**SHAPE AS A FUNCTION OF RAW MATERIAL + CONTEXT?**

**A PRELIMINARY ANALYSIS OF PERDIZ ARROW POINT MORPHOLOGY FROM THE SOUTHERN CADDO AREA**

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*It is generally assumed that raw material differences articulate with stone tool morphology, and the role of differential raw material quality and preference in Caddo lithic technology has not been fully explored.*

The assumption is that the ability to execute formal technological designs is severely limited by the quality of the raw material. Toolkits based on high quality raw materials are thought to be easier to design because fracture is easier to control ([Goodyear 1989:3](#_ENREF_22); [Luedtke 1992](#_ENREF_31)). In contrast, toolkits based on poor quality raw material are more difficult to design because fracture is unpredictable and results in severe, irreparable errors during reduction. Even where low raw material abundance would encourage formal technological design, raw material quality is thought to be the overriding factor constraining lithic technological organization ([Brantingham, et al. 2000:257](#_ENREF_8)).

East Texas geologic formations are poor in lithic raw materials ([Banks 1990:Figure 2.1](#_ENREF_3)), or at least knappable lithic materials. Consequently, lithic materials suitable for the manufacture of Perdiz arrow points would have been a carefully conserved resource for the sedentary aboriginal Caddo populations that lived in East Texas. In the general region, only the Pisgah Ridge chert in the Trinity River basin, Manning fused glass in the Manning Formation (part of the Jackson group of Eocene age), and various cherts and quartzites in the Catahoula Formation (exposed in the Neches River basin) are in “geological formations that contain in situ rocks suitable for the manufacture of stone tools” ([Banks 1990:49](#_ENREF_3)). There are also upland stream gravels that are relatively widespread in parts of East Texas ([Banks 1990:56-57](#_ENREF_3)). High quality and knappable cobbles of chert, novaculite, and quartzite are present in the Red River gravels in northeastern Texas, to include the Bowie gravels in the Red-Sulphur River interfluve, per [Cliff, et al. (1996)](#_ENREF_10), which derive from chert-bearing formations in the Ouachita Mountains of southeastern Oklahoma ([Banks 1990:Figure 1.20](#_ENREF_3)).

In the study of lithic raw material sources in the Neches-Angelina river basin by [Girard (1995:69)](#_ENREF_20), he notes that there are redeposited gravels on stream terraces that contain small cobbles and pebbles of petrified wood, fine-grained quartzite, and various cherts. The local cherts tend to be red, gray, tan, and brown in color ([Girard 1995:66](#_ENREF_20)). Non-local cherts found on sites in the Neches and Angelina river basins are apparently from Central Texas Edwards Plateau sources, and these are lustrous gray, blue-gray, and dark brown in color.

Local lithic raw materials include coarse- and fine-grained quartzite, petrified or silicifed wood, ferruginous sandstone, jasper, and several varieties of earth-toned cherts: yellowish-brown, gray, red, light brown, brown, greenish-brown, and a reddish-brown color. Non-local raw materials are white and red novaculite, black chert, dark gray chert, white chert, bluish-gray chert, a yellowish-red chert, and quartz. A distinctive coarse-grained quartzite (or metaquartzite) may occur in this general area, though it probably is restricted to localized sources. The material is described by [Girard (1995:67)](#_ENREF_20) as being of sugary coarse-grained texture and light gray to yellowish-brown in color, and may originate in the Glover Sandstone (part of the basal Sparta Sand Formation) in northeastern Houston County ([Girard 1995:69](#_ENREF_20)). A quarry (41VN39) of grayish-white quartzite is known in the Sabine River basin in Van Zandt County, and has been noted to turn pink when heat-treated ([Malone 1972](#_ENREF_32)).

The most likely contributing source(s) of non-local cherts used for the manufacture of Perdiz arrow points in northeast and east Texas are those from various Edwards Formation localities in central Texas ([Banks 1990](#_ENREF_3); [T. K. Perttula 1984](#_ENREF_36)). These resources occur in a region that encompasses the Edwards Plateau and the southern Llano Estacado and occur in both massive ledge and cobble varieties. These materials also occur as significant gravel sources along the Colorado and Brazos River Valleys but may also occur as reworked and lagged members of Uvalde Gravel deposits.

*Shape, raw material, and human behavior*

Perdiz arrow points ([Suhm and Jelks 1962:283 and Plate 142](#_ENREF_60); [Suhm, et al. 1954:504 and Plate 131](#_ENREF_61)) occur across most of Texas from the Rio Grande eastward to the Neches River basin, and from the Red River (Texas and Oklahoma) south to the eastern and central parts of the Gulf coast, and have been noted to include more variation in size and proportions than most arrow point types in Texas. In outline, Perdiz arrow points have a “[t]riangular blade with edges usually quite straight but sometimes slightly convex or concave. Shoulders sometimes at right angles to stem but usually well barbed. Stem contracted, often quite sharp at base, but may be somewhat rounded. Occasionally, specimen may be worked on one face only or mainly on one face…Workmanship generally good, sometimes exceedingly fine with minutely serrated blade edges” ([Suhm, et al. 1954:504](#_ENREF_61)).

Perdiz arrow points fall within what [Bleed (1986:738-741)](#_ENREF_4) referred to as a maintainable tool; however, unlike dart points, morphological attributes of arrow points—generally small and thin—somewhat limit discussions of optimization related to planned breakage caused by impact ([Flenniken 1985](#_ENREF_16); [Flenniken and Raymond 1986](#_ENREF_18)), providing for differing expressions of maintainability ([Ahler and Geib 2000](#_ENREF_1)). The anticipated exploitation of raw material resources, coupled with perceived technological advantages using heat treatment ([Flenniken and Garrison 1975](#_ENREF_17)), may have resulted in longer and larger flakes (and more of them), provided that the temperature of the stone reached the requisite temperature ([Bleed and Meier 1980](#_ENREF_5)). Thermal properties of locally-available raw materials remain ill-understood in the southern Caddo area, and it is unclear whether Caddo knappers regularly enlisted an expedient ([Domanski and Webb 2007](#_ENREF_12); [Gregg and Grybush 1976](#_ENREF_23)), slow and steady ([Mercieca and Hiscock 2007](#_ENREF_33)), or a hybrid approach to heat treatment.

Inferences about human behavior drawn from stone tool raw material source use patterns are predicated on accurate knowledge of the locations of lithic sources actually used ([Ambrose 2006:365](#_ENREF_2)).

PERDIZ ARROW POINT SAMPLE

The Perdiz sample is from Camp, Harrison, Nacogdoches, San Augustine, Smith, and Shelby counties, and consists of whole/intact Perdiz arrow points from 10 sites across the southern Caddo area, manufactured using chert, quartzite, and silicified wood (Figure int1:a). Raw material distributions differ among sites, where chert is less geographically restricted, and quartzite was limited to sites in Camp County (Figure int1:a). Silicified wood was employed for Perdiz manufacture in Nacogdoches and Shelby Counties; however, Washington Square Mound (41NA49) represents the only burial context where silicified wood Perdiz points were recovered (Figure int1:a). While the full range of raw materials were used in Caddo burials, only chert and silicified wood points were found to occur outside of burial contexts (Figure int1:b). Raw materials also differ through the Middle, Late, and Historic Caddo periods, where chert and silicified wood are present throughout all three periods; while quartzite occurs only in Middle Caddo mortuary contexts (Figure int1:c). Radiocarbon and relative dates are discussed in more detail below; however, the median of that temporal range was used to assign the Perdiz points to a representative temporal period (Middle Caddo, A.D. 1200-1450; Late Caddo, A.D. 1450-1680; and Historic Caddo, A.D. 1680+) (Figure int1:d).



Figure int1. Raw materials a, by site; b, by mortuary context; c, by temporal period (Middle, Late, or Historic Caddo), and d, Temporal span of contexts in the Perdiz sample. *Double click image to view in full resolution.*

*41CP5, Tuck Carpenter Site*

The Tuck Carpenter site is a well-studied Late Caddo period Titus phase cemetery on Dry Creek in the Big Cypress Creek basin, and was occupied by the Caddo from the 15th to the 17th century A.D. Burials with Perdiz points are the earliest in the cemetery, and likely date from A.D. 1430-1500 ([Timothy K. Perttula, et al. 2017:197](#_ENREF_44)). A single radiocarbon date was obtained from Burial 10: 360 + 60 B.P. The calibrated age range at 2 sigma is A.D. 1442-1646, with a median probability of A.D. 1546 (using INTCal 20 and Calib 8.20).

Fifty seven Perdiz points have been recovered from burial features at the Tuck Carpenter site ([Timothy K. Perttula 2009](#_ENREF_37); [Turner 1978](#_ENREF_62), [1992](#_ENREF_63)). A second collection from the site includes an additional 18 Perdiz points from 13 of the burial features made from Ogallala quartzite and local chert gravel sources; including one that was made from a non-local novaculite ([Timothy K. Perttula, et al. 2017:Table 2](#_ENREF_44)).

*41CP12, Johns Site*

The Johns site is a Titus phase cemetery in the Prairie Creek valley in the Big Cypress Creek basin. No radiocarbon dates have been obtained from the site, but the decorative motifs associated with the ceramic vessels recovered from burials suggest that the cemetery was used from A.D. 1430-1600 ([Timothy K. Perttula, Walters, et al. 2010b](#_ENREF_42)). Forty-eight Perdiz points were recovered from 16 burial features. They were made from local chert, quartzite, and petrified gravel sources (87 percent), non-local sources (10.8 percent, mainly from Red River gravels), and chalcedony (2.2 percent).

*41CP20, B. J. Horton Site*

This ancestral Caddo cemetery in the Big Cypress Creek basin includes at least 19 burials, from which two Perdiz points were recovered ([Timothy K. Perttula, Walters, et al. 2010a:9](#_ENREF_41)). Use of the cemetery by the Caddo occurred primarily between A.D. 1500-1550 ([Timothy K. Perttula and Miller 2014:494](#_ENREF_40)).

*41HS15, Pine Tree Mound Site*

The Pine Tree Mound site is a large Titus phase mound center with associated habitation deposits, family cemeteries, and a large community cemetery ([Fields and Gadus 2012](#_ENREF_15)). Perdiz arrow points (n = 68) represent 53 percent of the arrow points that could be typed from the site, most (n = 50) from burial contexts and the remainder from habitation deposits. Perdiz points from burial contexts tend to have been made from non-local lithic raw materials, typically chert (42 percent), while none of the non-mortuary Perdiz points are made on non-local raw material ([Fields and Gadus 2012:566](#_ENREF_15)) (Fields and Gadus 2012:566).

There are 92 radiocarbon dates available from the Pine Tree Mound site ([Fields and Gadus 2012:Table 4.13](#_ENREF_15); [Selden Jr. and Perttula 2013:Table 2](#_ENREF_56)). Most of the calibrated dates fall between A.D. 1451-1495 and A.D. 1397-1429 ([Selden Jr. and Perttula 2013:Table 3](#_ENREF_56)), but calibrated age ranges suggest that the settlement “was established in the A.D. 1300s and persisted until at least the mid 1600s” ([Fields and Gadus 2012:299](#_ENREF_15)).

*41NA49, Washington Square Mound Site*

The Washington Square Mound site is located in the Angelina River basin and is a mound center with associated habitation deposits and a cemetery. Excavations in one mound uncovered two shaft tombs with abundant grave goods, but no Perdiz offerings ([Corbin and Hart 1998](#_ENREF_11); [Timothy K. Perttula, Walters, Nelson, et al. 2010](#_ENREF_43)). However, 14 Perdiz points were recovered from a burial feature in the Oak Grove Cemetery portion of the Washington Square Mound site ([Timothy K. Perttula, Walters, Nelson, et al. 2010:Figure 77](#_ENREF_43)). Another seven Perdiz points came from habitation areas near the main burial mound ([Timothy K. Perttula 2009:Table 14](#_ENREF_37)). Of those, 71 percent are on gray chert of likely central Texas origin, and the remainder were made from local quartzite.

Twelve radiocarbon dates have been obtained from the Washington Square Mound site ([Corbin and Hart 1998:Table 4](#_ENREF_11); [Selden Jr. and Perttula 2013](#_ENREF_56)), indicating use of the site in both Early (A.D. 900-1200) and Middle Caddo periods. The best dates that can be associated with Perdiz points at the site range from cal. A.D. 1238-1445.

*41NA206, Spradley Site*

The Spradley site includes late 17th to early 18th century archeological deposits with European trade goods from habitation deposits in the Bayou La Nana valley in the Angelina River basin ([Timothy K. Perttula and Marceaux 2018](#_ENREF_39)). Those habitation deposits, which have no associated radiocarbon dates, contain numerous Perdiz points (n = 31). Approximately 94 percent were manufactured from local silicified wood, quartzite, and gravel cherts, and the remainder are from non-local brownish-gray to translucent gray chert, likely from central Texas raw material sources ([Timothy K. Perttula and Marceaux 2018:Table 7](#_ENREF_39)).

*41SA135, Jack Walton Site*

This site is located on Attoyac Bayou ([Middlebrook 2010](#_ENREF_34)), and is an ancestral Caddo site with habitation deposits of likely Middle Caddo period age (A.D. 1200-1400). There are no radiocarbon dates from the site. Excavations at the site recovered seven Perdiz points.

*41SM193, Redwine*

The Redwine site (41SM193) site is a Middle Caddo period component located 22 km from the river on a north-flowing tributary (Auburn Creek) of the Sabine River ([Walters and Haskins 1998](#_ENREF_65)), which includes habitation deposits and a small cemetery. The site has one calibrated date of A.D. 1300-1454, at 2 sigma, with a median calibrated probability of A.D. 1356. The 11 Perdiz points from habitation deposits were manufactured on black, brown, and grayish-tan chert as well as Ogallala quartzite ([Walters and Haskins 1998:14](#_ENREF_65)). An additional 13 Perdiz arrow points were among the grave goods recovered from two burial features ([Walters and Haskins 1998:35](#_ENREF_65)).

*41SY43, Old Timers Site*

The Old Timers site is located in the Sabine River basin, and includes post-A.D. 1400 Late Caddo habitation deposits concentrated in the northern area of the site. Excavations recovered eight Perdiz points, all with serrated blades and made from cherts, 75 percent local gravel cherts, and an additional 25 percent of gray cherts from non-local raw material sources ([Timothy K. Perttula 2018:77](#_ENREF_38)).

*41SY280, Syb’s Site*

This ancestral Caddo site of the Late Caddo Salt Lick phase is located along the Toledo Bend Reservoir, west of the now inundated Sabine River floodplain ([Timothy K. Perttula 2018:Figure 55](#_ENREF_38)). It has a number of habitation clusters that include daub and fired clay from areas of burned ancestral Caddo house structures. There are no radiocarbon dates from the site, but the decorated ceramic vessel sherds in the collection areas suggest that the site relatively dates to a period beginning at A.D. 1400 through the late A.D. 1500s. One Perdiz arrow point was recovered from Area 13 of the site ([Timothy K. Perttula 2018:Table 33](#_ENREF_38)).

METHODS AND RESULTS

*Chi-squared*

*Elliptical Fourier Analysis*

Two-dimensional (2D) images of the Perdiz arrow points were collected at a 600dpi resolution to produce uncompressed tiff files. Images were masked in Adobe Photoshop 2020 (v. 21.2.3), exported as jpegs, then imported to R ([R Core Development Team 2020](#_ENREF_45)), where the Momocs package was used for the subsequent elliptical Fourier analysis (EFA) ([Bonhomme, et al. 2014](#_ENREF_7)). EFA is a common tool for analyses of stone tool shape ([Gero and Mazzullo 1984](#_ENREF_19); [Ioviţă 2009](#_ENREF_26), [2010](#_ENREF_27); [Ioviţă and McPherron 2011](#_ENREF_28); [Ioviţă, et al. 2017](#_ENREF_29); [Ivanovaitė, et al. 2019](#_ENREF_30); [Saragusti, et al. 2005](#_ENREF_47); [Serwatka 2015](#_ENREF_59)), and provides visualizations that can contribute meaningfully to traditional descriptions, as well as linear and/or orthogonal metrics. The outline of each projectile was retained, all specimens were normalized to a common centroid, then rescaled using centroid size ([Bonhomme, et al. 2017](#_ENREF_6)). The *calibrate harmonic power* function was used to identify the number of harmonics necessary to capture Perdiz point shape ([Bonhomme, et al. 2014](#_ENREF_7)), and 11 harmonics were retained to achieve 99 percent harmonic power.

An exploratory measure (EFA-PCA) was employed to assess variability among the raw materials (Figure gm1). The primary differences among PC1 occur most notably in blade width, while differences in PC2 relate most readily to stem length. This can be seen in the graph where a broader blade with a long stem occurs at the top right, and a narrower blade with a shorter stem at bottom left.



Figure gm1. EFA-PCA for Perdiz points by temporal period (Middle Caddo [MC], Late Caddo [LC] and Historic Caddo {HC]), mortuary context (Mortuary [M] and Not [N]), and raw material (chert [C], jasper [J], quartzite [Q], and silicified wood [S]). *Double click image to view in full resolution.*



Figure gm3. Comparison of mean shapes by temporal period (Middle Caddo [MC], Late Caddo [LC] and Historic Caddo {HC]), mortuary context (Mortuary [M] and Not [N]), and raw material (chert [C], jasper [J], quartzite [Q], and silicified wood [S]). *Double click image to view in full resolution.*

DISCUSSION

Recent morphological analyses of Caddo bottles and Gahagan bifaces have yielded new insights related to both Caddo ceramic and lithic production, as well as the identification of a previously unrecognized shape boundary that occurs in the southern Caddo area ([Selden Jr. 2017](#_ENREF_49), [2018a](#_ENREF_50), [2018b](#_ENREF_51), [2019](#_ENREF_52), [2021a](#_ENREF_53), [2021b](#_ENREF_54); [Selden Jr., et al. 2020](#_ENREF_55); [Selden Jr., et al. 2014](#_ENREF_57); [Selden, et al. 2018](#_ENREF_58)). This effort expands that research program to include morphological analyses of arrow points, and the working hypotheses employed in this study were derived from a series of ongoing exploratory network analyses that employ Caddo ceramic and lithic types ([Selden Jr. 2021a](#_ENREF_53)).

To test the hypothesis that Perdiz arrow point shape differs by raw material type, Perdiz arrow points from 10 Caddo sites were aggregated for a study of two-dimensional geometric morphometrics. Results demonstrate significant differences in Perdiz arrow point shape among the raw materials. Those points made from chert differ significantly from those made from jasper, quartzite, and silicified wood, and points made from silicified wood differ from chert, jasper, and quartzite. However, Perdiz points made from jasper and quartzite do not differ significantly in shape. Additional tests were run to assess whether Perdiz shape differs by site and mortuary context. Results demonstrate some significant morphological differences by site, providing additional information regarding potential geographic constraints. There was also a significant morphological difference between those Perdiz points that have been recovered in and out of mortuary contexts.

CONCLUSION

Reading:

* Discussion of what attributes influence lithic artefact form ([Eren, et al. 2011](#_ENREF_13))
* Fracture predictability and durability ([Braun, et al. 2009](#_ENREF_9))
* Raw material quality ([Brantingham, et al. 2000](#_ENREF_8))
* Role of raw material differences in shape variation ([Eren, et al. 2014](#_ENREF_14))
* Raw material selectivity ([Goldman-Neuman and Hovers 2012](#_ENREF_21))
* Flake shape ([Gurtov, et al. 2015](#_ENREF_24))
* Reduction continuums ([Hiscock and Attenbrow 2005](#_ENREF_25))
* Mental templates/mechanics ([Monnier 2007](#_ENREF_35))
* Style ([Sackett 1982](#_ENREF_46))
* Manufacturing traditions ([Schillinger, et al. 2016](#_ENREF_48))
* Expedient behavior ([Vaquero and Romagnoli 2017](#_ENREF_64))
* Raw material selection + gravity model ([Wilson 2007](#_ENREF_66))

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DATA MANAGEMENT

Data and analysis code associated with this study can be accessed through the GitHub repository (<https://aksel-blaise.github.io/perdiz>), which is digitally curated on the Open Science Framework (OSF) DOI 10.17605/OSF.IO/DEJ74. All scan data (unprocessed and processed) are embargoed for a period of five years from the date of the last manuscript submission that employs them. The unprocessed scan data were uploaded to the OSF, where the preprint of this paper and all supplementary materials have been made available.

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