

# CHARACTERISTICS AND GENESIS OF EL SAUZ CHERT, AN IMPORTANT PREHISTORIC LITHIC RESOURCE IN SOUTH TEXAS

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*Stone tools ranging in age from Early Archaic (3500–6000 B.C.) to Late Prehistoric (A.D. 700 to historic times), made of a distinctive light gray but sometimes colorful chert, have been identified in private collections in south Texas for at least 50 years. The source of this stone, known in the archeological literature as “El Sauz chert,” are two small bedrock outcrops in Starr County associated with altered rhyolitic ash of the Catahoula Formation. Physical characteristics, field evidence and major element chemical composition are used to infer an in situ origin of the chert associated with the devitrification of the volcanic ash and the remobilization of silica by ground and meteoric water. Distinctive characteristics of El Sauz chert include abundant vugs, opalized veins, smeared colorations, high aluminum content, and pale yellowish-green fluorescence under short-wave ultraviolet light. These geologically distinctive characteristics distinguish this material from other cherts and, as a result, have important implications for archaeologists interested in prehistoric exchange and resource procurement.*

KEYWORDS: *Catahoula Formation, chert chemistry, stone artifacts, silicification, Starr County, Lower Rio Grande Valley*

## INTRODUCTION

Chert, a sedimentary rock composed largely of silica, was the lithic resource most frequently used by stone-tool makers along the lower Rio Grande in south Texas and northern Mexico. Chert-dominated gravels are abundant in this large area. They are found accumulated as bed-load sediments and in fluvial terraces of the Rio Grande. They are also found in two formations — the Pliocene Goliad Formation and the Pleistocene Uvalde Gravels (Turner et al. 2011) — that contain thick gravel beds and occur across a large area of the surface geology in south Texas. Collectors of projectile points in lithic-poor areas of eastern Starr County and western Hidalgo County in Texas and in the Mexican states of Nuevo Leon and Tamaulipas noted, over 50 years ago, a distinctive light gray, but sometimes colorful variety of high quality chert that was not found in the local gravels. This lithic resource, dubbed by Mallouf in Banks (1990) as “El Sauz chert” was extensively used by stone-tool makers. Kumpe and Kryzwonski (2009) report that artifacts made of El Sauz range in age from Early Archaic (3500–6000 B.C.),

Hidalgo points, to Late Prehistoric (A.D. 700 to historic times), Caracara points, suggesting that native populations used this special lithic material to manufacture tools over a long period of time (see Turner et al. 2011, for description of Hidalgo and Caracara points).

Little is known about El Sauz chert, its mode of formation, or its chemical makeup. Mallouf and Tunnell (1978) postulated that the chert was initially an intrusive dike of bentonitic clay that was replaced with precipitated veins of opal and chalcedony after the silica necessary for opalization of the clay was dissolved from surrounding volcanic glass by ground water. They suggest that it probably originated within the volcanic ash in the Catahoula Formation. Two bedrock outcrops, which served as quarries of El Sauz chert have been reported in Starr County (Kumpe and Kryzwonski 2009). Our observations at these two bedrock outcrops indicate that El Sauz chert formed *in situ* in a terrestrial setting. Traditionally, chert occurrences are designated as bedded or nodular. Bedded chert is commonly found in oceanic and volcanically influenced environments, while nodular chert results from placement of existing rocks,

typically carbonates and evaporites (Pollock 1987). Other than bedded or nodular origins, chert formation in terrestrial settings is rare and poorly understood (Weis and Wasserburg 1987).

This study was conducted to provide an accurate interpretation of the geologic setting where El Sauz chert occurs and to determine its chemical composition. We present the first compositional analyses of major elements for a suite of samples representative of most of its textures and colors. These analyses, combined with field observations allow us to formulate a model for the origin of this source-restricted lithic resource and provide five distinct criteria for its recognition. This work has implications for archaeologists studying pre-historic exchange and procurement strategies in

the Lower Rio Grande region of south Texas and northern Mexico.

#### EL SAUZ CHERT

El Sauz is a mineralogically homogeneous and very fine-grained chert predominantly composed of micro- to crypto-crystalline quartz ( $< \sim 0.1 \mu\text{m}$ ). This chert is easily distinguished from other cherts because of its peculiar colorations and the consistent presence of vugs and veins. The bulk of El Sauz chert is light to medium gray. Approximately 10 percent of the samples, however, exhibit a wide range of coloration including pink, red, yellow, orange, purple, green and caramel which all occur as mottles, irregularly shaped patches and smeared-out colorations rather than solid colors. The gray shades are the most common and possess the best flaking properties (Figure 1). The colorful varieties are probably overrepresented in collections because they are more attractive. Luster of El Sauz chert ranges from dull to waxy to vitreous. The chert appears waxy on freshly broken surfaces and vitreous on older broken surfaces of the same worked piece. In flakes, cobbles, and boulders found at the two outcrops, the chert is dense and massive and lacks fossils, bedding, stratification, jointing or any current-generated structures. Its most noticeable characteristic is that it contains a variable amount of vugs, that is voids, pits, or cavities, ranging from millimeter to fist size, some of which are partially or completely filled with botryoidal, banded chalcedony; more commonly the vugs contain white opal with small clear to brownish quartz crystals. Very small vugs with the white opal and brownish quartz are often seen in finished artifacts made of El Sauz chert. Centimeter-thick, white, opal-filled veins are common in cobble and larger size pieces. Patches of the rock can exhibit a brecciated texture that appears to result from a network of  $< 1$ -millimeter thin veins surrounding 3–10 mm size chunks of angular chert.



FIGURE 1. Stone artifacts manufactured from El Sauz chert found in Hidalgo and Starr Counties, and the Mexican States of Tamaulipas and Nuevo Leon. The smeared coloration patterns and small vugs are diagnostic features of the chert. (A) preform broken in manufacture; (B) distal end of a dart point, a vug perforates this specimen; (C) proximal end of a Hidalgo point; (D and J) preforms; (E) Langtry point; (F, K and O) Matamoros points; (G) Cameron point; (H) a quarry blank; (I) reworked beveled triangular point; (L) beveled asymmetrical point; (M), biface scraper; (N) Hidalgo point broken along a vug; (P) beveled triangular point; (Q) Caracara point; (R) Hidalgo point with large vug at center. Typology from Turner et al. (2011).

#### BEDROCK OUTCROPS AND QUARRIES

Sixteen kilometers north of Rio Grande City, in an area characterized by low and gentle topography located within the Olmos Creek watershed, two small mounds  $\sim 30$  m in diameter stand out  $\sim 15$  m above the surrounding low-relief terrain (Figure 2). The two hills are 1.4 km apart, and are capped by massive 5 to 7 m thick chert deposits. At both sites the chert grades downward into a white to pale brown, calcite-cemented tuffaceous

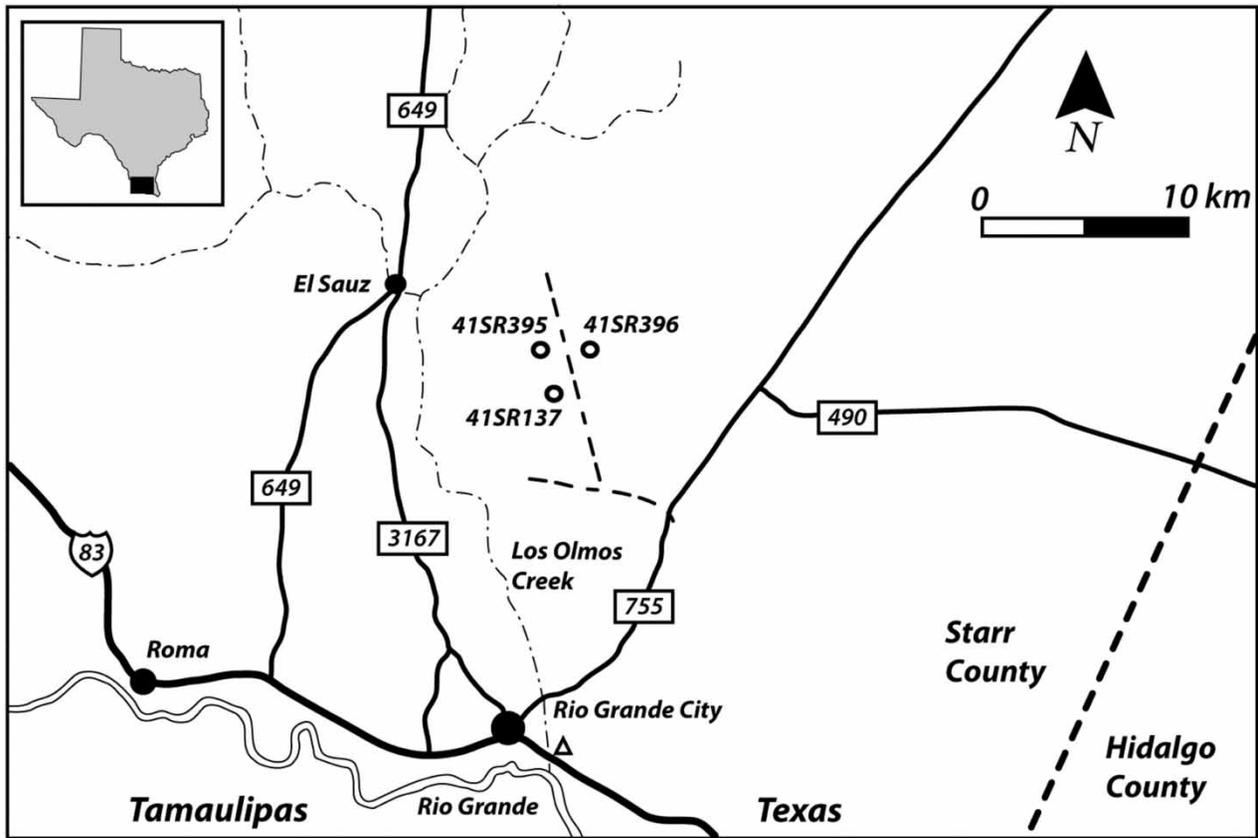


FIGURE 2. Map of the Lower Rio Grande Valley in Starr County. Open circles indicate the location of the El Sauz chert outcrops and paleoquarries and the nearby archeological site. Triangle denotes the location of the ash outcrop in Figure 4. Other sites mentioned in text are shown.

sandstone with varying degrees of induration. The top and the slopes of both hills are littered with poorly sorted lithic debris including flakes, cores, shatter and quarry blanks that completely cover



FIGURE 3. Boulder of El Sauz chert at paleoquarry 41SR395. Note large vug in the boulder and initial reduction debris littering the ground. Hammerstones in the foreground are fine-grained syenite, likely transported from the Big Bend area.

the bedrock. The slopes also have large boulders including some with a diameter of 1 m weighing over a ton and smaller talus blocks that may have been detached by quarrying activities.

Kumpe and Kryzwonski (2009) report the occurrence of large quantities of debitage and numerous artifacts of a lithic material indistinguishable from El Sauz chert in northeastern Nuevo Leon, Mexico. This suggests the possibility that other outcrops may be found on the Mexican side of the Rio Grande. In Texas, McBride et al. (1968) point out that there are more than 50 scattered siliceous hills or knobs to the north of Starr County, all along the path of the Catahoula Formation.

The quarry sites are identified as 41SR395 and 41SR396 by the Texas Archeological Research Lab (Figure 2). Approximately 2 km south of the quarries is a site with clear evidence of long-term human occupation (41SR137). At this site, the ground is covered with a high density of debitage with burned rock scattered and accumulations of land snail shells (*Rabdotus* sp.). Hester (1980)



FIGURE 4. Catahoula ash exposed east of Rio Grande City in Starr County. The ash outcrop is 15 m thick. The lack of internal discontinuity surfaces or layers suggest deposition occurred from an air fall in a geologic short time. The ash is capped with a gravel deposit that marks an ~25 million year unconformity, not visible in the picture. This unconformity suggest the deposit might have been originally thicker; the dark top 3 m is due to weathering.

points out that prehistoric occupation sites in south Texas often contain clusters of land snails, gathered as dietary supplement. These coupled with numerous hammerstones (Figure 3) made from volcanic rocks likely originally from the Big Bend area and possibly abraders, imply that these quarries were a sought out destination, and that the stone was not simply gathered from loose surface material.

## REGIONAL GEOLOGY

The two outcrops of El Sauz chert occur within (or immediately above) the Oligocene/Miocene Catahoula Formation. The Catahoula extends northeasterly from Rio Grande City, across southern and eastern Texas and continues into Louisiana. Throughout Texas the formation is regarded as a dominantly to partially volcanoclastic unit consisting of poorly sorted siltstone, sandstone, and mudstone (Ledger 1988). Catahoula deposition was characterized by intermittent influxes of rhyolitic air-fall ash into low-gradient fluvial and coastal lake environments (Galloway 1977). The volcanic material was likely derived from a western source, most probably from Trans-Pecos Texas and northern Mexico, these being the closest sources of appropriate age and chemical affinity (Ledger 1988). Delivery of ash was perhaps sporadic, but a 10–20 m thick outcrop of ash, 20 km south of the study area, formed apparently by uninterrupted deposition suggests that

sometimes massive ash falls occurred (Figures 2 and 4). Near the chert outcrops the ash is reworked into a light gray to pale brown tuffaceous sandstone with a large portion of calcite cement that is easily recognized in satellite imagery by its distinctive light color and high albedo or reflective nature.

Galloway's (1977) report on the analysis of the clay mineral in the Catahoula Formation in the southern and central coastal plain concludes it is composed of calcium-sodium montmorillonite. He interprets the general absence of illite and chlorite as an indication that clays in the Catahoula were derived primarily from the breakdown of Catahoula volcanic ash, rather than from reworking of older Tertiary, Cretaceous or Paleozoic strata. The Catahoula is a uranium-bearing unit, and the volcanic ash is the presumed source of the uranium deposits in the Texas Coastal Plain (Eargle et al. 1975; Galloway 1977).

## SAMPLE ANALYSIS

To characterize El Sauz chert, we performed several types of analysis on a variety of samples, including unworked chert representative of both of the outcrops, partially worked pieces, and finished tools. Techniques included X-ray diffraction (XRD) for mineralogical determination, and scanning electron microscopy with an energy dispersive X-ray detector system (SEM-EDS) for 10–100X images and determination of major element concentrations. Additionally, the fluorescence response of the chert to ultraviolet light was tested on one hundred samples of the stone.

### MINERALOGY BY X-RAY DIFFRACTION (XRD)

XRD analysis was performed by standard methods. Small pieces of samples were hand ground in ethanol in a 25 mm alumina mortar, poured onto glass slides, and air dried for analysis. We also obtained diffraction patterns from 15 mm<sup>2</sup> on fairly flat, smooth, raw chert surfaces where the primary X-rays sampled a 1 × 15 mm area. The instrument used is a Bruker D8 system using Cu K-alpha radiation. Phases were identified in the diffraction patterns using the search/match routine in Bruker's EVA software and the ICDD Powder Diffraction File minerals database.

El Sauz chert is mineralogically homogeneous, and is overwhelmingly dominated by cryptocrystalline quartz. The only mineral phase found regularly, in addition to quartz, was variable amounts of opal-A together with the quartz in thin to wide white veins and in the small to large vugs described

above. Even in the veins and vugs, the opal-A is always much less abundant than the well-crystallized quartz. The typical microcrystalline quartz grain size of ground and unground chert is estimated to be  $< \sim 0.1$  micron based on a  $\sim 20$  percent peak broadening (at FWHM) compared to coarsely crystallized quartz prepared in the same manner. As expected the opal-A diffraction peaks are considerably much broader than the microcrystalline quartz as a result of the opal's very poor crystallinity. Definite diffraction peaks attributable to clays were not found in any typical El Sauz chert samples.

One interesting variation was found in a few cobbles and larger pieces down slope south of quarry 41SR395. This rather uniform looking waxy brownish gray "chert" can be broken easily with finger pressure; this easy fracturing is due to a network of micro-fractures at all observable size scales. Bulk volume changes during wholesale alteration of chert to opal plus clay probably resulted in the intense incipient fracturing of this rare type. Such material could not be used for tool making, and would not endure natural transport any significant distance from the bedrock source. XRD analysis of sample ESC-51 shows this type is dominantly composed of opal-A with  $< 30$  percent quartz and clay. This is the only opal-dominated material we found.

#### SEM-EDS IMAGES AND MAJOR ELEMENT CONCENTRATIONS

SEM-EDS is a convenient semi-quantitative technique that does not require sample preparation. A Zeiss LS 10 system that can detect elements from carbon through uranium was used for characterizing the chemical composition of the chert. The detection limit of the SEM under the analytical conditions and integration time used is about 0.1–0.5 percent by weight for most elements. Nineteen samples representing the range of colors and textures from a large collection of hand specimens acquired from the outcrops were selected for analysis. Prior to the analysis, the samples were broken into smaller pieces to expose fresh, flat surfaces that were not coated prior to placing them in the SEM-EDS system's sample chamber. After an initial survey using electron beam energies of 10 and 20, 6.5 keV was used for imaging and elemental analysis to reduce sample charging effects.

For each sample at least two measurements were performed, first by positioning the electron beam

at a point, and then by rastering the beam over an area, typically a 10–100 micron square adjacent to the first measurement. Most images were recorded at  $\sim 100$  times magnification. Repeated measurements were performed on two samples with unusual coloration patterns (ESC-20 and ESC-27). A Late Prehistoric (A.D. 1200–700) Cameron projectile point (17 × 12 × 4 mm) found by the senior author in central Hidalgo County, 70 km east of the El Sauz chert outcrops, with all the textural and color characteristics of El Sauz chert, was also analyzed at nine spots. At eight of the spots the aluminum content varied between 2.5 and 4.7 weight percent; the ninth spot gave a value of 10 percent. The major element concentration results for all other samples are summarized in Table 1 where values represent the average of the multiple measurements on each.

The conversion of measured X-ray intensities to weight percent was done with the "standardless" routine provided by Zeiss. As oxygen and silicon X-rays are easily detected by our EDS system, and dominate the chert composition (quartz or silicon dioxide-  $\text{SiO}_2$ ) and the acquired EDS spectra, the assumption of a 100 percent total made by the computations is justifiable. Fifteen of our 19 samples had 95 percent or higher Si + O contents, including four samples that were found to be 100 percent Si + O. Some verification of the quality of the "standardless" quantitative calculation is obtained by converting the essentially pure Si + O samples' weight percent results to atom percent; this calculation produces an Si/O ratio close to the expected 1/2 ratio of quartz. Aluminum abundance is the defining chemical characteristic of El Sauz chert. This element was detected in all samples except those with 100 percent Si + O. Aluminum values are as high as 10 percent by weight; the average is 4 percent (Figure 5, Table 1).

Iron was measured in two samples with contents as high as 9 percent, magnesium in three samples with values of 1–2 percent, and one sample had 5 percent zinc (Table 1). All other elements were below detection limits in all samples. Two of the samples analyzed, ESC-20-c and ESC-23, have low Si + O values, 79 and 56 percent, respectively. In ESC-20-c the low Si + O total is due to the presence of 9 percent iron, and 10 percent aluminum. ESC-23 contains 33 weight percent calcium and 11 percent sulfur, and is the only sample measured with detectable amounts of these two elements; we suspect the calcium and sulfur are due to the presence of

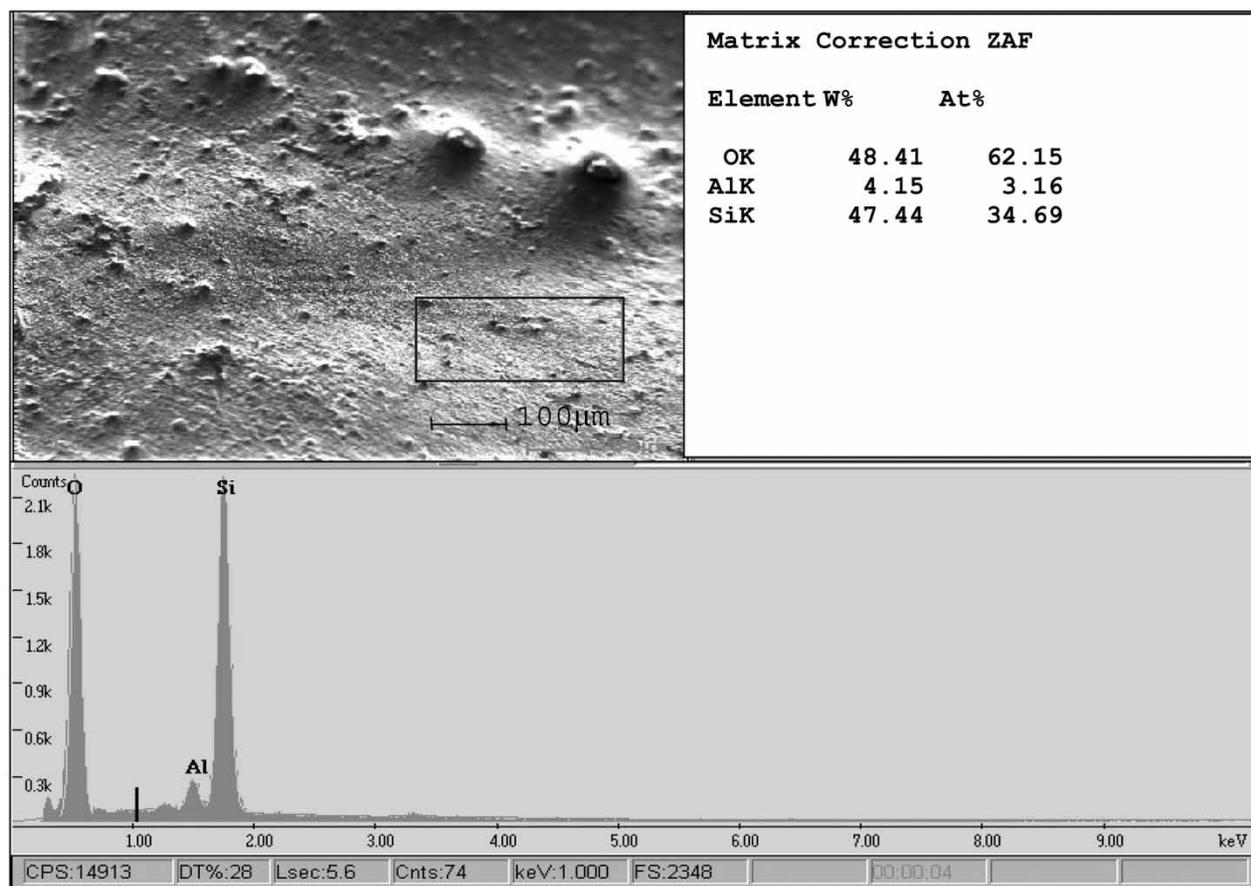


FIGURE 5. Representative SEM secondary electron image, EDS spectrum with O, Si and Al peaks marked, and “standardless” analysis of sample ESC-2. EDS spectrum acquired while rastering the electron beam over the outlined rectangular area.

calcium sulfate or gypsum ( $\text{CaSO}_4$ ), which is locally abundant in the modern ground water.

#### FLUORESCENT COLOR CHARACTERISTICS

Exposure of rock fragments to both, short and long wave ultraviolet light is an inexpensive and rapid way to further characterize distinctive attributes of a lithic resource. Hoffman et al. (1991) applied the technique with relative success in sourcing a collection of samples from the Edwards chert outcrop in central Texas. One hundred small samples from both outcrops of El Sauz chert, as well as some El Sauz chert artifacts, were exposed to short- and long-wave ultraviolet light. We found that <10 percent of the pieces fluoresce a pale yellowish-green in short-wave ultraviolet light, 254 nm. The fluorescence is mostly restricted to small veins and filled vugs (Figure 6). We suggest that the fluorescence may be linked to a uranium oxide mineral introduced at the time of opalization; several investigators have reported uranium concentrations associated

with the Catahoula ash, and the yellow-green colors observed are characteristic for most uranium minerals (Heinrich 1958). There was no visible fluorescence in any sample when using long-wave ultraviolet light.

#### GEOLOGICAL ORIGIN OF EL SAUZ CHERT

The genesis of El Sauz chert is unquestionably related to the large proportion of rhyolitic ash in the Catahoula Formation. There is no direct or indirect field evidence to suggest a shallow water or replacement origin. Post-depositional processes texturally and mineralogically modified the Catahoula volcanic ash which we interpret to be a rapidly deposited air-fall ( $30 \pm 5$  Ma) unit in Starr County. The modifications are a consequence of long-term devitrification and ground water and meteoric water moving through the silica-rich ash. Thus, we propose an authigenic or *in situ* sedimentary origin associated with the circulation of ground water for chert formation that may have began shortly after deposition of the volcanic ash.

TABLE 1. CHEMICAL COMPOSITION AND PHYSICAL CHARACTERISTICS OF RAW MATERIALS FROM EL SAUZ CHERT. OXYGEN VALUES NOT LISTED; WITH OXYGEN TOTALS = 100 PERCENT

| Sample                     | Color variations            | Texture/Luster                                 | Chemical composition Wt%                           |
|----------------------------|-----------------------------|--|--|
| ESC-2 (N = 5)              | Gray                        | Dull   | Si = 44.20<br>Al = 5.17                            |
| ESC-3 (N = 2)              | Gray                        | Vugs, 0.5 mm thick veins. Vitreous             | Si = 47.15   |
| ESC-20 (N = 3)             | Gray, yellow                | Waxy   | Si = 30.95<br>Fe = 5.81<br>Zn = 4.54*<br>Al = 4.19 |
| ESC-20-r (N = 2)           | Red                         | Waxy   | Si = 36.16<br>Al = 7.68                            |
| ESC-20-c<br>Matrix (N = 2) | Pink — pale gray            | Waxy   | Si = 28.36<br>Fe = 9.33<br>Mg = 1.77<br>Al = 10.32 |
| ESC-21 (N = 2)             | Light gray                  | Pseudobrecchia. Dull                           | Si = 33.22<br>Mg = 2.02<br>Al = 9.13               |
| ESC-22 (N = 2)             | Light gray                  | Vugs. Dull                                     | Si = 40.49<br>Al = 6.68                            |
| ESC-23 (N = 2)             | Pale gray                   | Partially filled vugs, Pseudobrecchia.<br>Dull | Si = 11.62<br>Ca = 32.74<br>S = 10.76              |
| ESC-24 (N = 2)             | Pale gray                   | Vugs. Vitreous                                 | Si = 47.63   |
| ESC-25 (N = 2)             | Bluish — pale gray          | Vugs. Dull                                     | Si = 47.11   |
| ESC-26 (N = 2)             | Bluish — pale gray          | Dull   | Si = 41.49<br>Al = 2.78                            |
| ESC-27 (N = 6)             | Red                         | Vitreous                                       | Si = 23.17<br>Al = 3.20<br>C = 6.13                |
| ESC-27 (N = 2)             | Yellow                      | Waxy   | Si = 32.36<br>Al = 4.34                            |
| ESC-27 (N = 2)             | Gray                        | Waxy   | Si = 36.82<br>Mg = 0.98<br>Na = 1.14<br>Al = 6.27  |
| ESC-28 (N = 2)             | Gray, pink, red             | Vugs. Dull                                     | Si = 41.82   |
| ESC-29 (N = 2)             | Pink, red, gray             | Vugs, Pseudobrecchia. Dull                     | Si = 39.39<br>Al = 4.23                            |
| ESC-42 (N = 4)             | Red, purple, pink,<br>gray, | Vugs. Dull                                     | Si = 35.69<br>Al = 0.95<br>C = 12.43               |
| ESC-105 (N = 6)            | Gray, pink                  | Pseudobrecchia. Waxy                           | Si = 48.61   |

*Continued*

TABLE 1. CONTINUED

| Sample            | Color variations   | Texture/Luster                                 | Chemical composition Wt%             |
|-------------------|--------------------|--|--------------------------------------|
| ESC-113a (N = 5)  | Gray-grayish pink  | Partially filled vugs, Pseudobrecchia.<br>Waxy | Al = 3.19<br>Si = 44.22              |
| ESC-132 (N = 3)   | Yellow, gray, pink | Waxy   | Al = 5.37<br>Si = 55.49              |
| ESC-137 (N = 2)   | Grayish — pink     | Pseudobrecchia. Dull                           | Al = 1.69<br>Si = 49.36              |
| ESC-313 (N = 4)   | Pinkish gray       | Waxy   | Al = 2.35<br>Si = 45.49              |
| ESC-246 (N = 4)   | Pinkish gray       | Waxy   | Al = 1.75<br>Si = 47.05              |
| ESC-point (N = 9) | Pinkish gray       | Waxy   | Al = 1.54<br>Si = 39.43<br>Al = 4.25 |

\*Zn was detected in only one of the three areas that were measured for this sample, the other two had Fe and no Zn.

This origin encompasses two of the three-stage ash alteration model of Galloway (1977), with minor modifications. The three stages can be summarized as follows:

PEDOGENESIS

Very fine crystalline or amorphous aluminum silicates were dispersed through the zone of soil formation by surficial alteration of ash shards. Fine silt- and clay-sized ash particles may have been completely destroyed. Montmorillonite formed in well-drained environments, and kaolinite in stagnant environments.



FIGURE 6. Typical light yellow-green fluorescent response of El Sauz chert under short wave (254 nm) ultraviolet light. Fluorescence is restricted to vugs and veins.

SHALLOW BURIAL

Circulation of meteoric waters through permeable ashy silts and sands and slower percolation through muds completed the alteration of ash to clay minerals containing minor amounts of zeolite, cristobalite, and free SiO<sub>2</sub>. Once the transformation of the fine-grained ash to clay was completed, the originally permeable, porous ash was converted to impermeable tuffaceous, silica enriched mudstone. Whereas everywhere else along the Catahoula silicification ended with the mudstone, locally in Starr County where the ash deposit is clean and has a thickness of 20 m, it continued and chertification was completed as two small pockets within or at the top of the ash. Timing of this transformation is unknown, and the rate of alteration would depend on the flux and geochemistry of the circulating ground waters.

OUTCROP WEATHERING

In the Late Pleistocene, some outcrops of tuffaceous beds, comprising the one underlying the chert at both quarries, were “calichified” or hardened into natural calcium carbonate cement which form in arid climates. The calichification resulted in destruction of clay minerals and zeolite.

Other studies exploring the origin of terrigenous chert have argued for hydrothermal fluids playing a role by remobilizing silica-saturated solutions (Graetsch et al. 1985; Hess 1996). There is no field evidence of hydrothermal alteration at El

Sauz chert outcrops, and there is no known local source of heat.

El Sauz chert's high aluminum content, up to 10 percent by weight, lends additional evidence against a hydrothermal origin. Studies of bedded chert attributed to hydrothermal fluids have low concentrations of aluminum, 0.82 to 1.80 weight percent  $Al_2O_3$ . These include, the Franciscan chert in California and the Shimanto Terrain chert in Japan (Yamamoto 1987); chert drilled in the north Pacific during Leg 32 of the Deep Sea Drilling Project (Adachi et al. 1986); the Nadan-Hechi-Basin chert in China (Zhou 1990); the Munsungun Lake Formation chert in Maine (Pollock 1987 and Pollock et al. 1999) and the Gusui chert in southern China (Zhou et al. 1994).

Aluminum concentrations reported by most geochemical studies that attempt sourcing chert quarries are low or even below instrument detection limits. Hoard et al. (1993) using neutron-activation analysis (NAA) to differentiate nine geological sources of chert from the Great Plains, based on their elemental composition, found that Al values were extremely low ranging from below detection limits to 0.22 weight percent. Cackler et al. (1999) studied the provenance of stone artifacts in Belize also using NAA and found Al concentrations to be  $\sim 0.13$  weight percent and in many of their sources aluminum was below detection limits. Unpublished studies on the geochemistry of the Edwards Plateau cherts have found that Al is within 0.05–0.09 percent (W. Crook, personal communication, 2014).

Although volcanic ash is common throughout the Catahoula Formation in Texas, no other outcrops of similar characteristics to those of El Sauz chert have been reported. This might be due to the fact that large volumes of clean, undiluted ash, such as those found in Starr County, do not occur elsewhere in the formation, and thus not enough authigenic silica was available to be remobilized by ground or meteoric water and form significant chert deposits. We do not find any support for the “intrusive dike of bentonitic clay” origin for the chert proposed by Mallouf and Tunnell (1978).

#### ARCHAEOLOGICAL IMPLICATIONS OF CHARACTERIZING EL SAUZ CHERT

Prehistoric exchange and procurement patterns may be understood by studying the dispersion of

stone tools provided that the quarry site of the lithic resource is known and that it has unique physical and chemical characteristics (Luedtke 1979). Stone toolmakers visited the small and restricted outcrops of El Sauz chert for several thousand years and tools they made were dispersed over a large area, thus offering archaeologists in south Texas and northern Mexico an exceptional opportunity to study procurement and exchange patterns.

The implications of this study will be extended in future characterization of other chert sources in south Texas including, gravels from the Pliocene Goliad Formation, the Pleistocene Uvalde Gravels and the identification of other siliceous knobs north of El Sauz chert outcrops. In an area where the lack of running water limits the mobility of foragers, the identification of a distinct chert type has profound implications for deciphering prehistoric occupation.

In summary this research defines five characteristics of El Sauz chert that can be used to identify this lithic material relative to other cherts found in archeological sites. These are: (1) abundant vugs ranging in size from mm to dcm, (2) cm-thick white opalized filled veins, (3) smeared colorations, (4) high aluminum content and (5) pale yellowish-green fluorescence to short-wave ultraviolet light. These geological observations can be used by archaeologists undertaking diachronic study of lithic procurement and exchange on both sides of the Rio Grande.

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#### REFERENCES

- Adachi, M., K. Yamamoto, and R. Sugisaki 1986  
Hydrothermal Chert and Associated Siliceous Rocks from the Northern Pacific their Geological Significance

- as Indication of Ocean Ridge Activity. *Sedimentary Geology* 47: 125–148.
- Banks, L. D. 1990 From Mountain Peaks to Alligator Stomachs: A Review of Lithic Sources in the Trans-Mississippi South, the Southern Plains, and Adjacent Southwest. *Oklahoma Anthropological Society Memoir* 4.
- Cackler, P. R., M. D. Glascock, H. Neff, H. Iceland, K. A. Pyburn, T. R. Hester, D. Hudler, and B. M. Chiarulli 1999 Chipped Stone Artefacts, Source Areas, and Provenance Studies of the Northern Belize Chert-Bearing Zone. *Journal of Archaeological Science* 26: 389–397.
- Eargle, D. H., K. A. Dickinson, and B. O. Davis 1975 South Texas Uranium Deposits. *American Association of Petroleum Geologist* 59: 766–779.
- Galloway, W. E. 1977 *Catahoula Formation of the Texas Coastal Plain: Depositional Systems, Composition, Structural Development, Ground-water Flow History, and Uranium Distribution* (No. DOE/GJ/01660-T1). Texas University, Austin. Bureau of Economic Geology.
- Graetsch, H., O. W. Flörke, and G. Mieke 1985 The Nature of Water in Chalcedony and Opal-C from Brazilian Agate Geodes. *Physics and Chemistry of Minerals* 12: 300–306.
- Heinrich, E. W. 1958 *Mineralogy and Geology of Radioactive Raw Materials*. New York: McGraw-Hill.
- Hess, S. C. 1996 Chert Provenance Analysis at the Mack Canyon Site, Sherman County, Oregon: An Evaluative Study. *Geoarchaeology* 11: 51–81.
- Hester, T. R. 1980 *Digging into South Texas Prehistory: A Guide for Amateur Archaeologists*. San Antonio: Corona Publishing Company.
- Hoard, R. J., J. R. Bozell, S. R. Holen, M. D. Glascock, H. Neff, and J. M. Elam 1993 Source Determination of White River Group Silicates from two Archaeological Sites in the Great Plains. *American Antiquity* 698–710.
- Hoffman, J. L., L. C. Todd, and M. B. Collins 1991 Identification of Central Texas Edwards Chert at the Folsom and Lindenmeier Sites. *The Plains Anthropologist* 297–308.
- Kumpe, D., and M. Kryzwonski 2009 El Sauz Chert: A Distinctive Lithic Resource on the Lower Rio Grande. *La Tierra* 36: 33–39.
- Ledger, E. B. 1988 The Catahoula Formation: A volcanoclastic Unit in East Texas. *Centennial Field Guide* 4: 383–385.
- Luedtke, B. E. 1979 The Identification of Sources of Chert Artifacts. *American Antiquity* 43: 744–757.
- Mallof, R. J., and C. Tunnell 1978 Field Notes at 41SR137: Geologic Notes and Postulations Concerning “opalite” (opalized tuffaceous bentonitic clay) found in Starr County. On file at the office of the State Archeologist, Austin, Texas. 6pp.
- McBride, E. F., W. L. Lindemann, and P. S. Freeman 1968 Lithology and Petrology of the Gueydan (Catahoula) Formation in South Texas. Bureau of Economic Geology Report of Investigations 63.
- Pollock, S. G. 1987 Chert Formation in an Ordovician Volcanic Arc. *Journal of Sedimentary Research* 57: 75–87.
- Pollock, S. G., N. D. Hamilton, and R. Bonnichsen 1999 Chert from the Munsungun Lake Formation (Maine) in Paleoamerican Archaeological Sites in Northeastern North America: Recognition of its Occurrence and Distribution. *Journal of Archaeological Science* 26: 269–293.
- Turner, E. S., T. R. Hester, and R. L. McReynolds 2011 *Stone Artifacts of Texas Indians*. Lanham: Taylor Trade Publications.
- Weis, D., and G. J. Wasserburg 1987 Rb/Sr and Sm/Nd Systematics of Cherts and Other Siliceous Deposits. *Geochimica et Cosmochimica Acta* 51: 959–972.
- Yamamoto, K. 1987 Geochemical Characteristics and Depositional Environments of Cherts and Associated Rocks in the Franciscan and Shimanto Terranes. *Sedimentary Geology* 52: 65–108.
- Zhou, Y. Z. 1990 Geochemical Characteristics of Siliceous Rocks Originated from a Fossil Hydrothermal System in the Upper Devonian Strata, Guangxi, Southern China. *Acta Sedimentol. Sinica* 8: 75–83.
- Zhou, Y. Z., E. H. Chown, J. Guha, H. Lu, and G. Tu 1994 Hydrothermal Origin of Late Proterozoic Bedded Chert at Gusui, Guangdong, China: Petrological and Geochemical Evidence. *Sedimentology* 41: 605–619.

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