clay loam matrix with a gravel component (~10%). The gravels are poorly sorted, subangular to rounded, and are typically 3 to 5 cm in diameter.

Stratum 2 is slightly coarser than Stratum 3. There is also a sharp increase in the percentage of calcium carbonate in Stratum 2 compared to Strata 1 and 3. Strata 2 and 3 are heavily overprinted with redoximorphic features. As such, post-depositional processes have resulted in a sharp visual difference between the two units. Yellowish brown redox concentrations are common in Stratum 2, while light gray redox depletions are common in Stratum 3.

Stratum 4. This unit is a dark, organic-rich paleosol with a fine-grained clay matrix. There is a decrease in the percentage of sand and an increase in silt and clay within Stratum 4, compared to the underlying strata. The decrease in the coarseness of the sediments indicates a switch to a distal floodplain setting from a proximal setting.

Strata 5 through 10. Continuing up the profile, several sequences of floodplain deposits were identified. The texture for each unit is clay, and in general, each unit fines upward.

Stratum 6. This unit is comprised of clay-rich floodplain deposits. The fluctuations in silt and clay in Stratum 6 suggests episodic flooding occurred during the deposition of this unit.

Stratum 7. Like Stratum 4, Stratum 7 is a dark, organic-rich paleosol with a fine-grained clay matrix deposited through overbank flooding. There is a drop in the calcium carbonate percentage, a slight increase in the low frequency magnetic susceptibility readings, and a change in the percentage of organic matter.

Stratum 8, 9, and 10. As with the underlying deposits, these deposits are primarily clay deposited in a floodplain setting, but unlike the underlying deposits, these strata have been subsequently altered by human occupation during the latter half of the Holocene to
form a midden, and then repeatedly disturbed by pot hunters during the Historic period. These layers are classified as Anthrosols, and are marked by elevated organic matter (52, 53), increased levels of magnetic susceptibility (54) and abundant thermal refuse and artifacts.

**Texture Analysis.** The general trend of the column is to fine upward (see fig. S5). There is a clear contrast between the coarser deposits in Strata 1-3 and the finer deposits in Strata 4-10. This contrast is strongly demonstrated by the mean partial size on the phi scale. For Strata 1, 2, and 3, the percentage of sand ranges from 14-30% with a mean of 5 phi. Correspondingly, the silt and clay percentages are low; silt never exceeds 30% and clay never exceeds 35%. In Strata 5-10, the percentage of clay ranges from 50-60% with a mean between 8-10 phi. Above Stratum 4, the percentage of sand, silt, and clay remains fairly consistent. There are pulses of gravel in Strata 5-10 that may have been deposited colluvially, or were culturally introduced. The presence of extensive amounts of phreatic calcium carbonate (which could not be removed without sacrificing the detrital sediments) in Strata 1, 2 and 3, most likely makes these deposits appear slightly coarser than they were when they were deposited.

**Calcium Carbonate.** The percentage of calcium carbonate decreases up the profile. The saprolitic limestone at the base of the profile exhibited the highest percentage of calcium carbonate (72%). Strata 1, 2, and 3 were carbonate rich, generally ranging from 20-35%; specifically, the percent carbonate increased in Stratum 1, peaked in Stratum 2, and decreased in Stratum 3. Much of this is secondary groundwater calcium carbonate. As is expected for paleosol A-horizons, the percentage of calcium carbonate strongly decreased in Stratum 4 to around 3% due to leaching by meteoric water. The carbonate percentage increased in Strata 5 and 6 and ranged between 10 and 20%. The spikes in carbonate in Strata 5-7 likely represent colluvium from the limestone valley walls. Similar to the paleosol in Stratum 4, the carbonate percentage weakly decreases at the paleosols in Stratum 7. In Stratum 8-10, the percentage of carbonate declines from 5 to 1% throughout the rest of the profile, consistent with a soil that was exposed at the surface for most of the latter half of the Holocene.

**Organic Carbon and Organic Matter.** Fluctuations in organic matter and carbon are weakly expressed, the general trend is for organic content to increase up the profile. As expected there are increased levels of organic carbon in Strata 4 and 7 as well as the modern A-horizon.

**Magnetic Susceptibility.** The low frequency magnetic susceptibility slowly increases up the profile with peaks at the top of Strata 4, 7, and 8 to 10. These elevated values generally coincide with the soils. The coefficient of frequency dependence is highly variable and does not consistently correlate with the soil A-horizons identified within the stratigraphic sequence.

**Micromorphology.** Soil micromorphology observations focused on pedogenic and other post-depositional processes. With depth, there is an increase in the percentage of calcium carbonate and redoximorphic features. In Strata 4 and 5, the carbonates have a fine-
grained, compound structure. The carbonates primarily envelop the peds, rather than form within the peds. By Stratum 3 there are two phases of carbonate: small, micritic grains along the edges of peds and larger, birefringent grains at the center of voids. Redoximorphic features are concentrated in the center of the peds, with 30-40% of the silty clay matrix having mottles with diffuse edges. In Stratum 2, the redoximorphic features begin to form within the carbonates. The carbonates, now up to 40-50% of the matrix, are highly phreatic in Strata 1 and 2 and are finely intermingled with the matrix.

Archaeological Deposits in Area 15
The Gault Assemblage artifacts were associated with Strata 1 and 2 (see Figs. 4, S4, S5). If defined by flake count, the Gault Assemblage occupation appears to have been the most intense during the deposition of Stratum 1.

Stratum 3 correlates with a break in occupation between the Gault Assemblage and the Clovis periods. The diagnostic Clovis artifacts were collected from Stratum 4, which is a dark, organic-rich paleosol with a fine-grained clay matrix. Diagnostic Late Paleoindian materials were collected from Strata 5 and 6, and like Stratum 4, have a clay-matrix. Strata 7-10 contain Archaic materials associated with the development of a midden (Strata 8-10) and represent intense human activity (55). Strata 8-10 also contain numerous heated rock features.

Stratum 8, which contains Archaic material, includes a significant Andice/Calf Creek assemblage. Andice projectile points are distinctive for the deep basal notches created using indirect percussion which produces diagnostic notching flakes that are ~1cm² (fig. S6). An analysis of the distribution of these flakes throughout the Area 15 excavation block found that these flakes were distributed between 94.90 m and 93.90 m (fig. S7) in association with the Early – Middle Archaic deposit and the disturbed midden above. These flakes indicate a high degree of stratigraphic integrity, demonstrating that the downward movement is limited.
Fig. S6. Andice projectile point (left) with representative diagnostic notching flakes (right).
Fig. S7. Backplots of northing (blue) and easting (red) profiles showing the elevation of diagnostic Andice notching flakes and the cultural components discussed in the text. This illustrates the integrity of the deposits in Area 15 of the Gault site.
**Discussion**

The results indicate that the earliest depositional events in Area 15 are characterized by fluvial processes before the avulsion of Buttermilk Creek and the deposition of overbank alluvium. Using the OSL dates reported here and elsewhere (32), it is possible to construct a depositional timeline using the established stratigraphy reported above.

Prior to 21.7 ± 1.4 ka, a channel was cut into the Comanche Peak limestone by Buttermilk Creek. The orientation of three sets of flutes scoured into the bedrock at the base of Area 15 record the staged shifting of the stream channel to the west prior to the deposition of the overlying sediments (fig. S8). This was calculated on the width and depth of each set of flutes, with the older ones being deeper and wider than the younger ones. The set of flutes furthest to the east are oriented at approximately due north (fig. S8 green arrows), the middle set at approximately 32 degrees (azimuth) (fig. S8 blue arrows), and the flutes to the west at approximately 26 degrees (fig. S8 red arrows). Stratum 1 consists of high-energy gravel deposits associated with this channel and occurred around 21.7 ± 1.4 ka.

Subsequently, Buttermilk Creek abandoned this course in favor of a new one to the south, closer to the modern channel of Buttermilk Creek. This abandoned channel (Strata 2 and 3) filled with coarse (proximal) deposits after avulsion due to a maintained open stream connection (56) between 18.7 ± 1.2 ka and 16.7 ± 1.1 ka. The shifting course of Buttermilk Creek, and its eventual avulsion, may have been triggered by climactic fluctuations occurring during the Last Glacial Maximum.

After the deposition of Strata 2 and 3, sedimentation within the abandoned channel occurred during periods of overbank flooding (i.e. Strata 4-10) which resulted in the accumulation of fine-grained, vertically accreted floodplain deposits and colluvium. Stratum 4 dates between 13.6 ± 0.6 ka and 11.9 ± 0.8 ka and indicates that this switch to a floodplain regime occurred at the time as Clovis occupation. Climate records indicate warmer and drier conditions during the Clovis period (57, 58). Arboreal pollen communities were identified at this time in Central Texas (59, 60, 61; fig. S9) and dominated the landscape during the Clovis period.

Strata 5-10 were deposited between 11.6 ± 0.5 ka and the modern day, a period characterized by a general increase in temperature and a decrease in moisture (57, 58, 61-63). Stratum 5 was deposited between 11.6 ± 0.5 ka and 9.6 ± 0.3 ka during a low magnitude hydrologic regime of Buttermilk Creek, characterized by calm, low energy deposition and a high percentage of arboreal pollen. In contrast, Stratum 6 represents a higher energy depositional setting characterized by a sharp increase in Poaceae between 9,200 and 8,500 (59; see fig. S9). Within error, the OSL age (10.1 ± 0.4 ka) is in stratigraphic order and agrees with diagnostic artifact evidence of the Late Paleoindian occupation of the site.

There is most likely an erosional surface between strata 6 and 7 as indicated by a significant break in OSL ages (9.1 ± 0.4 ka and 6.7 ± 0.2 ka). This correlates to a short
decrease in Poaceae pollen and an increase in arboreal pollen, during the return to cooler temperatures at approximately 6.8 ka (see fig. S9).

The sediments in Strata 7 through 10 have been deposited since 6.7 ± 0.2 ka. The climate was briefly mesic between 6800 to 6000 cal. years B.P. (59, 60). Between 5700 cal. years B.P. and 750 cal. years ago, the climate returned to warm and dry conditions. For the last 750 years, however, Central Texas has been mesic (60). Grassland communities, which were dominant across Central Texas until 1800 cal. years B.P. (59, 61; see fig. S9), covered the landscape during the deposition of Strata 7 and 8 and possibly Strata 9 and 10.
Fig. S8. Limestone bedrock of Area 15, with three sets of flutes scoured into the limestone (discussed in the text).
Fig. S9. Pollen data from Boriack Bog and the NGRIP and GRIP ice core record as compared to stratigraphic units at Area 15.
Conclusion
The diagnostic Gault Assemblage artifacts are contained in a clearly distinguishable stratigraphic context from the diagnostic Clovis material. The cultural sequence is supported by a correlating sequence of OSL dates across Area 15. The results of these geoarchaeological analyses, when paired with archaeological materials from Area 15, not only increase the understanding of the Paleoindian record at the Gault site but provide further evidence supporting an occupation of North America prior to Clovis.

Section S2. Context of early dates in North America
Introduction
There is increasing evidence for a human presence in the Western Hemisphere before 13,000 cal BP, however archaeological opinion and acceptance of this record remains divided and often based on a site by site analysis (4-6). The current evidence suggests that this early record is widespread and diverse, consisting of multiple reported localities in a variety of environmental settings (1, 3, 9, 64). Here we summarize a sample of archaeological localities and associated ages in North America to provide a contextual framework for the Gault Site. Many of these sites and localities require further scientific investigations but highlight the high probability of different occupational patterns in this early record. If validated, these recurrent patterns will further strengthen the argument for early sites in North America (65). Chronometric dating relies on radiocarbon and luminescence techniques, or a combination of the two. In a few cases, the relevant components also occupy stratigraphic positions beneath cultural components dating to ca. 13,000 cal BP.

The sites discussed represent an emerging picture of the complexity of the early record of human occupations in North America. From this emerging complexity, Collins et al. (1) have argued that seven patterns can be inferred from the synthesis of these data.

Spatial/Temporal Patterns
Pattern 1 consists of 12 sites in the vicinity of the Chesapeake Bay where thin, bipointed bifaces, quite similar to those of Solutrean affiliation in southwestern Europe, have been found (66-68). At one submerged site, Cinmar, a large thin biface was retrieved in a scallop dredge along with the skull of a Mastodon from 74 m of water at the outer edge of the continental shelf off Virginia. It is inferred that the skull and the biface are associated, which, if true, makes Cinmar the only Pattern 1 site to be dated. A radiocarbon age of 27,440 ± 394 cal BP was determined on the tusk of this Mastodon (69). A further site, Parson’s Island in the Chesapeake Bay exhibits material which may connect Pattern 1 and Pattern 2 (see below). A calibrated age of 20,672 ± 127 cal BP (OxCal v4.2.4; IntCal13) (68) has been reported from this site. Without a controlled scientific excavation of these sites, a full assessment of the validity of this pattern is problematic (70).

Pattern 2 is expressed at seven sites where small, thin bifacial projectile points, or prismatic blade production, or both, occur. These are toward the eastern side of the continent from Pennsylvania to Tennessee to Florida with dates between ca. 32,000 and 13,000 cal BP. Mastodon remains believed to be associated with points in this group are
dated to ca. 14,000 cal BP at the Page Ladson site in Florida (71, 72). Unlike pattern 1, this pattern has largely been validated through controlled scientific excavation, including Meadowcroft Rockshelter and Page-Ladson.

**Pattern 3** is characterized by proboscidean skeletons with evidence of butchery and/or high impact fractures of dense green long bones, but without the presence of stone or bone implements. Among 12 representative sites, 10 consist of Mammoth and 2 of Mastodon remains. These localities extend from the Great Lakes to Texas, east of the Rocky Mountains, and primarily in the Great Plains and include New Nebraska, Villa Grove, La Sena, Prettyman, Hamburger, Shaffert, Jensen, Selby & Dutton, Mud Lake, Sand Creek, Bonfire, and Fenske (73). These sites range in age from >30,000 to 13,000 cal BP. These sites remain controversial due to questions over whether these fractures are solely the domain of human agency or include natural causes (74).

**Pattern 4** includes at least seven sites with associated lithic artifacts and megafaunal remains. These sites include Schulz, Burnham, Cooperton, Lovewell, Hebior, Schaefer, and Lindsay (73). Three further sites may also fit within this pattern. At the Manis Site, Washington, a bone projectile point was discovered embedded in a Mastodon rib (75). The Manis find is dated to 13,800 cal BP. Evidence for possible butchering marks was discovered on a femur from a curated Jefferson’s Ground Sloth in Ohio which dated to 13,738 - 13,435 cal BP (76). While younger than the patterns reported here, evidence from Pleasant Lake, Michigan, indicates that a “bone technology” is evident in butchering of a Mastodon which was radiocarbon dated by wood fragments from the pulp cavities of both tusks to 12,258 ± 173 cal BP (OxCal v4.2.4; IntCal13) (77). This younger date was not included in the table but suggests a continuation of this pattern. Pattern 4 is similar to pattern 3 with the exception of lithic materials. Holen and Holen (73) put forward the Mammoth Steppe hypothesis as a possible explanation of these data and argue Palaeolithic groups skilled in Mammoth predation arrived in North America prior to the LGM. As with pattern 3, questions remain over the dating methods, human agency, and depositional environment.

**Pattern 5** consists of two sites with thick, stratified deposits, the Gault Site and the Debra L. Friedkin site, in Central Texas, each yielding a long sequence of cultural components from before Clovis and continuing through the Paleoindian, Archaic, and Late Prehistoric periods (32, 42, 78). Below Clovis, the assemblages from both sites consist of bifacial as well as blade technologies. Blades, small blades, and tools made on blades as well as examples of blade cores resemble, but are distinct from, Clovis blade technology. Bifaces are also similar in form to Clovis, but are smaller and technologically distinctive (for example, in lacking overshot flaking). Projectile points are small, corner notched, with short expanding stems. Stem edges are ground. Reported luminescence ages from the Debra L. Friedkin site place this occupation between 13.2 and 15.5 ka while the dates from the Gault Site (presented here) indicate an earlier occupation of the valley by ~16 ka. The sedimentary sequence at Debra L. Friedkin is 1.4 m in depth while the sequence at the Gault Site is a little over 3 m in depth however, comparisons between the depositional sequences at these two sites have not yet been undertaken.
Pattern 6 sites exhibit thick, narrow, projectile points (varieties of Western Stemmed, or Great Basin Stemmed, Sluiceway, Mesa, Haskett, Agate Basin, El Jobo, and Monte Verde). These occur widely in the Great Basin and along the Arctic and Pacific margin from Beringia to southern South America (4, 5, 79). These sites also yield bifaces that exhibit more than one technology and “type”. Importantly these sites lack macro blades. The dated sites range from 14,500 to 13,200 cal BP. Except for Paisley Caves and Coopers Ferry, few other stratified sites have been excavated.

Pattern 7 is another cultural manifestation of ca. 13,200 cal BP, very unlike Clovis although partly contemporaneous with it. It is found along the Pacific coastal margin and is distinguished by small stemmed projectile points, bifacial crescent tools, and a strong maritime subsistence signature. The name, “Paleocoastal,” has been given to this as seen on the Channel Islands (80).

Discussion
These hypothetical seven patterns highlight the possibility of a long and diverse cultural history concerning the earliest human occupations of North America. In a wider context, it suggests that North America exhibits a low-level occupational sequence of possibly isolated groups both before and during the LGM. Following the end of the LGM ~15 ka there appears to be a marked increase in the number of dated sites. The sites and patterns presented above are not intended to provide a scenario for the initial human occupation of the America but highlight the increasing diversity and complex in this early record.

From the perspective of the Gault site, these patterns highlight the unique cultural signature present in the Gault Assemblage deposits. With the exception of the Debra L. Friedkin site, no other early assemblage exhibits similar technological or typological characteristics. Furthermore, when combined with the ages presented in this paper, the earliest occupation of the Gault site coincides with the full glacial period of the LGM. This would suggest that the group or groups that inhabited Central Texas during the LGM either arrived during fully glacial conditions in the North or represent the local adaptations of groups established in North America prior to the onset of glaciation.

While the existing evidence does not allow for any in-depth examination of this hypothesis, these data highlight the increasing need for researchers to focus on understanding the nature and extent of these earliest occupations before speculating on possible on the roots of this increasing complexity.
Section S3. Gault Assemblage in Area 15

Introduction
Excavations in Area 15 recovered a substantial assemblage of stone tools from the lowest deposits (Strata 1 and 2). These oldest materials are referred to as the Gault Assemblage. This assemblage is comprised of over 150,000 artifacts of mostly flakes and debitage. So far, over 200+ tools including artifacts directly related to manufacturing and maintenance have been identified and provide significant evidence of the earliest known prehistoric human activities at the Gault Site. Analysis of these tools and associated cultural materials is ongoing, and some current archaeological interpretations are subject to future refinement. Results from preliminary analyses of these items from below the known Clovis strata in Area 15 are presented as discussions focusing on the more exceptional pieces in this tool kit.

Preliminary examination of the 200+ stone tool collection yielded 184 culturally diagnostic pieces. These consist of bifaces, projectile points, blades, blade cores, and modified and/or utilized flakes (table S3 and fig. S10).
Table S3. Summary of the Gault Assemblage.

| Artifact Class Types | Total Artifact Count | Sample % (n=184) |
|----------------------|----------------------|------------------|
| Bifaces              | 30                   | 16.3             |
| Projectile points    | 11                   | 6.0              |
| Blades               | 53                   | 28.8             |
| Blade cores          | 5                    | 2.7              |
| Unifaces             | 14                   | 7.6              |
| Gravers              | 7                    | 3.8              |
| Burins               | 2                    | 1.1              |
| Burin spalls         | 10                   | 5.4              |
| Modified flakes      | 52                   | 28.3             |
| **Total**            | **184**              | **100%**         |

Fig. S10. Gault Assemblage stone tool types and frequency (see table S2).
**Projectile point assemblage**

There are eleven artifacts identified as projectile points (Figs. 3 and S11). Most were found in fragmentary condition except for one nearly intact projectile point made on non-local smoky quartz (Fig. 3g). This point is relatively thick in cross-section likely from frequent retouch. The morphology demonstrates weak shoulders suggesting a remnant of a stem.

The three stemmed projectile points (Fig. 3h, 3i, and 3j) are small basal fragments made on Central Texas chert. These have smoothed and/or polished basal stems and edges, and all three have evidence of haft wear. Figure 3i is a shouldered basal fragment with asymmetrical barbs, a single stem and a *slightly* expanding base with a detectable concavity. Figure 3h is basal fragment with a deep basal concavity, flared lateral edges and polished rounded ears. Figure 3j is also a basal fragment and is missing one basal ear – apparently detached by a hard impact. However, unlike Fig. 3i, the lateral edge of the remaining stem gently expands ending in a moderately polished ear. Figure 3k is a thin, well-made dart point tip from same context as Fig. 3j. The blade segments (Fig. 3i and 3k) are alternately beveled to the right while all three stems are alternately beveled to the left. The morphologies of the projectile points suggest general continuity in form. Consistent use of parallel and parallel-oblique to the midline (comedial) flaking appears to be the primary reductive and/or retouch technique in most of these specimens. This clearly demonstrates that these projectile points are manufactured using the same technological repertoire.
Fig. S11. Gault Assemblage projectile points. Identifying letters are retained from Fig. 3 and match those in-text.
The three stemmed and one distal point fragments resemble Early Archaic Uvalde and Gower points common to the region. However, these point types tend to be larger and thicker, averaging over 50 mm in length and 7 mm in thickness compared to 36 mm (reconstructed) and 5.3 mm for the Gault Assemblage items. Bevels on the Fig. 3k distal blade fragment and the Fig. 3i proximal blade segment are narrow and steep compared to the broad gentle bevels on Uvalde and Gower types. Neck widths of the three stemmed Gault Assemblage points are significantly narrower than the averages noted on the later types. While stem (haft) lengths and base widths are similar, they are at the shorter and narrower end of the ranges observed for Gower and Uvalde. Statistical analysis of these three projectile point types further highlights these differences. Principle Component Analysis (fig. S12) demonstrates that the Gault assemblage points are smaller than the Gower and Uvalde types based on the following variables; maximum thickness (M. th), blade depth (Blade D), neck width (N.W), base width (Base W), haft length (H.L), base depth (Base D).

A significant difference is observed in treatment of the Gault Assemblage bases. These points are thinned on one or both faces by removal of a series of short adjacent flakes in a manner that creates a narrow bevel or collar around the bases. Gower points are usually thinned on one or both faces by removal of single large flakes while Uvalde points typically have multiple upward flake removals with scars much longer than those observed on the Gault Assemblage pieces.
Fig. S12. Principal components analysis of the Gault Assemblage stemmed projectile points and the Gower and Uvalde types.
The lanceolate projectile points are still undergoing analysis. Both exhibit to the midline flaking (comedial). One fragment has a collar (small basal trimming flakes) and the other has multiple invasive longitudinal thinning scars. The largest of the two lanceolate points (Fig. 3x) has a snapped fracture at the distal end of the haft which precludes any observations of the blade. Both lateral edges of the stem are smoothed, and the base is deeply concave and smoothed. The base is thinned by the removal of short flakes that create a bevel; the opposite face exhibits a large single flake scar. This projectile point was burinated post-manufacture to create a tool. The second lanceolate point fragment (Fig. 3y) is snapped at the haft and was subsequently burinated at least four times.

These lanceolate points exhibit general traits similar to Barber, Plainview, and St Mary’s Hall point types but the size, morphological, and technological traits on these points, as well as the stratigraphic integrity of Area 15 reveal they stand on their own.

**Projectile point context**
All eleven projectile point specimens were recovered from excavated units within the Gault Assemblage strata 1 and 2. All but one of the units containing the projectile points exhibited signs of post-depositional disturbance or pedo-turbation. The smoky quartz point (Fig. 3g) was recovered from a unit with a krotovina that was identified as starting in that unit and not in the excavation unit above. Pedo-turbation, including rodent burrows and root disturbances were identified and excavated individually in the field. Coupled with the evidence from the Archaic notching flakes which strongly support the overall integrity of the archaeological deposits in Area 15 reveal the projectile points have not moved downward from upper deposits.

**Biface assemblage**
Thirty bifaces and bifacially flaked artifacts, comprised of mostly identifiable fragments, have been recovered (table S4). The reductive technologies used to produce the large bifaces indicates the primary use of comedial flaking to thin and marginal flaking to shape the bifaces and is the same type of reductive technology used to produce the projectile points. The bifacially flaked knife (Fig. 3l) exhibits one or more occurrences of retouch, and clearly demonstrates the use of comedial flaking seen as parallel and parallel-oblique flake scars. Some of the larger bifaces reveal the occasional removal of a full-face flake. At least two bifaces exhibit multidirectional flake scars with no distinctive flake removal patterning (Figs. 3f and 3p).

Three out of the six bifaces pictured show trace evidence related to subsistence tasks, specifically Figs. 3a, 3b, and 3l, which were used for butchering soft tissue. Of note, is the transverse edge of a large distal fragment resulting from a manufacturing failure that was subsequently used to cut soft tissue (Fig. 3b). In addition, microwear analysis revealed that one of the bifaces (Fig. 3l) was hand-held.

The bifaces exhibit morphological inconsistencies, which vary between triangular, subtriangular, ovate, and oblong, as well as irregular. These observations correlate with those made regarding the projectile points and demonstrates consistency in the reduction technologies.
Table S4. Summary counts of the Gault biface assemblage.

| Biface Status           | Count |
|-------------------------|-------|
| Distal fragments        | 6     |
| Medial fragments        | 3     |
| Proximal fragments      | 3     |
| Edge fragments          | 8     |
| Miscellaneous fragments | 4     |
| Complete/Intact         | 6     |
| **Total**               | **30**|
Unifaces
Fourteen specimens have been identified that exhibit unifacial retouch. One piece (Fig. 3n) exhibits usewear indicative of being hand-held and has been sharpened and then resharpened using invasive retouch and was used to cut soft tissue. Seven artifacts have been identified as single beaked gravers, two of which have traces associated with piercing or cutting soft tissue. One is made on a wide, flat thinning flake (Fig. 3o) that has a finely retouched beak. The other piercing tool is considerably less formal because the flake terminated in a way that produced a sharp protrusion (Fig. 3t). A large thinning flake fragment has evidence of being used for multiple tasks such as processing plant materials and butchering activities (Fig. 3r). There is one formal scraper (Fig. 3q) made on a blade, which was used on hard tissue and bone.

Blade-and-core assemblage
There are fifty-three blades represented in this sample. Thirty-six were recovered in fragmentary condition. A proximal blade fragment (Fig. 3v) exhibits wear traces related to butchering soft tissue. One large blade used for butchering tasks has trace wear that indicates it was hand-held (Fig. 3w). A large plunging blade was negative for microwear (Fig. 3m). Platform preparation of these blades prior to detachment indicate the use of faceting, reducing and grinding, but the majority of platforms appear plain, exhibiting only one facet.

At least five abandoned blade cores were also recovered. Four are flat-backed or wedge-shaped (Fig. 3e) and one is conical-like in shape. Most of the blades are longer than the discarded blade cores indicating the cores were originally much larger.

Modified and Utilized Flakes
Fifty-two flakes have been identified as exhibiting intentional modifications or microscopic evidence of implementation. The flakes in the Gault Assemblage tool sample consist of primary, secondary, and tertiary flakes which suggests that no specific flake type was preferred. It is assumed that the flakes with three or more scars and relatively little or no cortex, can be associated with biface reduction or manufacture. Preliminary microwear results reveal that a large secondary flake was hand-held when used to butcher soft tissue (Fig. 3s). The largest flake tool (Fig. 3u) is currently the only specimen used for heavy butchering activities related to animal tendon or bone.

Other Artifacts (not pictured)
Other artifacts that are being actively analyzed include two burins made on flakes and at least ten burin spalls. One of the flake burins was apparently used to work hard plant material. In addition, a small rounded quartzite pebble with possible evidence of battering or pecking as well as a grooved limestone fragment that appears to have been used as a small abrader.

Summary
All artifacts appear to be made from Central Texas and local Edwards chert except for the smoky quartz projectile point and the quartzite pebble.
The highest frequency of tool types occurs on blade and flake blanks. The Gault Assemblage flake tools exhibit formal retouch or have evidence for utilization that identifies them as flake tools based on microscopic analysis. The high number of modified and utilized blades and flakes thus far strongly suggests they were being produced for use as tools, expedient or otherwise. Evidence presented above reveals a substantial reliance on both blade-and-core and biface manufacturing as the preferred medium of producing these tool blanks. This strongly supports the interpretation that the projectile points and the smaller triangular cortical-butted knife were manufactured using these flake blanks (80).

In general, the bifaces and projectile points reveal nothing definitive in their morphological arrangement, and many of the larger bifaces as well as the projectile points discussed here share overall consistency in the reductive techniques. However, it should be noted that the bifaces show little evidence of serial flake removals or systematic reduction techniques. The three small projectile fragments, although reworked, are highly comparable in size, as well as reductive technology, specifically the flaking patterns, smoothing of stems and edges and evidence of haft wear.

To recap, the flaking technology used to produce many of the bifaces and projectile points show the use of comedial flaking (midline) with parallel and parallel-oblique trajectories. The small size of the projectile points indicates that pressure flaking was likely preferred for shaping and retouch. It is also assumed that the larger bifaces were made using direct percussion based on current analysis of flake striking platforms (81), as well as depth and length of flake scars. Flintknapping skills vary and appear to range from expedient to proficient.

A multidisciplinary approach was used in determining these preliminary interpretations. Technological evidence indicates that some of bifaces were manufactured to produce flake blanks based on lack of microwear traces (Figs. 3c, 3d, 3f and 3p). However, retouch and maintenance on some of the bifaces may have eliminated any detectable traces of use wear. Nevertheless, evidence has been found that some of the bifaces were being maintained and used for subsistence activities (Figs. 3a, 3b, 3l). While blades and modified flakes appear to dominate this tool kit, multiple lines of evidence have shown that bifaces were fundamental and an essential part of tool production.

Conclusion
These flaked stone tools were created and used by an undefined hunter-gatherer group(s) of humans who exploited the local chert resources and engaged in multiple subsistence activities in and around the Area 15 locality at the Gault Site. Preliminary analyses and resulting evidence establishes that bifaces, blades, and flakes sustained hunting and foraging activities such as processing meat, hide, and bone (82, 83), as well as rendering plant materials. The Gault Assemblage tools in this sample demonstrate the following: (1) low variability of tool types; (2) the tools are utilitarian in form and function; (3) there appear to be a small number of excessively retouched and exhausted tools (84, 85); (4) most tools appear to be made on-site; (5) no particular morphology appears to dominate
the bifaces or projectile points in this sample, and (6) bifaces were used as butchering tools (80).

The presence of a blade-and-core industry strongly suggests that the blades and blade cores represent the earliest evidence of an early macro-blade technology, which may have continued into the Clovis period. Conversely, the bifaces and projectile points appear unrelated to Clovis technology. Furthermore, the technological traits and features observed in the bifaces and projectile points reveals that they share similar reductive methods seen in the consistent use of comedial flaking and pressure flaking to produce bifacial implements and as such represent a single technology.

The different projectile point morphologies within the Gault assemblage raise a number of important questions concerning the early occupation of the Gault site, and the wider issue of the peopling of the Americas. Were these two styles used concurrently? Did they serve different purposes? Does the Gault Site represent a meeting point between two different early groups, or the adaptive behavioral practices of a single group? These questions are beyond the scope of this paper but it is clear that the OSL age estimates and archaeological assemblage from the Gault Site contribute significant new data to the early archaeological record.

In conclusion, based on the OSL evidence, stratigraphic integrity, and technological analysis presented in this publication it is clear that there is a unique human occupational signature present in North America prior to ~16-thousand years ago.