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Experimental sourcing of Edwards Plateau chert using LA-ICP-MS

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ABSTRACT

Sourcing artifacts is a key method for addressing anthropological issues of mobility and interaction. Although chert was one the most common toolstones used in prehistory, sourcing chert artifacts remains problematic. In this study an approach for sourcing chert is introduced that links a specific sampling protocol, Laser Ablation-Inductively Coupled Plasma-Mass Spectrometry (LA-ICP-MS), and multivariate statistical analysis. The effectiveness of this approach is demonstrated through a controlled experiment examining intersource and intrasource variability at four different scales of analysis. The statistical analysis at four spatial scales allows determination of the spatial resolution of the chemical matching procedure outlined here. In this experiment geologic chert samples from the Edwards Plateau of Texas of known provenience are chemically evaluated allowing comparison of their expected origin against their known origin. This experiment used Edwards Plateau chert as it is a high quality material and was a major lithic source across the Southern High Plains and was often transported great distances. Macroscopic identification of Edwards Plateau chert can be problematic and at its best is unable to effectively discern from where within the 120,000 km^2 of the region cherts originated. An understanding of the geological formation processes of chert provides a useful framework for addressing this issue. This study shows that through an effective methodology Edwards Plateau chert can be sourced to a finer spatial scale than previous studies.

1. Introduction

Artifact sourcing is a critical method for understanding hunter-gatherer mobility in prehistory. The sourcing of chert artifacts is very difficult, but the need is great due to the common use of chert as a toolstone in prehistory. The research explained here provides a methodological approach for chert sourcing using a specific sampling protocol, an instrumental technique, and multivariate statistical analysis. The value of this methodological approach is confirmed through a controlled experiment examining intersource and intrasource variability at four different scales of analysis. The statistical analysis at four spatial scales allowed determination of the spatial resolution of the chemical matching procedure outlined here.

Intersource variability is the geochemical differences between chert samples from different geologic formations; while intrasource variability is the geochemical differences between chert samples in the same geologic formation. A discussion of the geology of the Edwards Plateau cherts and their associated geologic formations and processes behind their creation is presented.

An experiment was conducted with Edwards Plateau chert from Texas, as it is a high quality material and was a major lithic source across the Southern High Plains and was often transported great distances (Banks, 1990; Hofman et al., 1991; Collins et al., 2003; Bement and Carter, 2010). Therefore, the Edwards Plateau was chosen as an ideal location to develop geochemical sourcing. Macroscopic identification of Edwards Plateau chert can be problematic and at its best is unable to effectively discern from where within the 120,000 km^2 of the Edwards Plateau region chert originated. This study provides an effective methodology to source Edwards Plateau chert at several spatial scales.

A fundamental issue in sourcing is demonstrating that variability within a source (intrasource) is less than the variability between sources (intersource); therefore, allowing particular sources to be differentiated (Shackley, 2008). It is widely believed that chert sources have too much variability to be accurately differentiated from other sources. Many chert sourcing studies have difficulty demonstrating clear differences among sources in the same manner that has been demonstrated for obsidian using elemental biplots (Glascock, 2004; Roll et al., 2005; Huckell et al., 2011). Many times sources of volcanic glass are pinpointed to a particular volcanic eruption or flow event with clear chemical contrasts among flows (Shackley, 2005). Thus far, chert studies have not been able to

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accomplish this level of resolution. Chert can be classified with some success using techniques such as Instrument Neutron Activation Analysis (INAA) at the scale of large geologic formations but breaks down at finer spatial scales, such as within a geologic formation (Hoard et al., 1993; Huckell et al., 2011). An understanding of the geological formation processes of chert provides a useful framework for addressing this issue.

2. Edwards Plateau cherts

In contrast to obsidian, chert does not retain its geochemical signal as effectively through geologic time; as it is especially subject to movement of mobile elements in the matrix (Knauth, 1994; Malyk-Selivanova et al., 1998; White, 2013). This property of chert can serve as a beneficial medium for understanding local variability in sources. The formation processes and diagenetic events that cause variability in chert sources must be understood in order to better evaluate those settings where geochemical variation may be greatest; such as at peripheral edges of geologic formations (Boggs, 2009). Geologic formation processes can lead to different geochemical signatures in chert and affect inter-source variability. In order to effectively understand how geologic formations may create these different geochemical signatures it is important to fully understand the geologic formation history of the areas being studied (White, 2013). This information can reveal whether individual outcrops formed quickly, under the same circumstances, or were formed much more slowly and perhaps were subject to different geologic processes (Knauth, 1979, 1994).

Globally, chert is present in stratigraphic sequences ranging hundreds of millions of years in age from Precambrian to Quaternary (Heaney et al., 1994). The Edwards Plateau region and all associated limestone formations occur over an area nearly a fifth the size of Texas (120,000 km^2) (see Fig. 1). The Edwards Plateau region is considered one of the largest chert bearing zones in North America (Banks, 1990). The areas studied are spread across several geologic groups of the Lower (Early) Cretaceous Comanche Series in Texas (Housh, 2007). A geologic group is a lithostratigraphic unit that is a collection of two or more adjoining formations that diagnostic lithologic properties in common. A geologic formation is the fundamental lithostratigraphic unit that is distinctive in appearance as either a homogenous stratum or a group of heterogeneous strata that vary from adjacent or overlying and underlying units (Waters, 1992; Brookfield, 2004; Boggs, 2011). The changes in textural appearance of strata determine the boundaries of formations.

Geologic chert samples of known provenience from geologic formations within the Edwards Plateau region (see Fig. 1) were chemically evaluated allowing comparison of their expected origin against their known origin. The formations investigated included: the Edwards Limestone formation, the Georgetown Limestone formation, an undivided part of the Edwards and Comanche Peak Limestone formations, and an undivided part of the Fredericksburg Group. For detailed geologic information about these formations see Banks (1990), Frederick and Ringstaff (1994) and Housh (2007).

2.1. Formation processes of Edwards Plateau cherts

The primary limestone formations comprising the Edwards Plateau region are the result of calcareous shelled organisms that filled the Early (Lower) Cretaceous marine waters covering Texas from 100 to 146 million years ago (Spearing, 2008; Cohen et al., 2013). The formation of chert throughout the Edwards Plateau is based upon the pelagic sediments laid down during this period and subsequent diagenesis and consolidation of silica (Knauth, 1994; Boggs, 2009). The elevated Edwards Plateau region that is seen today occurred 10–20 million years ago during the Miocene. This was created during a period of active tectonic movement and faulting which resulted in an uplifting event of the formation to around 600 m a.s.l in Central Texas. This regional uplift also formed the Balcones Escarpment (fault zone) which skirts the eastern edge of the Edwards Plateau.

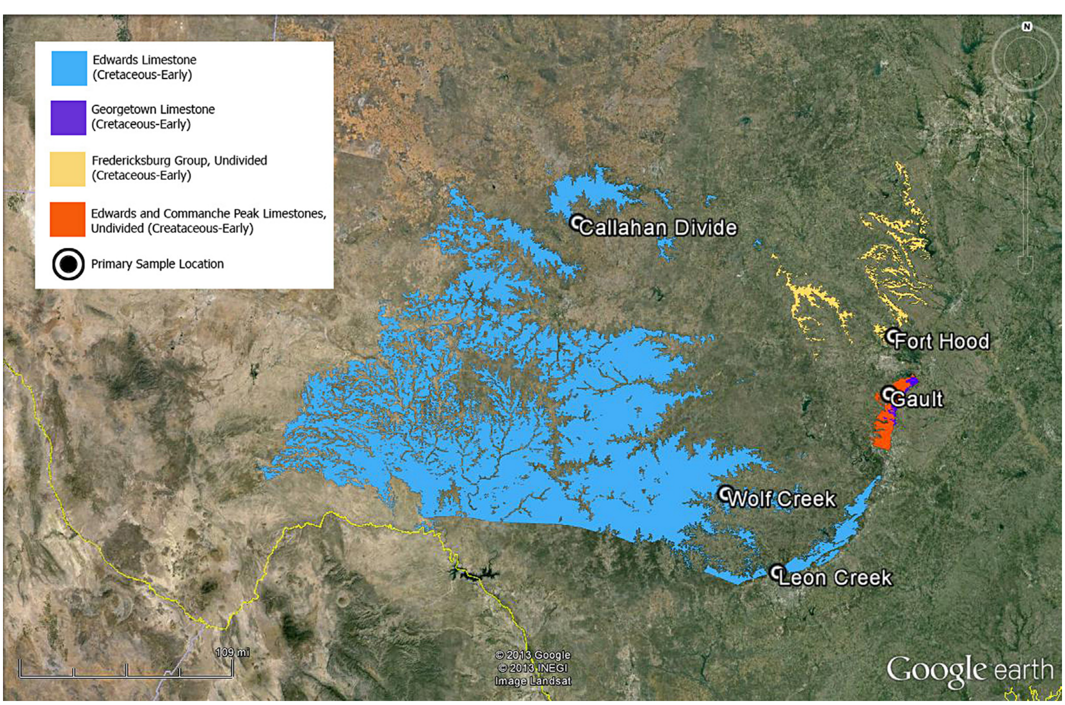

Fig. 1. Edwards Plateau study area with associated geologic formations and primary sample locations. Information derived from USGS Mineral Resources Online Spatial Data.