Plains Anthropologist

ISSN: 0032-0447 (Print) 2052-546X (Online) Journal homepage: http://www.tandfonline.com/loi/ypan20

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To cite this article: Sean G. Dolan, M. Steven Shackley, Don G. Wyckoff & Craig E. Skinner (2017): Long-distance conveyance of California obsidian at the Hayhurst lithic cache site (34ML168) in Oklahoma, Plains Anthropologist

To link to this article: http://dx.doi.org/10.1080/00320447.2017.1352559

Published online: 26 Oct 2017.

REPORT

Long-distance conveyance of California obsidian at the Hayhurst lithic cache site (34ML168) in Oklahoma

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A piece of obsidian was found during excavations of a possible Middle Holocene Calf Creek biface cache at site 34ML168 in Oklahoma. Energy dispersive X-ray fluorescence analysis of the obsidian flake shows that the source material derives from Glass Mountain in California. This is the first instance of California obsidian in this region. However, most intriguing is that Glass Mountain erupted thousands of years after the presumed Calf Creek artifacts were made. By examining the depositional history and lithic technology of the cache, and source provenance of the obsidian, we discuss the significance of this find and present possible scenarios regarding the long-distance conveyance of the obsidian artifact. This study complements other archaeological cases where the use of geochemical sourcing connects people, places, and things of unexpected distances across ancient North America.

KEYWORDS long-distance conveyance, obsidian, lithic cache, Oklahoma, Calf Creek

DOI 10.1080/00320447.2017.1352559

A growing movement and interest within North American archaeological method and theory focuses on regional, mid-continental, and continental-wide long-distance social interaction, information flow, and conveyance of people, objects, and ideas (DeBoer 2004; Gilman et al. 2014; Lekson 2011; Peregrine and Lekson 2006, 2012; Smith and Fauvelle 2015). Scholars are more cognizant than ever that Native American groups were conscious of others living far distant from them. There is evidence for interaction between, for example, groups in the Plains and the Southwest, the Southwest and Mesoamerica, and the Southeast and Mesoamerica (Ericson and Baugh 1993; Mathien and McGuire 1986; Spielmann 1991; White and Weinstein 2008).

It has long been recognized that geochemically sourcing artifacts made from exotic raw materials, like obsidian, contributes to our understanding of long-distance social interaction through time and across space (Caldwell 1964; Griffin 1965; Renfrew et al. 1965). In many cases, without the aid of material science and archaeometry (Jones 2002; Martinón-Torres and Killick 2015), archaeologists would not have known about the unlikely social connections that took place millennia ago resulting from one-time chance encounters or regular (or sometimes seasonal) face-to-face interaction. Native American groups moved obsidian, marine shell, turquoise, and other materials hundreds and sometimes even thousands of kilometers across diverse environmental and cultural regions using extensive down-the-line exchange networks, as well as by acquiring materials directly from primary source outcrops (Barker et al. 2002; Dillian et al. 2010; Hatch et al. 1990; Hull et al. 2014; Kozuch 2002; Vokes and Gregory 2007).

Obsidian is one of the well-documented raw materials seemingly favored for long-distance movement across North America. Archaeologists know people moved this highly knappable and extremely sharp volcanic glass across vast distances because the trace elements can be accurately and reliably characterized and correlated with primary source outcrops using a host of archaeometric techniques (Glascock 2011; Shackley 2005). Studying which obsidian sources people used, and how far they may have traveled to acquire it, or from which exchange network(s) they utilized, is key for achieving perspective on larger anthropological issues like economy, interconnectivity, and mobility (Dolan et al. 2017; Lazzari 2010; Renfrew 1977).

Obsidian outcrops are not present on the Southern Plains, so the recovery of obsidian artifacts from archaeological contexts entails explaining this material's geochemical source and the social interactions that enabled its conveyance from groups beyond the region. Since it is a non-local chipped stone resource, determining the source of obsidian is an important part of archaeological research across the Plains, including in Oklahoma (Quigg 2012; Roper and Hughes 2014; Vehik and Baugh 1994). Obsidian played a small role in lithic manufacture in most parts of Oklahoma, but sourcing studies demonstrate that people primarily used obsidian from the Southwest and Great Basin (Baugh and Nelson 1987; Brooks et al. 2014; Brosowske 2004, 2005).

Prehistoric groups in Oklahoma had social and economic ties with others throughout the continent, but there is no firm archaeological evidence to support connections between Southern Plains Village tribes and tribes in northern California. However, in this paper, we present geochemical evidence for the first documented occurrence of California obsidian on the Southern Plains at site 34ML168 in central Oklahoma. During excavations at the site, an obsidian flake was recovered in association with a cache of chert artifacts that we argue were made by Calf Creek hunter-gatherers sometime during the Middle Holocene. Using energy-dispersive X-ray fluorescence (EDXRF) spectrometry, the obsidian flake matched the trace elemental composition of the Glass Mountain obsidian source in northern California. Glass Mountain erupted in 885 ± 40 years BP (Donnelly-Nolan et al. 1990; see also Chesterman 1955), which means that obsidian from Glass Mountain could not have been used until after around AD 1000. The Glass Mountain obsidian flake helps place a timeline on the secondary reburial of this feature at around the Late Prehistoric period. Consequently, the arrangement and taphonomy manifest by the cache probably result from the actions of people many millennia apart given the early prehistoric date of the chert artifacts and the late prehistoric age for the Glass Mountain obsidian flow.

The presence of the Glass Mountain obsidian flake with the cache indicates that the cache was reburied some five millennia after its constituent chert objects were made. However, it is challenging to tell archaeologically whether the reburial of the cache was intentional or not. By examining the depositional history and lithic technology of the in situ artifacts, and the source provenance of the obsidian flake, we discuss the significance of this find and present possible scenarios for the long-distance conveyance of this artifact into Oklahoma. Although difficult to fully understand, our study highlights the importance of geochemically sourcing artifacts to show the long-distance movement of objects across ancient North America, a topic pertinent to advancing Plains archaeology.

Site 34ML168 and the Hayhurst lithic cache

Located in McClain County, central Oklahoma (Figure 1), the Hayhurst lithic cache first came to the attention of archaeologists in the spring of 2009. At that time, the

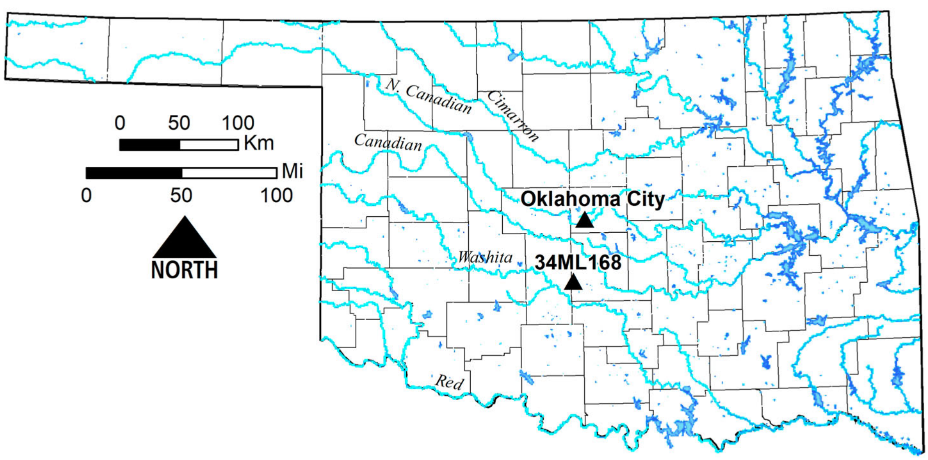

FIGURE 1 Location of 34ML168 in central Oklahoma.

landowner plowed a sandy garden plot on a ridge overlooking a southwest flowing tributary of the Washita River. A subsequent rain uncovered seven palm-sized flakes and two segments of a large biface at the field's very west end. This part of the field was previously not cultivated because the sandy topsoil was underlain by an almost impermeable clay-rich horizon that typically perched rainwater and this hampered agricultural production.

The landowner brought the artifacts to the Sam Noble Oklahoma Museum of Natural History at the University of Oklahoma where Wyckoff recognized them as being made from a variety of Edwards chert from central Texas. Wyckoff visited the garden plot when the landowner scraped the topsoil off where the artifacts had been found. Another large flake was found 9 cm below the surface during the visit. Between 2009 and 2011, half dozen larger flakes of the same chert material were recovered as the field continued to be tilled. In the spring of 2013, the landowner plowed much deeper, and in doing so, machinery nicked the east end of an in situ cache of lithic artifacts. The artifacts were subsequently uncovered and plotted in March 2013. Five large chert bifaces and 41 large flakes were found within a shallow 29 cm pit. The bifaces were stacked on three flakes laid on edge in the pit bottom while the flakes were closed packed around and on the bifaces. Plowing in the fall of 2013 and spring of 2014 exposed more flakes.

In May 2014, Oklahoma Archeological Survey staff, University of Oklahoma graduate students, and volunteers set up a grid of 21 by 1 meter squares east, west, and north of the cache. Workers dug to the bottom of the tilled soil, and several plow-broken large flakes and numerous small flakes were recovered during excavation and screening. All recovered artifacts were east and north of the cache. The artifact distribution is thought to be the result of five years of plowing in a consistent manner wherein the turned soil was moved east. In addition to the 42 artifacts found in situ (Figure 2), another 26 artifacts originated from the surface of the disturbed soil. These 26 artifacts are thought to have been part of the

FIGURE 2 Chert bifaces and flakes associated with the in situ cache.

FIGURE 3 Selected chert artifacts from the Hayhurst cache.

cache. In total, five ovate bifaces, one large triangular biface, four unused scrapers, 60 palm-size slightly smaller flakes, and 60 1 cm or smaller flakes were recovered from the site (Figure 3). Over half of the very small flakes could be refitted either to the broken large triangular biface or to a half dozen large flakes that were shattered or scraped by the plow.

No major prehistoric camp or village occupation has been found close to the site. So far, only a hammerstone of Ogallala quartzite about 30 m north of the site and the barb of a Calf Creek projectile point consisting of heated Frisco chert less than a quarter mile southeast of the site have been found. Except for the obsidian flake (discussed below), the artifacts recovered from site 34ML168 consist of Edwards Formation (Cretaceous Period) chert. Numerous caches of Edwards chert artifacts are known to be located in the southwest quarter of Oklahoma (Hammatt 1970a, 1970b; Hurst 2002; Levick 1975). Edwards chert has a blue-gray microcrystalline color with a chalky limey cortex. Traditionally, Edwards is thought to derive from the Georgetown–Round Rock–Austin area located east of the Balcones Escarpment in Texas (Banks 1990; Hofman 1991; Hofman et al. 1991). However, the Gault

Archaeological Research Center (Texas State University, San Marcos) geochemically sourced 42 of the in situ chert artifacts using XRF, and the trace elements were compatible with those of early Cretaceous Edwards chert found in the Callahan Divide area near Abilene, Texas.

Several clues implicate the Hayhurst cache as having a complicated taphonomic history. The five large bifaces found in place and the broken triangular one each exhibit a face that displays patination and abrasion scars. Patination is caused by those particular faces being exposed to the sun for many years (Glauberman and Thorson 2012; Miller 2010:572–573). The abrasion scars on the biface cores and a few large flakes attest to wear from carrying the items a long distance in a bag of some kind. The patina evident on most of these abraded surfaces implicates they were exposed to the sun for many years before being reburied at 34ML168. Notably, the five ovate bifaces were in the center of the cache and had their patinated and abraded faces down.

Wyckoff's study of the chert artifacts shows that the large bifaces and many of the large flakes have relatively wide and flat platforms. Some of the platforms have cortex, while some do not. Moreover, one restored large flake with a flat non-cortex platform was refitted to the non-patinated and unabraded face of one of the large bifaces. The large flakes served as biface cores, and some of which were made into end scrapers. The platforms characteristically have perpendicular platform angles, and they lack any traces of platform trimming, abrasion, or other signs of preshaping before flake removal. Several of the platforms display ring cracks, which is a feature of hard hammer direct percussion in the removal of large flakes (Cotterell and Kamminga 1990:140; Pelcin 1997).

Similar to many other lithic caches in North America (Hurst 2002; Muñiz 2014), no diagnostic artifacts were part of the Hayhurst cache, and this made temporal and cultural affiliation unclear. When viewed altogether, the technological attributes of the chert artifacts compare well with large biface cores associated with Middle Holocene Calf Creek Horizon (5500–4500 BP), which is known for this region (Thurmond and Wyckoff 1999; Wyckoff and Shockey 1994, 1995; Wyckoff et al. 1994). We suspect Calf Creek hunter-gatherers cached the chert bifaces and flakes because of the paucity of bedrock sources of highly isotropic chert in central Oklahoma. The abrasion scars on the chert biface cores and a few flakes likely derive from bag wear that occurred when these artifacts were carried north from their bedrock sources near the Callahan Divide area of West Texas. Before caching the artifacts at site 34ML168, the bifaces and large flakes were exposed to air and sunlight for many years, as evidenced by patination on some artifacts. The location of this initial stockpiling of the chert artifacts is unknown, but the number and the total weight of all bifaces and flakes, and the lack of surface abrasions on both faces of most artifacts is taken as evidence they were not reburied far from the original cache spot.

The obsidian flake

The triangular elongated obsidian flake (Figure 4) came from a 50 by 50 cm area, approximately two meters north and one meter east of the in situ cache.

FIGURE 4 The obsidian flake from 34ML168.

Unfortunately, the flake was not found in situ during excavations but instead was recovered after screening the sediment collected near the cache. Two lines of evidence support the obsidian flake association with the Hayhurst cache. First, plow-broken and damaged larger chert flakes were found east and north of the cache. We think the broken and damaged flakes were scattered from the destroyed eastern half of the feature because of plowing. Second, obsidian micro-flakes (Figure 5) were found following DNA analysis of the remaining sediment of the in

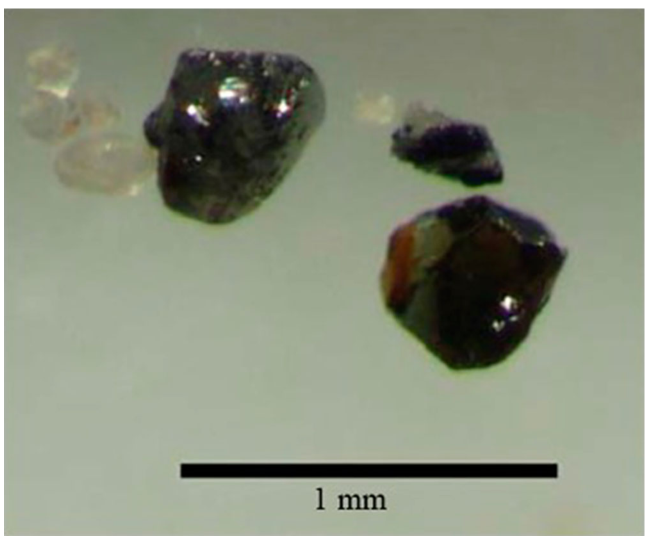

FIGURE 5 Obsidian micro-flakes from the in situ cache. Photo taken at 25× magnification by J.B. Sudbury.

situ chert scrapers (Fratpietro 2013). If the geochemical source of the micro-flakes matched the larger flake, then the obsidian artifact in question is part of the cache. However, the micro-flakes are too small and too thin for EDXRF spectrometry and may be likely too small for other sourcing methods (Davis et al. 2011).

Obsidian artifacts in Oklahoma originate from many geographic regions across North America. Sourcing studies indicate the majority of the obsidian comes from the Southwest in the Jemez Mountains, Mount Taylor, and No Agua Peak in New Mexico, the San Francisco Volcanic Field in Arizona, and sources in the Great Basin including Malad, and Owyhee in Idaho, Obsidian Cliff and Fish Creek/Teton Pass in Wyoming, and Black Rock Desert in Utah (Baugh and Nelson 1987; Baugh and Terell 1982; Brooks et al. 2014; Brosowske 2004, 2005; Hofman and Blackmar 2012; Vehik and Baugh 1994). Baugh and Nelson (1987) sourced two obsidian artifacts from the Alcorn site (34ML1), also in McClain County. The site dates to the Late Prehistoric or Early Plains Village (AD 1100–1450) and both artifacts sourced to the Black Rock Desert source in Utah. There is also the obsidian scraper from Spiro Mound in eastern Oklahoma that comes from the Pachuca obsidian mine in Hidalgo, Mexico (Barker et al. 2002). Pachuca is approximately 1800 km south of Spiro. Additionally, reported by Bell (1959), but not geochemically sourced as far as the authors know, an obsidian core that resembles that of Mesoamerican manufacture was found at the Edwards I site (34BK2) in southwest Oklahoma. Baugh and Terell (1982) sourced obsidian artifacts from the site, but they did not mention the polyhedral obsidian core.

Based on previous obsidian sourcing studies from Oklahoma, our assumption was that the obsidian flake from site 34ML168 most likely derived from a source either in the Southwest or the Great Basin. Nonetheless, the Southwest and Great Basin are hundreds of kilometers in opposite directions, and there are many geochemically distinct obsidian sources in both regions. The precise source identification using EDXRF spectrometry was critical for learning more about the obsidian flake from the Hayhurst cache.

EDXRF instrumentation and results

EDXRF spectrometry is arguably the most widely used geochemical sourcing method used by archaeologists to source obsidian artifacts for three reasons: (1) this method is non-destructive with little sample preparation required; (2) EDXRF is more cost-efficient compared to other methods; and (3) EDXRF spectrometers are available at most universities and research labs (Glascock 2011: Table 8.1). Archaeologists compare the elemental composition of obsidian artifacts with geologic samples from known primary sources around the world to connect archaeological artifacts to sources with a very high degree of confidence (Shackley 2011).

Shackley (2015) analyzed the obsidian flake at the Geoarchaeological XRF Laboratory using a ThermoScientific *Quant*'X EDXRF spectrometer for major oxide, minor oxide, and trace elements for the mid-Z elements Ti, Mn, Fe, Zn, Rb, Sr, Y, Zr, and Nb, and the high-Z element Ba. The instrumental protocol and settings for this analysis are outlined in Shackley (2005, 2011), and online at http://www.swxrflab.net/anlysis.htm. Results indicate the obsidian flake matches the USGS comparative sample RGM-1 (Rhyolite Glass Mountain) source standard from Glass Mountain in the Medicine Lake Highland Volcanic Field in Siskiyou County, northeastern California. Furthermore, the specimen does not match any other source in Shackley and Skinner's database of 210 individual and source groups (6650 individual cases) in North America. Sample RGM-1 is used as the standard for obsidian studies by most archaeological XRF laboratories (http://crustal.usgs.gov/geochemical_reference_standards/rhyolite.html; Table 1).

The obsidian artifact and Glass Mountain samples are a close match for most mid-Z elements (Rb, Sr, Y, Zr, and Nb), and similarly, the composition of the artifact and Glass Mountain source standard overlap completely for the mid-Z elements Ti–Nb and but less so Ba (Table 1 and Figure 6). Shackley sent the raw data to Skinner at the Northwest Research Obsidian Studies Laboratory for a blind test, because source characterization has verified good comparative results when data are generated by multiple knowledgeable analysts using instruments that are calibrated to published international geologic standards (Dillian 2016; Shackley 2008). Source material from Glass Mountain was analyzed from both Shackley's and Skinner's source standard libraries for comparison, and Skinner corroborated Shackley's earlier results.

Glass mountain obsidian

The Glass Mountain obsidian flake at site 34ML168 is the first documented case of northern California obsidian found in a Southern Plains archaeological context. Because of the great geographic distance between the Glass Mountain source and the site, approximately 2200 km (Figure 7), most Plains archaeologists are

TABLE 1

ELEMENTAL CONCENTRATIONS FOR THE ARTIFACT AND USGS RGM-1.

Sample	Ti	Mn	Fe	Zn	Rb	Sr	Y	Zr	Nb	Ba	Pb	Th	Source
34ML168-1	1828	292	14735	54	161	113	26	230	6	1030	24	18	Glass Mtn
GM-1	1793	291	14113	72	148	113	22	223	7	972	17	17	Glass Mtn source
GM-2	1980	344	16135	54	167	127	23	240	12	1101	19	21	Glass Mtn source
GM-3	1692	279	14157	43	154	115	24	232	9	1082	18	20	Glass Mtn source
GM-A	1976	327	16505	54	169	128	26	243	11	1234	21	16	Glass Mtn source
RGM1-S4	1623	283	13254	35	149	111	23	219	9	810	20	14	USGS Glass Mtn standard
	Na_2O %	MgO %	Al_2O_3 %	SiO_2 %	K_2O %	CaO %	TiO_2 %	MnO %	Fe_2O_3 %				
34ML168	4.103	0	13.216	74.345	4.4	1.251	0.282	0.041	2.017				
RGM1-S4	4.043	0	13.109	73.765	4.888	1.415	0.286	0.04	2.201				

Note: Measurements in parts per million (ppm) or percent by weight as noted. Values in parts per million (ppm). Ba typically runs higher for raw obsidian samples than pressed powder standards (see discussion at http://www.swxrflab.net/anlysis.htm.

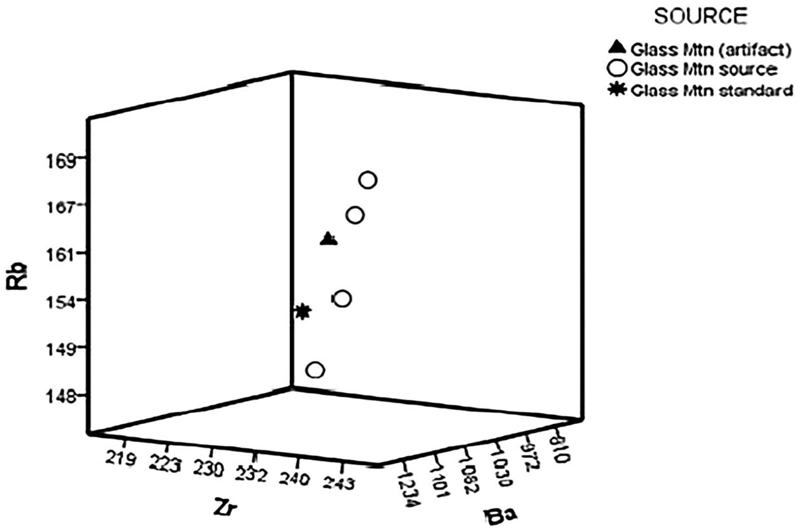

FIGURE 6 Three-dimensional plot of Zr, Rb, and Ba (ppm) on the artifact, Glass Mountain source (GM-1, GM-2, GM-3, GM-A), and Glass Mountain source standard (RGM1-S4). The higher Ba values for glass versus pressed powder standards is typical for Glass Mountain, including pieces analyzed at the Geoarchaeological XRF Lab from the original obsidian piece used by USGS (Stephen Wilson, USGS, Denver, personal communication, and see http://www.swxrflab.net/analysis.htm).

unfamiliar with the Glass Mountain source. Consequently, a brief description of Glass Mountain is provided.

Located approximately 60 km west of Mount Shasta in northern California, and 45 km south of the California/Oregon border, Glass Mountain is a high-quality obsidian source that is one of the better studied and well-dated sources due in part to early geologic, ethnographic, and archaeological work in California during the twentieth century (Anderson 1933; Ericson et al. 1976; Goldschmidt and Driver 1940; Heizer 1958; Hughes 1978, 1982, 1986; Kroeber 1925; Loud 1918; Rust 1905). Glass Mountain obsidian is therefore a time marker, and archaeologists have dated sites in California with tools and debitage made from Glass Mountain material (Hughes 1982). Today, flintknappers usually do not use Glass Mountain obsidian, because the area is restricted as the land is occupied by the Modoc and Achomawi tribes.

The archaeological and ethnohistoric record supports the importance of Glass Mountain to the people of the region. During and after the eruption the area was filled with poisonous gasses, fires, lightning, and lava flows. Dillian (2002, 2007) argues that the formation of Glass Mountain imprinted on people's social memory and created a prominent place in their cosmology. Among the Wintun, men journeyed two to three days while fasting to obtain Glass Mountain obsidian. The men fasted during the trip because "obtaining obsidian was seen as a semi-religious quest" (Hodgson 2007:307). Dillian (2002) demonstrates that rather than people making obsidian projectile points and tools from Glass

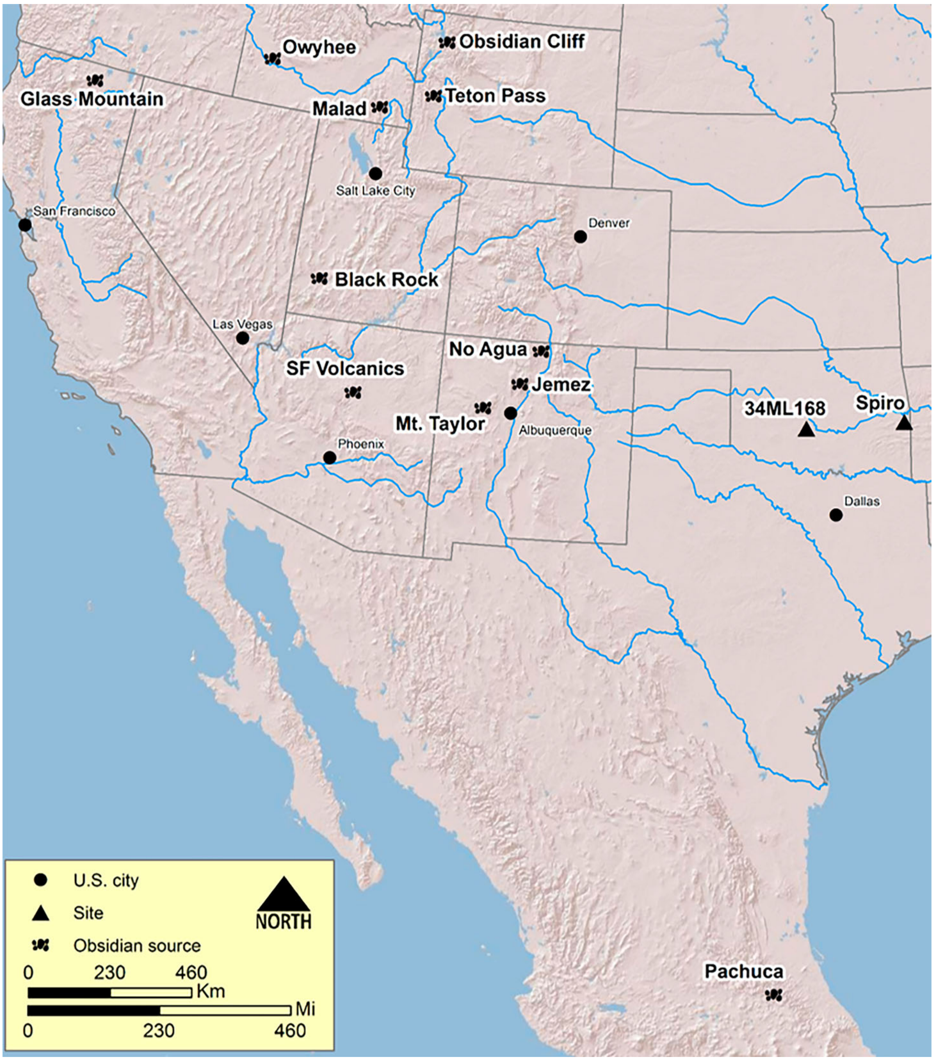

FIGURE 7 Location of obsidian sources and sites mentioned in the text.

Mountain obsidian, large ceremonial bifaces were made instead. The large bifaces were placed in high-status burials and were used as dance paraphernalia by many of the local tribes (Dillian 2002:43–53; Goldschmidt and Driver 1940; Heflin 1982; Hughes 1978; Loud 1918; Rust 1905). If people used Glass Mountain obsidian to make large bifaces like those illustrated in Kroeber (1925:Plate 2), and the circulation of Glass Mountain obsidian away from northern California is uncommon (Dillian 2002, 2016; Jackson and Ericson 1994:404), then how and why did a flake end up 2200 km east in a cache in central Oklahoma?

Discussion and conclusion

Despite establishing that a piece of Glass Mountain obsidian was moved 2200 km east into central Oklahoma and placed with a cache of Middle Holocene Calf Creek chert artifacts, our study still presents a chronological and interpretive anomaly for the archaeological record of Oklahoma and California. The creation of the Hayhurst cache is difficult to unpack because of the absence of diagnostic artifacts, absolute or relative dates, and limited material connections between northern California and the Southern Plains in antiquity. However, our results have regional and continent-wide significance.

Glass Mountain erupted around the time in North American prehistory when people began living in sedentary farming communities while continuing to rely to some extent on hunting and gathering. In central Oklahoma, the eruption is contemporaneous with the Paoli phase (AD 900–1250), and sedentary communities continued into the subsequent Washita River phase (AD 1250–1450) (Drass 1998, 1999, 2012). Elsewhere at this time, political complexity increased in the Cahokia region (Pauketat 2004), in the southern and northern Southwest (Di Peso 1974; Lekson 2006), and in southern California among the Chumash (Arnold 2004). Movement of goods between parts of California and the Southwest also occurred during the Late Prehistoric period (Smith and Fauville 2015), so it is possible that Southwestern groups could have played a role in the movement of Glass Mountain obsidian into the Southern Plains. However, discussion of contact between northern California and Plains peoples has been neglected because little in culture contact or raw material connects the two regions.

North American archaeologists have integrated Helm's (1988, 1991) ideas about the movement of people, objects, and ideas across long distances into their studies (Carr 2005; Gilman et al. 2014). Helms (1988, 1991) argues that forays into dangerous and sometimes unknown lands are undertaken for the purpose of acquiring foreign objects and esoteric knowledge from geographically and socially distant places to pursue power and prestige. Not only are the physical objects that people return with significant, but the raw material, color, smell, sound, and the place where the object or knowledge originates from can be equally powerful. The raw material of an object can connect people to faraway places that may hold significance to people's history and cosmology as pieces of places (Bradley 2000; Haskell 2015).

The Glass Mountain obsidian flake has a different texture and visual appearance from Southwestern and Great Basin obsidians. The visual aspect, as well as knowing the obsidian flake came from far distances may have been the reason for its incorporation into the Hayhurst cache. Torrence (2005:366) discusses how unmodified pieces of exotic raw materials "are more easily linked to distant, unknown, unpeopled and mysterious places than are products that exhibit identifiable, known places or individuals." The obsidian flake from site 34ML168 does not represent a formal tool or a large biface, but at one point it could have been a part of a large biface, a heavily imbued ritual object to the people of northern California. While impossible at this stage to provide adequate evidence, from our above discussion, it begs the question, did someone from northern California make the long-distance journey to central Oklahoma with a piece of Glass Mountain obsidian as tribute to gain esoteric knowledge from Southern Plains Village tribes, or did someone from Oklahoma travel to Glass Mountain and return with a piece of foreign obsidian?

Geochemical sourcing methods like EDXRF identify the primary source material of the artifact. Sourcing the artifact, however, does not help determine the mode of conveyance (Hughes 2011). The obsidian flake could have been moved down-the-line over generations or centuries through many hands beginning in northern California and ending in central Oklahoma alongside the Calf Creek artifacts. Periodic down-the-line exchange of obsidian artifacts occurred through time on the Southern Plains (Baugh and Nelson 1987). Down-the-line movement of artifacts may have resulted in the very slow conveyance of objects, particularly when the artifact originates far away (Dillian et al. 2010). Groups from the Southwest and Great Basin could have played a role in the movement of this obsidian flake since Southern Plains groups had loosely structured exchange networks with groups to the west.

The most vexing part of our study is that the biface technology that closely resembles the Hayhurst cache chert artifacts is Middle Holocene Calf Creek, yet Glass Mountain erupted thousands of years later. In other words, the chert artifacts were made many millennia before Glass Mountain obsidian came into existence. We cannot know the social significance of having a piece of Glass Mountain obsidian within the Hayhurst Calf Creek lithic cache, but it is not uncommon to have objects of varying antiquity and origin together to create a cache representing temporal curation. A similar practice happened inside the Great Mortuary inside Craig Mound at Spiro (Brown 2012).

The identification of a single obsidian artifact of demonstrable northern California origin at site 34ML168 is not indicative of culture contact between California and Plains groups, but we hope our research initiates such a discussion. The results provided in this paper are significant because no California obsidian artifacts have been found previously in archaeological contexts on the Southern Plains. Whether the obsidian artifact at site 34ML168 was the result of long-distance direct or indirect conveyance between groups in northern California and central Oklahoma is unknown. We are unclear if this event happened in prehistory or more recently because no radiocarbon samples were found during excavation and obsidian hydration dating was not permitted on the artifact. Similarly, we are uncertain about who or why people may have placed the Glass Mountain flake with a cache of artifacts made during the Middle Holocene. This research presents future opportunities for discussion concerning caches containing objects of varying antiquity and exotic raw materials.

Finally, Oklahoma archaeologists can expect a high frequency of obsidian deriving from sources in the Southwest and Great Basin. This study and that of Barker et al. (2002) offer the possibility that obsidian from Oklahoma archaeological contexts may come from other exotic sources from across North America. We encourage the continuation of sourcing obsidian from

Oklahoma and the Southern Plains to see if other artifacts originate from sources in California. We underscore the importance of using geochemical sourcing analyses to investigate the archaeological record because sourcing connects people-to-places-to-things, which help to unwrap the entanglements of extreme long-distance conveyance.

Acknowledgements

Special appreciation is expressed to Cole Hayhurst and his family for allowing the investigation of the site. Don Wyckoff, Marjorie Duncan, Amanda Regnier, Kristina Wyckoff, Sean Dolan, Ali Livesay, and John Young conducted excavations in 2014. J. Byron Sudbury (J.S. Enterprises of Ponca City, Inc.) performed the sediment analysis and discovered the obsidian micro-flakes. Mike Collins and the Gault Archaeological Research Project at Texas State University sourced the chert artifacts. Finally, we thank *Plains Anthropologist* editor Marcel Kornfeld, Timothy Baugh, Stance Hurst, Christopher Lintz, and anonymous reviewers for commenting on earlier drafts.

Disclosure statement

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

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References

Anderson, Charles A. (1933) Volcanic History of Glass Mountain, Northern California. *American Journal of Science* 26:485–506.

Arnold, Jeanne E., ed. (2004) *Foundations of Chumash Complexity*. Perspectives in California Archaeology 7. Cotsen Institute of Archaeology, Los Angeles.

Banks, Larry D. (1990) *From Mountain Peaks to Alligator Stomachs: A Review of Lithic Sources in the Trans-Mississippi South, the Southern Plains, and Adjacent Southwest*. Memoir 4, Oklahoma Anthropological Society, Norman.

Barker, Alex W., Craig E. Skinner, M. Steven Shackley, Michael D. Glascock, and J. Daniel Rogers (2002) Mesoamerican Origin for an Obsidian Scraper from the Precolumbian Southeastern United States. *American Antiquity* 67:103–108.

Baugh, Timothy G., and Fred W. Nelson (1987) New Mexico Obsidian Sources and Exchange on the Southern Plains. *Journal of Field Archaeology* 14:313–329.

Baugh, Timothy G., and Charles W. Terrell (1982) An Analysis of Obsidian Debitage and Protohistoric Exchange Systems in the Southern Plains as Viewed from the Edwards I Site (34BK2). *Plains Anthropologist* 27:1–17.

Bell, Robert E. (1959) Obsidian Core Found in Western Oklahoma. *El Palacio* 66:72.

Bradley, Richard (2000) *An Archaeology of Natural Places*. Routledge, New York.

Brooks, Robert L., Christopher Lintz, and Timothy G. Baugh (2014) *If It's Bright and Shiny: An Assessment of Sites with Obsidian in Oklahoma*. Paper presented at the 72nd annual plains anthropological society meeting, Fayetteville.

Brosowske, Scott D. (2004) Obsidian Procurement and Distribution During the Middle Ceramic Period of the Southern High Plains: Evidence for the Emergence of Regional Trade Centers. *Council of Texas Archaeologists Newsletter* 28:16–28.

Brosowske, Scott D. (2005) The Evolution of Exchange in Small-Scale Societies of the Southern High Plains. Ph.D. dissertation, University of Oklahoma, Norman.

Brown, James A. (2012) Spiro Reconsidered: Sacred Economy at the Western Frontier of the Eastern Woodlands. In *The Archaeology of the Caddo*, edited by Timothy K. Perttula and Chester P. Walker, pp. 117–138. University of Nebraska Press, Lincoln.

Caldwell, Joseph R. (1964) Interaction Spheres in Prehistory. In *Hopewellian Studies*, edited by Joseph R. Caldwell and Robert L. Hall, pp. 133–143. Scientific Papers Vol. 12. Illinois State Museum, Springfield.

Carr, Christopher (2005) Rethinking Interregional Hopewellian 'Interaction.' In *Gathering Hopewell: Society, Ritual, and Ritual Interaction*, edited by Christopher Carr and D. Troy Case, pp. 575–623. Springer, New York.

Chesterman, Charles W. (1955) Age of the Obsidian Flow at Glass Mountain, Siskiyou County, California. *American Journal of Science* 253:418–424.

Cotterell, Brian, and Johan Kamminga (1990) *Mechanics of Pre-Industrial Technology.* Cambridge University Press, Cambridge.

Davis, M. Kathleen, Thomas L. Jackson, M. Steven Shackley, Timothy Teague, and Joachim H. Hampel (2011) Factors Affecting the Energy-Dispersive X-Ray Fluorescence (EDXRF) Analysis of Archaeological Obsidian. In *X-Ray Fluorescence Spectrometry (XRF) in Geoarchaeology*, edited by M. Steven Shackley, pp. 45–63. Springer, New York.

DeBoer, Warren R. (2004) Little Bighorn on the Scioto: The Rocky Mountain Connection to Ohio Hopewell. *American Antiquity* 69:85–107.

Dillian, Carolyn D. (2002) More than Toolstone: Differential Utilization of Glass Mountain Obsidian. Ph.D. dissertation, Department of Anthropology, University of California, Berkeley.

Dillian, Carolyn D. (2007) Archaeology of Fire and Glass: The Formation of Glass Mountain Obsidian. In *Living Under the Shadow: Cultural Impacts of Volcanic Eruptions*, edited by John Grattan and Robin Torrence, pp. 253–273. Left Coast Press, Walnut Creek, California.

Dillian, Carolyn D. (2016) Current Questions and New Directions in Archaeological Obsidian Studies. doi:10.1093/oxfordhb/9780199935413.013.2.

Dillian, Carolyn D., Charles A. Bellow, and M. Steven Shackley (2010) Long-Distance Exchange of Obsidian in the mid-Atlantic United States. In *Trade and Exchange: Archaeological Studies from History and Prehistory*, edited by Carolyn D. Dillian and Carolyn L. White, pp. 17–35. Springer, New York.

Di Peso, Charles C. (1974) *Casas Grandes: A Fallen Trading Center of the Gran Chicimeca*. Vols. 1–3. Amerind Foundation, Dragoon, Arizona and Northland Press, Flagstaff.

Dolan, Sean G., Michael E. Whalen, Paul E. Minnis, and Shackley M. Steven (2017) Obsidian in the Casas Grandes World: Procurement, Exchange, and Interaction in Chihuahua, Mexico, CE 1200–1450. *Journal of Archaeological Science: Reports* 11:555–567.

Donnelly-Nolan, Julie M., Duane E. Champion, Miller C. Dan, Timothy L. Grove, and Deborah A. Trimble (1990) Post-11,000 Year Volcanism at Medicine Lake Volcano, Cascade Range, Northern California. *Journal of Geophysical Research* 95:19693–19704.

Drass, Richard E. (1998) The Southern Plains Villagers. In *Archaeology on the Great Plains*, edited by W. Raymond Wood, pp. 415–455. University Press of Kansas, Lawrence.

Drass, Richard E. (1999) Redefining Plains Village Complexes in Oklahoma: The Paoli Phase and the Redbud Plains Variant. *Plains Anthropologist* 44:123–133.

Drass, Richard E. (2012) Planting the Plains: The Development and Extent of Plains Village Agriculturalists in the Southern and Central Plains. In *Oxford Handbook of North American Archaeology*, edited by Timothy R. Pauketat, pp. 373–385. Oxford University Press, New York.

Ericson, Jonathon E., and Timothy G. Baugh, eds. (1993) *The American Southwest and Mesoamerica: Systems of Prehistoric Exchange*. Plenum Press, New York.

Ericson, Jonathon E., Timothy A. Hagan, and Charles W. Chesterman (1976) Prehistoric Obsidian in California II: Geologic and Geographic Aspects. In *Advances in Obsidian Glass Studies: Archaeological and Geochemical Perspectives*, edited by R.E. Taylor, pp. 218–239. Noyes Press, Park Ridge, New Jersey.

Fratpietro, Renee (2013) SER050-13 Final Report. Lakehead University Paleo-DNA Laboratory, Thunder Bay, Ontario. Report prepared for J. Byron Sudbury, J.S. Enterprises of Ponca City, Inc., and Don Wyckoff, Department of Anthropology, University of Oklahoma, Norman.

Gilman, Patricia A., Marc Thompson, and Kristina C. Wyckoff (2014) Ritual Change and the Distant: Mesoamerican Iconography, Scarlet Macaws, and Great Kivas in the Mimbres Region of Southwestern New Mexico. *American Antiquity* 79:90–107.

Glascock, Michael D. (2011) Comparison and Contrast Between XRF and NAA: Used for Characterization of Obsidian Sources in Central Mexico. In *X-Ray Fluorescence Spectrometry (XRF) in Geoarchaeology*, edited by M. Steven Shackley, pp. 161–192. Springer, New York.

Glauberman, Philip J., and Robert M. Thorson (2012) Flint Patina as an Aspect of 'Flaked Stone Taphonomy': A Case Study from the Loess Terrain of the Netherlands and Belgium. *Journal of Taphonomy* 10:21–43.

Goldschmidt, Walter R., and Harold E. Driver (1940) The Hupa White Deerskin Dance. *University of California Publications in American Archaeology and Ethnology* 35:103–142.

Griffin, James B. (1965) Hopewell and the Dark Black Glass. *Michigan Archaeologist* 11:115–155.

Hammatt, Hallett H. (1970a) A Cache of Flint Tools from Tillman County. *Newsletter of the Oklahoma Anthropological Society* 18:15–21.

Hammatt, Hallett H. (1970b) A Paleo-Indian Butchering Kit. *American Antiquity* 35:141–152.

Haskell, David L. (2015) Places to Go and Social Worlds to Constitute: The Fractal Itinerary of Tarascan Obsidian Idols in Prehispanic Mexico. In *Things in Motion: Object Itineraries in Anthropological Practice*, edited by Rosemary A. Joyce and Susan D. Gillespie, pp. 63–80. School for Advanced Research, Santa Fe.

Hatch, James W., Joseph W. Michels, Christopher M. Stevenson, Barry E. Scheetz, and Richard A. Geidel (1990) Hopewell Obsidian Studies: Behavioral Implications of Recent Sourcing and Dating Research. *American Antiquity* 55:461–479.

Heflin, Eugene (1982) The Huge Obsidian Ceremonial Blades of the Pacific Northwest. *Central States Archaeological Journal* 29:122–129.

Heizer, Robert F. (1958) Radiocarbon Dates from California of Archaeological Interest. *University of California Archaeological Survey Reports* 44:1–16.

Helms, Mary W. (1988) *Ulysses' Sail: An Ethnographic Odyssey of Power, Knowledge, and Geographical Distance*. Princeton University Press, Princeton, New Jersey.

Helms, Mary W. (1991) Esoteric Knowledge, Geographical Distance, and the Elaboration of Leadership Status: Dynamics of Resource Control. In *Profiles in Cultural Evolution*, edited by Robert D. Drennan, pp. 333–350. Anthropological Papers No. 85. Museum of Anthropology, University of Michigan, Ann Arbor.

Hodgson, Susan F. (2007) Obsidian: Sacred Glass from the California Sky. In *Myth and Geology*, edited by Luigi Piccardi and Bruce Masse, pp. 295–313. Geological Society of London Special Publications 273, London, England.

Hofman, Jack L. (1991) Folsom Land Use: Projectile Point Variability as a Key to Mobility. In *Raw Material Economy Among Prehistoric Hunter-Gatherers*, edited by Anta Montet-White and Steven R. Holen, pp. 335–355. Publication in Anthropology 19, University of Kansas, Lawrence.

Hofman, Jack L., and Jeannette M. Blackmar (2012) A Cody Complex Site on the Southern Prairie Plains. *Plains Anthropologist* 57:393–410.

Hofman, Jack L., Lawrence C. Todd, and Michael B. Collins (1991) Identification of Central Texas Edwards Chert at the Folsom and Lindenmeier Sites. *Plains Anthropologist* 36:297–308.

Hughes, Richard E. (1978) Aspects of Prehistoric Wiyot Exchange and Social Ranking. *Journal of California Anthropology* 5:53–66.

Hughes, Richard E. (1982) Age and Exploitation of Obsidian from the Medicine Lake Highland, California. *Journal of Archaeological Science* 9:173–185.

Hughes, Richard E. (1986) *Diachronic Variability in Obsidian Procurement Patterns in Northeastern California and Southcentral Oregon*, Vol. 17. University of California Publications in Anthropology, University of California Press, Berkeley.

Hughes, Richard E. (2011) Sources of Inspiration for Studies of Prehistoric Resource Acquisition and Materials Conveyance in California and the Great Basin. In *Perspectives on Prehistoric Trade and Exchange in California and the Great Basin*, edited by Richard E. Hughes, pp. 1–21. University of Utah Press, Salt Lake City.

Hull, Sharon, Mostafa Fayek, Frances Joan Mathien, and Heidi Roberts (2014) Turquoise Trade of the Ancestral Puebloan: Chaco and Beyond. *Journal of Archaeological Science* 45:187–195.

Hurst, Stance C. (2002) Caching Behavior on the Southern Plains. Master's thesis, Department of Anthropology, University of Oklahoma, Norman.

Jackson, Thomas L., and Jonathon E. Ericson (1994) Prehistoric Exchange Systems in California. In *Prehistoric Exchange Systems in North America*, edited by Timothy G. Baugh and Jonathon E. Ericson, pp. 385–415. Plenum Press, New York.

Jones, Andrew (2002) *Archaeological Theory and Scientific Practice*. Cambridge University Press, Cambridge.

Kozuch, Laura (2002) Olivella Beads from Spiro and the Plains. *American Antiquity* 67:697–709.

Kroeber, Alfred L. (1925) *Handbook of the Indians of California*. Bureau of American Ethnology, Smithsonian Institution. US Government Printing Office, Bulletin 78. Reprinted 1976 by Dover Publications, New York.

Lazzari, Marisa (2010) Landscapes of Circulation in Northwest Argentina: The Workings of Obsidian and Ceramics During the First Millennium AD. In *Social Archaeologies of Trade and Exchange: Exploring Relationships Among People, Places, and Things*, edited by Alexander A. Bauer and Anna S. Agbe-Davies, pp. 49–68. Left Coast Press, Walnut Creek, California.

Lekson, Stephen H., ed. (2006) *The Archaeology of Chaco Canyon: An Eleventh-Century Pueblo Regional Center.* School of American Research, Santa Fe.

Lekson, Stephen H. (2011) Historiography and Archaeological Theory at Bigger Scales. In *Movement, Connectivity, and Landscape Change in the Ancient Southwest*, edited by Margaret C. Nelson and Colleen Strawhacker, pp. 457–466. University Press of Colorado, Boulder.

LeVick, Lawrence E. (1975) A Cache of Preforms from Southwestern Oklahoma. *Bulletin of the Oklahoma Anthropological Society* 23:177–183.

Loud, Llewellyn (1918) Ethnogeography and Archaeology of the Wiyot Territory. *University of California Publications in American Archaeology and Ethnology* 14:221–436.

Martinón-Torres, Marcos, and David Killick (2015) Archaeological Theories and Archaeological Sciences. In *Oxford Handbook of Archaeological Theory*, edited by Andrew Gardner, Mark Lake and Ulrike Sommer. doi:10.1093/oxfordhb/9780199567942.013.004.

Mathien, Frances Joan, and Randall H. McGuire, eds. (1986) *Ripples in the Chichimec Sea: New Considerations of Southwester-Mesoamerican Interactions*. Center for Archaeological Invitations and Southern Illinois University Press, Carbondale and Edwardsville.

Miller, James C. (2010) Lithic Resources. In *Prehistoric Hunter-Gatherers of the High Plains and Rockies* by Marcel Kornfeld, George C. Frison and Mary Lou Larson, pp. 553–598. Left Coast Press, Walnut Creek, California.

Muñiz, Mark P. (2014) Determining a Cultural Affiliation for the CW Cache from Northeastern Colorado. In *Clovis Caches: Recent Discoveries and New Research*, edited by Bruce B. Huckell and J. David Kilby, pp. 107–131. University of New Mexico Press, Albuquerque.

Pauketat, Timothy R. (2004) *Ancient Cahokia and the Mississippians*. Cambridge University Press, Cambridge.

Pelcin, Andrew W. (1997) The Effect of Core Surface Morphology on Flake Attributes: Evidence from a Controlled Experiment. *Journal of Archaeological Science* 24:749–756.

Peregrine, Peter, and Stephen H. Lekson (2006) Southeast, Southwest, Mexico: Continental Perspectives on Mississippian Polities. In *Leadership and Polity in Mississippian Society*, edited by Brian M. Butler and Paul D. Welch, pp. 351–364. Southern Illinois University Press, Carbondale.

Peregrine, Peter, and Stephen H. Lekson (2012) The North American Oikoumene. In *Oxford Handbook of North American Archaeology*, edited by Timothy R. Pauketat, pp. 64–72. Oxford University Press, New York.

Quigg, J. Michael (2012) Obsidian Distribution: Evidence of West to East Movements in the Southern Plains Prior to the Plains Village Tradition. *Plains Anthropologist* 57:141–148.

Renfrew, Colin (1977) Alternative Models for Exchange and Spatial Distribution. In *Exchange Systems in Prehistory*, edited by Timothy K. Earle and Jonathan E. Ericson, pp. 71–90. Academic Press, New York.

Renfrew, Colin, Joseph Cann, and John Dixon (1965) Obsidian in the Aegean. *The Annual of the British School at Athens* 60:225–247.

Roper, Donna C., and Richard E. Hughes (2014) Source Analysis of Obsidian Debitage from Two Early Archaic Sites in Nebraska. *Plains Anthropologist* 59:58–69.

Rust, Horatio N. (1905) The Obsidian Blades of California. *American Anthropologist* 7:688–695.

Shackley, M. Steven (2005) *Obsidian: Geology and Archaeology in the North American Southwest*. University of Arizona Press, Tucson.

Shackley, M. Steven (2008) Archaeological Petrology and the Archaeometry of Lithic Materials. *Archaeometry* 50:194–215.

Shackley, M. Steven (2011) An Introduction to X-Ray Fluorescence (XRF) Analysis in Archaeology. In *X-Ray Fluorescence Spectrometry (XRF) in Geoarchaeology*, edited by M. Steven Shackley, pp. 7–44. Springer, New York.

Shackley, M. Steven (2015) Energy Dispersive X-Ray Fluorescence (EDXRF) Analysis of Major Oxide, Minor Oxide and Trace Element Concentrations for an Obsidian Flake from Archaic Contexts in Oklahoma. Report prepared for Don Wyckoff, University of Oklahoma, Norman.

Smith, Erin M., and Mikael Fauvelle (2015) Regional Interactions Between California and the Southwest: The Western Edge of the North American Continental System. *American Anthropologist* 117:710–721.

Spielmann, Katherine A., ed. (1991) *Farmers, Hunters, and Colonists: Interaction Between the Southwest and the Southern Plains*. University of Arizona Press, Tucson.

Thurmond, J. Peter, and Don G. Wyckoff (1999) The Calf Creek Horizon in Northwestern Oklahoma. *Plains Anthropologist* 44:231–250.

Torrence, Robin (2005) Valued Stone – How So? In *Many Exchanges: Archaeology, History, Community, and the Work of Isabel McBryde*, edited by Ingereth MacFarlane, Mary J. Mountain, and Robert Paton, pp. 357–372. Aboriginal History Monographs 11, Aboriginal History, Inc, Canberra.

Vehik, Susan C., and Timothy G. Baugh (1994) Prehistoric Plains Trade. In *Prehistoric Exchange Systems in North America*, edited by Timothy G. Baugh and Jonathon E. Ericson, pp. 249–274. Plenum Press, New York.

Vokes, Arthur W., and David A. Gregory (2007) Exchange Networks for Exotic Goods in the Southwest and Zuni's Place in Them. In *Zuni Origins: Toward a New Synthesis of Southwestern Archaeology*, edited by David A. Gregory and David R. Wilcox, pp. 318–357. University of Arizona Press, Tucson.

White, Nancy Marie, and Richard A. Weinstein (2008) The Mexican Connection and the Far West of the U.S. Southeast. *American Antiquity* 73:227–277.

Wyckoff, Don G., William L. Neal, and Marjorie A. Duncan (1994) The Primrose Site, 34MR65, Murray County, Oklahoma. *Bulletin of the Oklahoma Anthropological Society* 40:11–67.

Wyckoff, Don G., and Don Shockey eds. (1994) *Bulletin of the Oklahoma Anthropological Society* 40.

Wyckoff, Don G., and Don Shockey eds. (1995 Bulletin of the Oklahoma Anthropological Society 42.

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Article received July/18/2016; accepted June/12/2017