EDITORIAL

Welcome to part two of issue #6 of The Quarry which includes a research report on the prehistoric Dover quarry sites and the provenance of chert swords in Tennessee.

As ever I would like to reiterate my call for papers / reports or brief notes from the membership. This is your newsletter and an easy way to get your information out to our 700+ members. There is no cost involved, and if material is forthcoming I can put newsletters out as frequently as needs be. And as you will have discovered, The Quarry is also now available on the SAA website in the members section devoted to interest groups, so circulation is about as good as it could be. We are interested in news stories, discoveries, research reports, notification of meetings or conferences, new publications and generally anything to do with studies of prehistoric extraction sites – and without any geographical bias. As Seasick Steve says ‘It’s all good’. So what are you waiting for, get a paper in to the Editor at:

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Notes for contributors

Contributions can be any length but ideally up to 2000 words maximum and supplied in Word format. Plans and photographs should be supplied as low resolution jpegs; try to keep these to 5 or less to keep the Editors job as simple as possible and prevent the file size from growing too large. It will also help authors focus their efforts and use only the critical images. If you do use photographs please ensure that you can also supply written permission from the photographer for their use, and if anyone is featured in a photo that they also give their written permission for their image to be used in the e-newsletter and on the SAA website. These copyright procedures are essential to protect the interests of all concerned and must be in place before web dissemination can take place.
Ongoing provenance research of non-utilitarian Mississippian chert “swords” preliminarily indicates that local lithic materials were used in their manufacture despite being in close proximity to the large prehistoric quarry sites of Dover, Tennessee. The pilot study utilizes non-destructive reflectance spectroscopy techniques to source a Mississippian sword fragment to locally outcropping Fort Payne chert despite the occurrence of visually similar Dover chert extensively quarried 52 linear kilometers to the north. Though small in scope, the study provides data that point to exploitation of local resources contrary to conventional visual assignment of the material to the Dover Quarry sites of north-central Tennessee.

Figure 1. The four recorded Dover Quarries; Brigham (40Sw64) top left, Commissary Ridge (40Sw80) top right, Cross Creek (40Sw66) bottom left, Thompson Hollow (40Sw67) bottom right, individual quarry pits overlaying aerial photograph, hydrology, and elevation layer data.
Dover chert is synonymous to the prehistoric Southeastern United States. This lithic type is thought to have been exploited throughout all prehistoric temporal components reaching an apex during the Mississippian Period (1000-1600 AD). At this time, a large quarry complex developed near Dover, Tennessee, though the quarry sites themselves have never been directly dated. Presently there are four known Dover quarry sites (Brigham [40Sw64], Cross Creek [40Sw66], Thompson Hollow [40Sw67], and Commissary Ridge [40Sw80]) occurring in a four kilometer radius of each other near the Cumberland River (Figure 1). The largest quarry, the Brigham Quarry, consists of 341 pits/amorphous trenches covering 39 square kilometers. Quarry pits dug into the silt-clay soil matrix and talus debris blanket the hillslopes and bluff faces (Figure 2). Potential evidence for bedrock mining exits at one of the sites, Cross Creek Quarry, but most of the mining activity is evidenced by numerous quarry pits up to 5 meters in diameter dug into the soil matrix.

Dover chert can be described as a light to dark brown, medium to fine grained chert with varying dark to light lenticular mottles (Figure 3). Calcite geodes are often found as inclusions in the matrix ranging in color from a milky white to light blue either solid or crystalline in nature. The
chert occurs in nodular form ranging from a few centimeters to fifty centimeters in diameter. The larger nodules are commonly referred to as ‘cannonballs’. No tabular or bedded forms of Dover chert were noted at the quarries however frost fracturing of many of the nodules result in the presence of half cobbles. The color variation present in the material can be directly attributed to varying degrees of silicate replacement processes and weathering to which the individual nodule or piece has been subjected.

Figure 3. Visually similar dark varieties of Fort Payne (left) and Dover (right).

Problem Statement

Dover chert is assigned to the Lower St. Louis Limestone Formation which has a conformal relationship with the underlying Warsaw Limestone Formation (Marcher 1962a, 1962b). In situ deposits of Dover chert nodules can be observed at three (Brigham, Cross Creek, and Thompson Hollow) of the four quarry sites. South of the Dover quarries the Carlisle Fault line exposes outcrops of the Fort Payne Limestone Formation, oldest of the Mississippian aged limestone formations. The Fort Payne contains both nodular and bedded chert deposits ranging in color from tan/brown, blue, and black often with the same dark mottling as observed in Dover chert (Figure 3). Both the dark fine grained varieties of Dover and Fort Payne are visually similar and it is the hypothesis of the current study that they may have been misidentified based on traditional visual chert provenance identification.

During the Mississippian period Dover, in addition to Mill Creek, Kaolin and Burlington chert, were often used to manufacture a wide range of agricultural implements including hoes, adzes, chisels, and celts. In addition to these utilitarian items, large bifaces were manufactured whose function seems to best fit into esoteric or ideology realms. Maces, hooks, discs, effigies, daggers, and swords manufactured from Dover chert can be found across the Southeastern and Midwestern United States and make up part of what has collectively become known as the Southern Cult (Marceaux and Dye 2007). Large caches of these items have been recovered
from habitation sites and mortuary contexts. Probably the best known of these caches, the Duck River Cache, comes from the Link Farm Site (40Hs6) where 46 bifaces were recovered. Large (20-70cm) bifacial thin parallel sided swords make up a portion of the cache and have traditionally been identified as Dover chert from the Dover Quarries (Figure 4).

![Figure 4](image-url)  
*Figure 4. A portion of the Duck River cache ‘sword’ forms visually identified as Dover chert. Figure adapted from Lewis and Kneberg (1958).*

Though Dover chert nodules large enough have been observed at the quarry sites and fragments of swords have been recovered in close proximity to the Brigham Quarry (Gramly 1992), the presence of visually similar Fort Payne chert at the Link Farm site and surrounding area should not be overlooked as a potential source for the swords. Definitive evidence for prehistoric exploitation of Fort Payne chert at the Link Farm site has yet to be found however
the presence of thin high quality lenses of chert in the soil matrix and thick bedded deposits in the hillslopes surrounding the site lends doubt to previous provenance determinations for the swords (Figure 5 and 6).

Figure 5. Fort Payne chert outcrop at the Link Farm site, Tennessee, approximately 40 cm in length.

Methodology

A single chert sword fragment recovered during excavations at the Link Farm site was analyzed to determine whether the source of the material was manufactured from locally outcropping Fort Payne or the visually identified Dover chert source (Figure 7). A total of 40 chert samples, 20 from the four Dover quarry sites and 20 from Fort Payne chert outcropping from both the site and abroad, were analyzed in addition to the sword fragment using non-destructive Fourier-Transform Infrared (FT-IR) reflectance spectroscopy. The study is admittedly limited in scope with the analysis of a single sword fragment and a small chert sample database which almost certainly does not effectively characterize the deposit, however, analysis was conducted to investigate two main objectives. First the study tested whether reflectance spectroscopy (FT-IR) could accurately differentiate the two material types and secondly whether the sword fragment was indeed manufactured from the more distant Dover chert or from locally outcropping Fort Payne deposits.
Figure 6. Fort Payne chert outcrop 5 kilometers to the west of the Link Farm site showing bedded horizons within the soil matrix.

Fourier Transform Infrared (FT-IR) reflectance spectroscopy is potentially a fast, cost efficient and accurate method for identifying chert provenance (Figure 8). The technique records electromagnetic radiation/matter interactions in the middle-infrared region (2,500-25,000nm) of

Figure 7. Mississippian ‘sword’ fragment found during excavations at the Link Farm site 40Hs7.
the electromagnetic spectrum. FT-IR reflectance spectroscopy records how electromagnetic radiation is differentially absorbed or reflected by the molecular content of the sample being analyzed. Certain molecules with specific bonding properties will react to the incoming electromagnetic radiation at specific wavelengths. These interactions in the form of molecular stretching, bending, and rotating will absorb a portion of the radiation at that specific wavelength. These multiple molecular interactions within a sample will produce a series of reflectance peaks and absorption valleys, termed spectral features, when graphically portrayed (Figure 9). Each series of spectral features for a sample are collectively called the sample’s spectrum and is potentially diagnostic for the chert type and/or outcrop location. A more comprehensive discussion of the geologic application of the method may be found in Salisbury (1993). The FT-IR method is similar to the Portable Infrared Mineral Analyzer (PIMA) described by Hughes et al. (1998); Emerson and Hughes (2000); Wisseman et al. (2002); and Wisseman et al. (2010) which analyzes radiation/matter interactions in the near-infrared (1300-2500nm) region of the electromagnetic spectrum.

Figure 8. BioRad FTS-40 Fourier Transform Infrared Spectrometer used during analysis.

The FTIR technique provides qualitative information regarding elemental data and the atomic configuration of mineral assemblages in chert. The mineralogical and chemical content of chert is dominated by SiO₂ molecules. The SiO₂ spectral features are the largest within the chert spectrum occurring as reflectance and absorption peaks between 8,000-9,500 nm and again at
12,000-13,500nm (Figure 9). Though the mineralogical content of chert is essentially alpha quartz, impurities including iron oxides, carbonates, magnesium, and organic matter either can be visualized by small spectral features or alter the slope of the SiO$_2$ features (Figure 9). The culmination of this spectral variation may potentially be diagnostic for chert type (i.e. geologic parent formation) or outcrop location.

**Figure 9.** Four reflectance spectra of Fort Payne and Dover chert samples with SiO$_2$ and Carbonate features highlighted. Spectra vertically offset for display.

Spectral reflectance analysis of the 40 total Dover and Fort Payne chert samples were compiled into a spreadsheet database and derivative transformed in order to remove the continuum and smooth signal to noise interferences (Clark 1999; Mark and Workman 2003) (Figure 10). The spectral database consisting of chert samples with known provenance provided a means to internally test the ability of the technique/method to differentiate Dover from Fort Payne. The accuracy test treated each of the 40 samples as an unknown and compared it to the other 39 chert samples. A Pearson’s correlation matrix was the statistical method chosen to match each hypothetical unknown spectrum to a known spectrum. The absolute highest correlation score was determined to be the match of the sample. A correct match was assigned if a chert sample had its highest correlation score with another chert sample of the same type (e.g. Dover to Dover or Fort Payne to Fort Payne) (Table 1).
Figure 10. First derivative transformed reflectance spectra of Fort Payne and Dover chert samples. Spectra vertically offset for display.

Table 1. Partial correlation matrix showing absolute highest scores highlighted in red. This internal accuracy test showed that the technique/method was able to correctly identify Dover chert from Fort Payne chert 95% of the time.
Results

Results of this internal test demonstrated that the technique (FT-IR reflectance spectroscopy) and analytical method (Pearson’s correlation) correctly differentiated Dover from Fort Payne chert 38 out of 40 (95%) of the time. One Dover sample mismatched with a Fort Payne and one Fort Payne mismatched to a Dover sample. Taken the high degree of accuracy of the internal test the chert type of the unknown sword fragment should be identified with only a small margin of error.

A series of three spectral measurements were taken on the sword fragment and averaged together to control for intra-artifact variation. The average spectrum of the sword fragment was derivative transformed and analyzed using the Pearson’s correlation coefficient method within the chert spectral database to determine its best match. The absolute highest correlation score of the chert sword fragment was with a Fort Payne sample obtained from an outcrop five kilometers to the west (Figure 11). In fact, the first 16 highest correlation scores were with Fort Payne samples obtained locally, both on site and up to 20 km distant.

Figure 11. First derivative transformed reflectance spectra of the average sword fragment, Fort Payne, and Dover chert samples. The sword fragment had its highest correlation score ($r = 0.992$) with Fort Payne sample 12. Spectra vertically offset for display.
Conclusions

The results demonstrate the ability of the FT-IR reflectance technique to quickly, non-destructively, and accurately provenance chert at the inter-outcrop variation scale. Spectral measurements of 20 samples of Dover and 20 samples of Fort Payne chert shows that despite some overlapping variation, enough differences inherent in the molecular bonding, impurities, and mineral composition exists to accurately differentiate the two visually similar chert types. The collection of more samples from geographically and geologically defined outcrops will increase the reliability of the results. The collection and analysis of more samples may also aid in the characterization of distinct outcrops in turn facilitating sourcing artifact to outcrop.

The analysis of a single Mississippian sword fragment tells us little about human behavior related to lithic selection and procurement for these non-utilitarian items at the Link Farm site. More provenance analysis of a larger sample of Mississippian swords is required to begin to answer questions relating to material type and geologic/geographic origins. The relationship that the Dover Quarries has with the production of this unique artifact type is of particular interest. The study highlights the need for analytical chert provenance studies which provides a more robust method for determining geologic/geographic source than visual identification. Our explanations for Mississippian trade, craft specialization, and resource acquisition will be different if future studies demonstrate greater lithic source variability for the sword forms.

References


