Journal Title: Bulletin of the Texas Archeological Society

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Article Title: Lithic Tool Resources of the Eastern Llano Estacado

Volume: 52

Issue: 

Month/Year: 1981

Pages: 201-214

Trans. #: 390932

Call #: F381 .T32

Location: Main Library

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NOTES

Lithic Tool Resources of The Eastern Llano Estacado

Vance T. Holliday and Curtis M. Welty

ABSTRACT

A survey of lithic tool resources of the eastern Llano Estacado was aimed at characterizing the types and availability of material suitable for tool making found in the various geologic units that make up the bedrock of the area. Five major units are present along the eastern Llano Estacado: Quartermaster Formation; Dockum Group; Antlers Sand; Edwards Limestone; and Ogallala Formation. The Quartermaster Formation (uppermost Permian) contains the Alibates Dolomite Lentil, providing the well known, multicolored Alibates agate found along the Canadian River Valley. The Dockum Group (upper Triassic) has a basal gravel with quartzite and cherts, common throughout the survey area. Along the east central Llano Estacado, the Dockum contains the T ecovas Formation which often yields lenses of jasper (Tecovas or Quitaque jasper) and chert. The Antlers Sand (lower Cretaceous) found on the southeastern Llano Estacado has a basal gravel with quartzites, cherts, and jasper. The Edwards Limestone, occurring in the same areas as the Antlers, sometimes contains nodules and lenses of chert. The Ogallala Formation (Miocene-Pliocene) has the most variety and abundance of suitable and available raw material for artifacts. Gravels are found throughout the area, including quartzites, cherts, flint, and jasper. Pedogenic caliches formed in the upper Ogallala, Edwards, and Blanco Formation (Pliocene) are often silicified and occasionally opalized, providing marginal to good quality material. The presence of such quantities of varied, readily available material imposes severe limitations on the use of particular rock types as indicators of trade with other areas.

INTRODUCTION

The types, quantities, and availability of rocks suitable for manufacturing lithic tools in a given area should have considerable influence on the quantity and quality of lithic tools and debitage found in archeological sites. The physical properties of a particular rock type will, in large measure, control the workability of a tool and its wear resistance. The availability and amount of usable material would be expected to control the degree of reutilization and conservation of tools and debitage. As Ahler (1977:133) stated, a geological survey aimed at linking “. . . stone types to an area of natural occurrence . . . is an essential step in any meaningful investigations of lithic or any other raw material selection and procurement system.”

The importance of proximity and quality of geological outcrops to archeological investigations is not new to archeology (Bryan, 1950; Coffin, 1951). However, such systematic surveys of lithic resource areas are rela-
tively rare in archeology. Surveys and petrographic studies of specific, well known rock types or outcrops are more common (Clayton et al., 1970; Hood, 1978; Schaeffer, 1958).

The Llano Estacado (Southern High Plains of Texas and eastern New Mexico) has been the scene of archeological investigations for over half a century (Collins, 1971; Kelly, 1964; Holliday, in press). The importance of raw material availability and types to the quality and quantity of tools and debitage in archeological sites has been recognized (Green and Kelly, 1960; Hester, 1975; Hood, 1978; Hughes, 1976). The area contains outcrops and quarries of Albite agate, one of the best known raw materials on the Plains. Considerable attention has been given the material (Asquith, 1975; Bowers and Reaser, 1974; Bryan, 1950; Green and Kelly, 1960; Schaeffer, 1958).

Hester (1972, 1975) reviews some of the more common rock types available in the area and mentions several specific locations. Several reviews of rock types common in specific areas and some associated outcrops are available (Etchieson et al., 1977, 1978; Hughes and Hood, 1976; Harrison and Killen, 1978). Hughes (1978) and Willey and Hughes (1978) review the bedrock stratigraphy in the MacKenzie Reservoir area. Hughes (1976) provides a review of references to lithic resources in the Texas Panhandle.

Despite previous work, a regional, systematic research concerning the characteristics of lithic material as they relate to bedrock types is lacking. Such a survey is particularly important on the Llano Estacado because the surface is mantled by a thick cover of Pleistocene eolian sediments. Hence, rock outcrops are common only along the escarpments that form the west, north, and east boundaries of the Llano Estacado. Limited outcrops also occur along the deeper drainages (draws) and lake basins (playas). To procure material, inhabitants of the interior of the area would have to travel some distance to the outcrops or trade. Additionally, by determining the nature of available local material, identification of rock types from other areas is feasible.

**METHODOLOGY**

A preliminary survey of available lithic tool resources on the eastern Llano Estacado was conducted. The principal goal was to characterize, macroscopically, the types of materials available in each of the major bedrock units in the region. Petrographic analysis was not undertaken nor an intensive study of the knapping characteristics of individual rock types. Field investigations centered on the Lubbock area and included the eastern escarpment of the Llano Estacado extending from the eastern end of Palo Duro Canyon (Briscoe County) south and west to Fluvanna (Scurry County) and Lamesa (Dawson County) and extending east from the escarpment a short distance onto the Rolling Plains (Fig. 1).

Roadcuts and quarries were examined along the escarpment, reentrant canyons, draws, and larger playa lake basins. An effort was not made to locate archeological quarry sites. A survey of geological and archeological literature dealing with rock types and stratigraphy and specific outcrop areas and quarries also was conducted.
Fig. 1 Generalized Geologic Map of the Llano Estacado (Texas Portion) with Units and Localities Mentioned in the Report.

Exposures of suitable raw materials were recorded and sampled even if they occurred as gravel too small to be utilized for tool manufacture. Although specific localities may not have provided rocks of sufficient size for flaking, it was considered that the material would be an indication of what could be available in other exposures of the same formation. Identification of rock types was based on macroscopic properties such as color, texture, and mineralogical composition.

ROCK AND MINERAL NOMENCLATURE

When describing rocks and minerals used for manufacturing artifacts, it is advisable to follow classification schemes established by geologists. Confusion exists among archaeologists concerning certain rock types (e.g., flint vs.
chet); and in many cases, terms have been improperly used by geologists, primarily because a general agreement on terminology is lacking. The following summary of various rock and mineral types commonly used for artifacts, particularly on the Southern High Plains, follows those of Blatt et al. (1980) and Lapedes (1978). Definitions can vary depending on the source consulted.

Most lithic tools are made from various forms of fine crystalline quartz (silica). This quartz generally occurs as either fibrous varieties, termed chalcedony (a mineral), or microcrystalline or cryptocrystalline forms termed chert (a rock). Differentiating chalcedony from chert (which can have chalcedony in it) is very difficult in hand specimens. Color is the best key for a general classification of forms of chert. The best known variety of chalcedony is agate, which has multicolored bands. Cherts are most commonly various shades of gray to tan. Very dark gray or black cherts usually are referred to as flint. Cherts strongly colored with red, brown, or yellow are termed jasper.

Other common rock types for tools are quartzite and silicified and opalized caliche. Quartzite is a metamorphic rock, usually a metamorphosed sandstone (i.e., subjected to high temperature and pressure). Quartz sandstone cemented with silica is often mistempered quartzite. Individual grains of quartz usually are not apparent in metamorphic quartzite (metaquartz). In silica cemented quartz sandstone (often called orthoquartz), individual, rounded quartz grains generally are visible, particularly with the aid of a hand lens. Ebright (1979) presents a summary of quartzite genesis and terminology oriented toward the archeologist and lithic technician.

Caliche, also referred to as calcrite, is a frequently misused term. Caliche is a massive, well indurated form of calcium carbonate, precipitated during very long periods of soil formation in semiarid to arid regions. Under proper conditions, calcium carbonate can be replaced by silica resulting in the formation of silicified caliche. Generally, obvious visual differences are lacking between caliche and silicified forms but the latter tends towards greenish hues. It also breaks in concoidal fractures.

The silicification process also can result in the formation of opalized caliche. Opal is a hydrated form of silica, usually a lustrous white and sometimes exhibiting various spectral colors. The opal often is found in the caliche as irregularly shaped nodules.

Much of the raw material used for tool making comes from gravels in unconsolidated sediments or conglomerates in consolidated deposits. Size classification of the clasts is of considerable importance in assessing suitability for flaking into an artifact. They are as follows: boulders — 256 mm (10 in); cobbles — 64-256 mm (2½-10 in); pebbles — 4-64 mm (3/16-2½ in).

BEDROCK STRATIGRAPHY

The stratigraphy and structure of the Southern High Plains is well known from diverse studies (Meade et al., 1974; Evans, 1949; Evans and Brand, 1956; Nicholson, 1960; Sellards et al., 1947). Geologic maps of the area include 1:250,000 scale maps of the Amarillo (Barnes, 1969), Plainview
(Barnes, 1968), Lubbock (Barnes, 1967) and Big Spring (Barnes, 1974) areas.

Five major (sedimentary rock) units contain material suitable for lithic tool manufacture. From older to younger, these are: Quartermaster Formation; Dockum Group; Antlers Sand; Edwards Limestone; and Ogallala Formation. Various pedogenic caliches occasionally yield material of varying quality.

The Quartermaster Formation (uppermost Permian) and older Permian redbeds crop out at the surface of the Rolling Plains east of the Llano Estacado (Fig. 1). The Quartermaster is the oldest unit near the Llano Estacado containing suitable material for lithic tools. The redbeds consist of silty, evenly bedded, locally massive shales; sandy, well indurated siltstone; and silty, fine grained sandstone. Gypsum and dolomite beds occur discontinuously.

The Albates Dolomite Lentil, in the upper Quartermaster has been mapped along the northern Llano Estacado, primarily in the Canadian River drainage. The unit, parts of which have been altered to agate, is found near the top of the Quartermaster Formation (Gould, 1907; Barnes, 1969; Patton, 1923), although on some correlation charts it is shown as a separate unit, underlying the Quartermaster (Nicholson, 1960: Fig. 45). The Quartermaster Formation crops out continuously near the foot of the Llano Estacado escarpment from Donley to Kent counties (Fig. 1).

The Dockum Group (upper Triassic) forms the lower portion of the Llano Estacado escarpment. Because the unit was deposited in a large northwest southeast trending basin (McGowan et al., 1979), outcrops occur only along the northwestern, eastern, and southeastern Llano Estacado with beds generally becoming thicker from north to south (Figs. 1, 2). Along the northern and northeastern Llano Estacado, the Dockum often is subdivided into the Tecovas and Trujillo Formations.

The Tecovas Formation, the oldest unit, is composed of a basal conglomerate with discontinuous chert lenses and overlying varicolored shales. The Trujillo Formation consists of red, interbedded sandy conglomerates, conglomeratic sandstones, and shales. To the south, the Dockum consists of a complex sequence of conglomerates, fine to coarse grained, red, indurated sandstones, reddish brown sandy clays, and varicolored sandy shales. Discontinuous chert lenses occur throughout the Unit (Barnes, 1969; McGowan et al., 1979).

The Antlers Sand and Edwards Limestone are lower Cretaceous deposits found along the east central and southeast Llano Estacado. The Antlers, which is the basal Cretaceous unit in the area, consists of varicolored siltstone, sand, sandstone, and a basal conglomerate. The Edwards Limestone is separated from the Antlers by the Walnut Formation and Comanche Peak Limestone. The Edwards consists of fine to medium grained limestone with occasional chert lenses (Brand, 1953; Barnes, 1974; Meade et al., 1974).

The Ogallala Formation (Miocene-Pliocene) is the most ubiquitous rock unit of the High Plains, cropping out continuously along the northern and eastern Llano Estacado. The unit consists of a basal red to brown sand and conglomerate (Couch Formation of Evans, 1949); and an upper, reddish, unconsolidated sand, silt, and clay with occasional gravel lenses (Bridwell Formation of Evans, 1949; Barnes, 1974). Along the northern Llano Estacado...
Fig. 2 Composite Stratigraphic Column of Geologic Units and Respective Rock Types Suitable for Tool Manufacture (above). Generalized North-South Geologic Cross Section of the Eastern Llano Estacado Showing Relative Thicknesses and Stratigraphic Relationships of Units (below).

cado, Patton (1923) identified a basal gravel, termed the Potter Formation or Potter gravel (Hood, 1978), lithologically different from the basal gravel common in the Ogallala to the south.

A very well developed, well indurated caliche formed at the top of the bedrock, the ledge forming caprock caliche. Generally, the unit developed by soil forming processes in the upper Ogallala. On the southern Llano Estacado, where the Ogallala thins and the Edwards Limestone forms the surface outcrop, caliche formed in the

On the south central Llano Estacado, along the escarpment and in draws, outcrops of the Blanco Formation (upper Pliocene) consist of discontinuous deposits of dolomite set into the top of the Ogallala. A well developed caliche often is found at the top of the Blanco. The Ogallala and Blanco caliches are often silicified and occasionally opalized.

The surface of the Llano Estacado is mantled by a thick deposit of Pleistocene eolian sediments referred to as the cover sands (Frye and Leonard, 1965) or Blackwater Draw Formation (Reeves, 1976). The Ogallala appears present virtually everywhere beneath the Pleistocene deposits (Oetking, 1959).

BEDROCK MATERIAL SUITABLE FOR TOOL MANUFACTURE

Alibates agate is the only material in the Quartermaster Formation suitable for manufacturing tools. This multicolored material, occurring as lenses and nodules, is the result of silicification of the dolomite (Gould, 1907; Asquith, 1974; Bowers and Reaser, 1974). The best known outcrops are in Alibates National Monument near Fritch (Fig. 1). Other outcrops are found on both sides of the Canadian River northeast of Amarillo and sometimes in local gravels (Etchieson et al., 1978; Gould, 1907; Hughes, 1976; Patton, 1923). The colors in the agate occur mainly in bands, but also as mottles (Patton, 1923). Most colors are maroon to reds to tans with milky white interbands. Other colors observed include chocolate brown, blue, and yellow.

Several different kinds of materials are available from the Dockum Group. Most common are the pebble and cobble conglomerates, particularly notable in the lower Dockum. In outcrops west of Flomot (Fig. 1), dominant lithologies are coarse to medium grained, light colored quartzites and red jaspers. Other materials included flint and light glassy, fine grained, tan and light to medium gray cherts. Similar lithologies are reported from a variety of areas (McGowan et al., 1979) and outcrops appear to be quite common throughout the survey area. Outcrops with cobbles were not observed. Some probably are available and presumably lithologies would be similar.

Artifacts made from a jasper from the Tecovas Formation of the lower Dockum Group are common in many archeological sites in the area. The material is known locally known as Tecovas or Quitaque jasper (after the best known outcrop near the town of Quitaque) (Fig. 1). Other reported outcrops are in Palo Duro Canyon (Etchieson et al., 1978; McGowan et al., 1979) and along the Canadian River Valley northwest of Amarillo (Jack T. Hughes, personal communication). The material usually occurs as lenses. Colors usually are maroon with mottles of yellow and brown common.

Tecovas jasper has been confused with Alibates agate, particularly if the specimens are small such as flakes (Hughes, 1976; Green and Kelley, 1960; Katz and Katz, 1976). Banding has been used as an indicator of Alibates agate. However, Alibates also can be mottled. Alibates agate often has faint suggestions of other colors within the red, whereas Tecovas jasper usually has an even red color. Tecovas jasper tends to have more tiny quartz vugs than Alibates agate.

Recent studies of the Lubbock lithic assemblage indicate that Alibates agate and Tecovas jasper are the most frequently used materials for tool manufacture on the Llano Estacado.
magnifications (10-20x) (Doug Bamforth, personal communication). Alibates agate tends to have a more vitreous, waxy luster and frequently, it is possible to see a short distance into the stone. Tecovas jasper, on the other hand, is opaque and bluish white quartz vugs are apparent.

A quartzite that is coarser grained than the jasper but otherwise has a similar appearance (Tecovas quartzite) also is found in the Tecovas Formation (Etchieson et al., 1978).

Outcrops of the Antlers Sand are found in Borden, Dawson, and Garza counties, south of Post and west of Fluvanna and Gail (Barnes, 1974) and in Shafter Lake, Andrews County (Meade et al., 1974) (Fig. 1). The unit often contains a basal gravel with lithologies similar to the Dockum gravel, including some light colored quartzites, jasper, flint, and petrified wood. Observed outcrops of Antlers yielded only pebble clasts. It is not known if cobbles are available.

Outcrops of material adequate for tool making were not found in the Walnut Formation nor Comanche Peak Limestone. However, Evans and Brand (1956: 10) mention "a prominent quartzose conglomerate in the basal 3 feet of the [Comanche Peak Limestone]" in southeast Lubbock County.

Tan to gray cherts quite similar to cherts commonly found in the Edwards Limestone in Central Texas are ubiquitous in archeological sites on the Llano Estacado (Hester, 1972; Johnson and Holliday, 1981). In the survey area, outcrops of light gray to tan cherts were found in the Edwards Limestone along the southeast escarpment of the Llano Estacado in Borden and Garza counties. The chert was not present everywhere in the Edwards outcrops.

This particular material probably does not account for the high percentages of similar chert in local archeological sites. Hester (1972, 1975) reports outcrops of chert in the Edwards Limestone in the Sterling City - San Angelo area, 50-90 mi southeast of Big Spring. Harrison and Killen (1978) mention an outcrop in Jones County, northeast of San Angelo.

In the survey area, gravel of the Ogallala Formation produces the most abundant and varied material for making lithic tools. The material is common throughout the area. Within the Ogallala, the basal gravel generally seems to have the largest clasts and highest quality materials. Light colored, medium to coarse grained quartzites are most common. Several experimental tools were made of this material by the authors, with most satisfactory results.

Dark gray to black, medium grained quartzites also were found; and red to brown jaspers, medium to dark gray and dark blue chert, and flint were common. Outcrops of the upper Ogallala yielded a generally finer grained (pebble sized) gravel and contained light colored, coarse grained quartzite, purple quartzite, flint, some medium gray chert, and brown to yellow jasper. Along the northeastern Llano Estacado, cherts apparently are rare in Ogallala gravels, quartzites being the dominant lithology (Jack T. Hughes, personal communication).

Potter chert is found in gravel of the Potter Formation of the lower Ogallala on the northern Llano Estacado (Hood, 1978). The material is a dense, gray to brown, silica cemented, very fine grained siltstone; it possibly is derived from the Morrison Formation (Jurassic) in New Mexico. Other materials found in the Potter gravels are purple quartzite, some jasper, chert, petrified
(silified) wood, and various quartzites referred to as Potter quartzite (Hood, 1978; Etchiesen et al., 1977).

The various well developed caliches in the area provide occasionally marginal to high quality raw materials for lithic tool manufacture. The caprock caliche in the upper Ogallala Formation and Edwards Limestone and the caliche formed in the upper Blanco Formation are silicified in places. Such silicified caliche, although of poor quality, can be used for lithic tools. Despite its poor workability the material is common in some archeological sites (Johnson and Holliday, 1981), particularly where outcrops are nearby.

In some areas, the silicification process has gone so far as to produce an opalized caliche, usually in the lower caprock caliche (Reeves, 1970). The opal is of fairly good quality and flakes of the material are common in archeological sites in the area (Hughes, 1976; Hughes and Willey, 1978). Opal outcrops were observed in exposures of the caprock at the Muleshoe Wildlife Refuge (MWR) and reported from Cedar Lake (C.C. Reeves Jr., personal communication) and in the MacKenzie Reservoir area (Hughes, 1978). (Fig. 1).

Outcrops of other materials sometimes found in sites on or near the Llano Estacado are outside of the survey area. The Seymour Formation (Pleistocene) occurs in a north south trending outcrop 80 to 100 mi east of the Llano Estacado. The deposit consists of gravels apparently derived from the Potter gravels of the Ogallala Formation and the siliceous conglomerates from the Dockum Group (Hood, 1978). Presumably, Ogallala gravels with lithologies similar to those found south of the Potter outcrops would be found in the Seymour gravels.

Durler (1976) discusses a conglomerate with quartzites and other siliceous material suitable for tool manufacture that makes up early or pre-Pleistocene terraces of the Pecos River near Carlsbad (New Mexico), southwest of the Llano Estacado.

Quartzite considered to be from outcrops of the Dakota Formation (upper Cretaceous) near Ft. Sumner and Tucumcari (New Mexico), along the north-west escarpment, is a common artifact material on the northern Llano Estacado (Hester, 1975; Willey and Hughes, 1978). Although the material has been described as “metamorphosed sandstone” (Willey and Hughes, 1978:47), this description is misleading as it is not a metamorphic rock. The material is a silica cemented sandstone more properly termed Dakota orthoquartzite (Hughes and Hood, 1976). The material is coarse grained and varies from reds to browns, causing some problem in differentiating it from Tecovas quartzite.

Obsidian occasionally is found in archeological sites in the area. The nearest source of this material is believed to be central New Mexico.

SUMMARY AND CONCLUSIONS

A variety of materials suitable for manufacturing lithic artifacts is available along the eastern escarpment of the Llano Estacado. Most of the material is available in the form of gravel and includes flint, chert, jasper, and various
quartzites. Material found in situ in various deposits includes high quality agate and jasper, chert, and some opal. The Ogallala Formation has the greatest variety and abundance of material in the area.

Due to the amount of raw material available in gravels in the region, caution should be exercised in naming rock types. Such distinctive in situ materials as Alibates agate and Tecovas jasper are properly named. However, materials found in gravels should only be described by rock type and not formally named. The geological convention for naming a formation using its lithology (e.g., Edwards Limestone, Antlers Sand) is employed only when the unit is predominately of one lithology. When a variety of rock types is present, the term Formation is used in place of the lithology (e.g., Ogallala Formation). By analogy, the use of such terms as Potter chert or Ogallala chert (Hughes, 1976) implies that the material formed in the deposit. Ogallala chert or opal may be properly applied to the silicified or opalized caliche in the Ogallala (Hughes, 1976).

The availability of such a variety of material places considerable limitations on the use of rock types found in archeological sites for estimating possible trade routes. A notable example are the gravels of high quality chert and flint in the Ogallala. The material is macroscopically identical to chert found in the Edwards Limestone in Central Texas and may have been derived from previously existing Cretaceous outcrops in the area during deposition of the Ogallala.

The availability and quality of chert from the Ogallala along the eastern and southeastern Llano Estacado escarpment probably accounts for the large number of tools made from it in archeological sites in the area rather than trade networks between this area and Central Texas. Such trade routes may have existed but lithic artifact materials should not be used as evidence.

ACKNOWLEDGMENTS

The survey of lithic resources on the Eastern Llano Estacado was the culmination of several years of interest and sporadic research in the topic. During this time, a number of individuals provided considerable information on types and outcrops of regional lithic materials. Dr. Jack T. Hughes (West Texas State University) freely shared his considerable knowledge of the subject. Dr. C. C. Reeves Jr. (Texas Tech University), Dr. John P. Brand (formerly with Texas Tech University), and Michael J. Kaczor (Arkansas Archeological Survey) also made available valuable information concerning rock types and specific outcrops. Douglas Barnforth (University of California, Santa Barbara) provided valuable comments on the manuscript in light of his research on the Lubbock Lake lithic assemblage.

Dr. Eileen Johnson (Director, Lubbock Lake Project) provided considerable encouragement and support for this undertaking and reviewed drafts of the manuscript. Drs. James B. Benedict (Center for Mountain Archeology) and Peter W. Birkeland (University of Colorado) also reviewed drafts of the manuscript and provided constructive criticism. Anne Kneedler typed final drafts of the manuscript. The survey was part of continuing research of the Lubbock Lake Project, funded by National Science Foundation (Grants SOC75-14857, BNS 7612006, BNS 7612006-A01, BNS78-1155), National Geographic Society, Center for Field Research (EARTHWATCH), Texas Historical Commission (National Register Program), City and County of Lubbock, and the Museum, Texas Tech University.
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