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All that glitters isn't calcite: a research update on crystalline artifacts from the Middle Cumberland Region

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ABSTRACT
This report offers updated information from crystalline artifact research results initially presented in 2014 by Michael C. Moore and colleagues. At that time, worked and raw crystal items from four Mississippian sites in the Middle Cumberland Region of Tennessee were assessed by the Tennessee Geological Survey as calcite through visual techniques. Subsequent analysis using Fiber Optic Reflectance Spectroscopy (FORS) has determined these specimens are, in fact, fluorite. The known sample of six worked crystal artifacts in 2014 has also increased by 50% through the recent discovery of two earplugs and one bead from three Mississippian period sites. FORS analysis determined these three artifacts to be fluorite as well.

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Crystalline objects; Mississippian sites; Middle Cumberland Region; FORS analysis; fluorite; Tennessee

In 2014, initial results regarding worked crystalline artifacts recovered from Middle Cumberland Region sites in Tennessee were presented at the Society for American Archaeology meeting in Austin, Texas, and later published in *Southeastern Archaeology* (Moore et al. 2014a; 2014b). This research focused on six finished crystal objects, one partially ground crystal specimen, and 21 raw crystals recovered from four Mississippian period sites (Castalian Springs, 40SU14; Rutherford-Kizer, 40SU15; Cheyenne Trace, 40DV195; and an unrecorded location in Williamson County). This admittedly modest assemblage comprised the only known crystalline artifacts within the study area at that time.

New information from continuing research of study area crystalline artifacts is presented in this work (Bow et al. 2016; Moore et al. 2017). Most notably is an updated analysis of the crystal assemblage elemental and mineralogical make-up through Fiber Optic Reflectance Spectroscopy (FORS). This technique has refined our initial identification of these crystal items as calcite through visual inspection, to a more accurate classification as fluorite.

This report also introduces three finished crystal specimens added to our dataset after 2014. These recently discovered artifacts comprise two earplugs and one bead, raising our known sample of worked items from six to nine. The earplugs originated from two Mississippian period sites (Logan, 40DV8; and Patterson, 40CH69) where crystal artifacts had been previously unreported (Figure 1). The bead, recovered from the Mississippian period Castalian Springs site (40SU14), comprises yet another item from a locale that has yielded the most worked and raw crystal artifacts known from the Middle Cumberland Region (see Figure 1).

2014 Investigation results

The 2014 study focused upon the Middle Cumberland Region (see Figure 1), an area that encompasses those drainages in north-central Tennessee between the confluence of the Caney Fork and Cumberland Rivers to the east, and the confluence of the Red and Cumberland Rivers to the west (Moore et al. 2006:90). Readers interested in learning about Middle Cumberland Mississippian archaeology have numerous choices to consult (e.g., Beahm [2013]; Cobb et al. [2015]; Jones [1876]; Klippel and Bass [1984]; Krus and Cobb [2018]; Moore et al. [2006]; Moore et al. [2016]; Moore and Smith [2009]; Putnam [1878]; Sharp [2019]; Smith [1992]; Smith and Miller [2009]; Thruston [1972]; Vidoli [2012]; and Worne [2017]). Despite the extensive archaeological investigations performed

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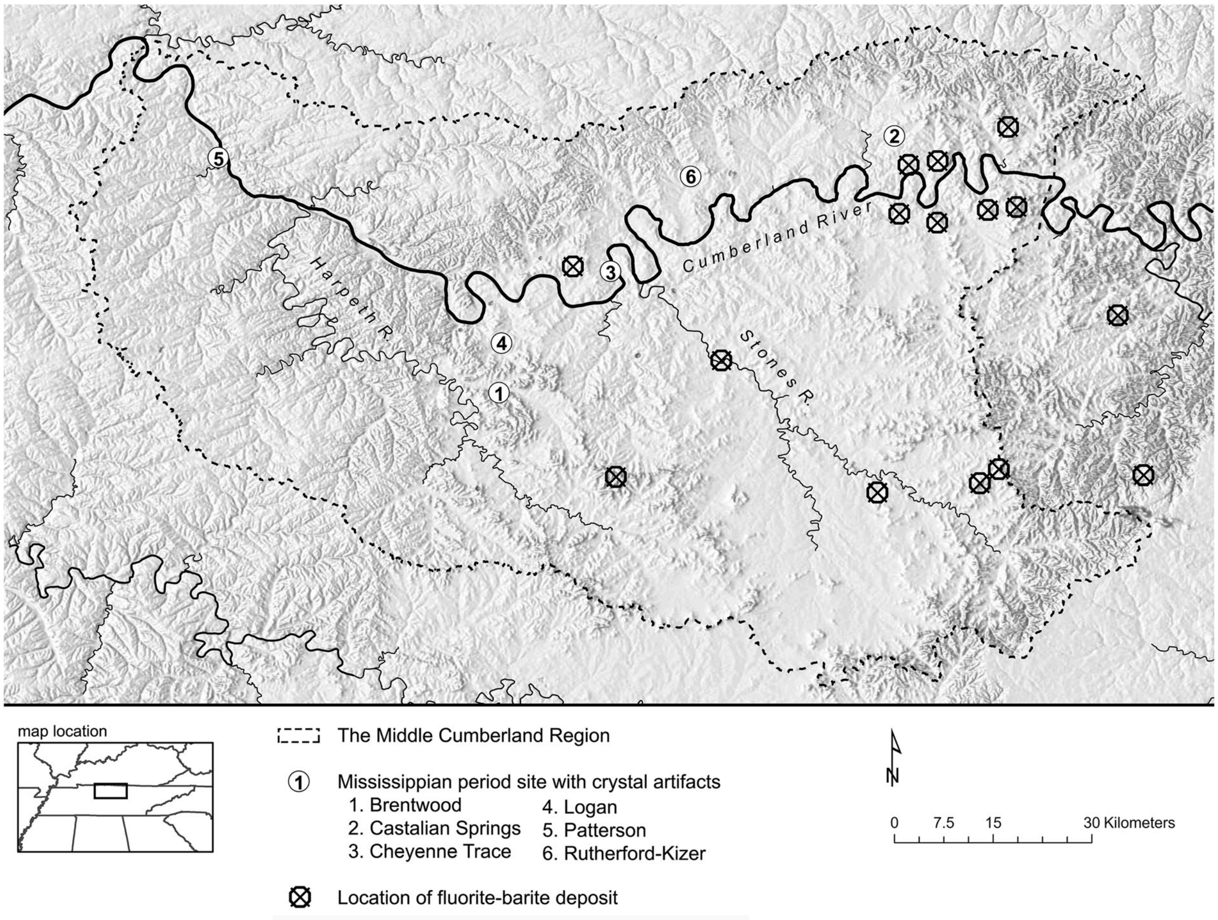

Figure 1. The Middle Cumberland Region of Tennessee (after Eckhardt and Deter-Wolf 2020) and the six recorded Mississippian sites with crystal artifacts.

throughout the study area since the 1800s, just a few worked crystalline objects were mentioned and/or recorded in the literature (Ball 2014; Clark 1878; DuVall & Associates 1993; Moore and Smith 2009; Myer 1923).

A review of the potential origin of these artifacts determined the parent material did not necessarily come from locales outside the Middle Cumberland Region (such as the Illinois-Kentucky Fluorspar District of southeastern Illinois and western Kentucky). In fact, such crystals were determined to be available in mineral veins that occurred within faults and fissures inside the deep Ordovician limestone deposits beneath the study area (Moore et al. 2014b:32–33; see Figure 1). These mineral veins, composed primarily of barite and fluorite, also included calcite, galena, and sphalerite (Floyd 1965; Hardeman and Miller 1959; Jewell 1947). Further discussion regarding how the ancient inhabitants acquired these materials noted no ancient crystal quarry or surface spoil sites recorded within the study area.[1] Based on these factors, the authors proposed the known crystal artifacts may have been recovered from the numerous caves and sinkholes found throughout the region (Moore et al. 2014b:33).

Updated element/mineral analysis

The original 2014 analysis concluded the recorded specimens were calcite based upon visual examinations by the Tennessee Geological Survey. However, renewed examination using other techniques has yielded results that confidently define these items as fluorite.

The analytical analysis of this project began in late 2014 by examining a subset of crystal artifacts with a Bruker Tracer III-SD, handheld portable X-ray fluorescence spectrometer (PXRF). This instrument is equipped with a rhodium tube and a silicon drift detector that allows for the identification of multiple elements based on how atoms behave when they interact with radiation (Shackley 2011). More importantly, analyses are completely nondestructive to the specimen. Resulting data appear as spectral peaks, the sizes of which correspond to elemental concentration. Our qualitative analysis focused on exploring the presence or absence of elements as well as the relative concentrations. The most prominent element in the spectral data was calcium, a primary constituent in calcite ($CaCO_3$). Calcium is also the main element comprising fluorite (CaF_2), a well-documented crystal mineral used in the midcontinental region of Illinois and western Kentucky (Boles 2012). Unfortunately, light elements such as fluorine possess electron shells far too small to produce substantiative fluorescence. In short, our PXRF analysis could not distinguish between these two calcium-rich minerals. While the results could not confirm the crystals as calcite, the data do exclude quartz (SiO_2) as the raw material based on the minor amounts of silicon (Figure 2).

To elucidate the raw material further, in 2016 mineralogical spectral data were collected using an ASD Field-Spec4 Standard-Res portable spectroradiometer manufactured by Malvern Panalytical. This instrument uses a fiber optic cable to project the incident beam of light into the sample where it is reflected, scattered, and transmitted through the sample material. The light is reflected back toward the source, collected by the fiber optic cable, and directed to the instrument detector optics. Spectral software depicts this data as a waveform shape comprised of reflectance maxima (peaks) and absorptions (valleys) that can be broad or narrow features depending on the specimen mineralogy.

The instrument used in this study can identify the mineralogy of a specimen based on reflectance characteristics in the visible-near infrared (VNIR; 400–1000 nm) and short-wave infrared (SWIR) wavelength regions (1000–2500 nm). In addition to the base instrument (detector and fiber optics), an ASD Muglight was fitted to the end of the fiber optic cable to gather reliable reflectance and absorbance measurements while mitigating measurement errors associated with stray light and specular reflected components. To this, a black neoprene sleeve was added to provide a light seal and soft buffer between the attachment and artifacts. The instrument was calibrated prior to data collection using a Spectralon reflectance panel, a thermoplastic resin that is 96–99% reflective in the 250–2500 nm wavelength range.

The FORS spectral data were interpreted using ENVI image analysis software to compare spectral data to known references from multispectral data (Kokaly et al. 2017). Interpretations for this study were also informed by reference data collected on calcite and fluorite samples from the southeast (mainly Tennessee and Georgia) housed at the Tellus Science Museum in Georgia and samples from private collections.

An analysis was performed on 45 archaeological specimens from four sites across the Middle Cumberland Region.[2] This sample included modified as well as raw/unmodified crystals (Table 1). FORS absorption features from all archaeological crystals are consistent with the mineral fluorite rather than calcite. Carbonate absorption bands in the SWIR generally occur at 1900 nm, 2350, and 2500 nm, and are produced due to combination and overtones (Gupta 2003; Figure 3). Reflectance spectra are extremely sensitive to the presence of water, which has strong absorption features at 1400 and 1900 nm. Fluid inclusions are typical in carbonate minerals and are present in all the samples analyzed. Calcite spectral features identified include these water features as well as diagnostic absorptions

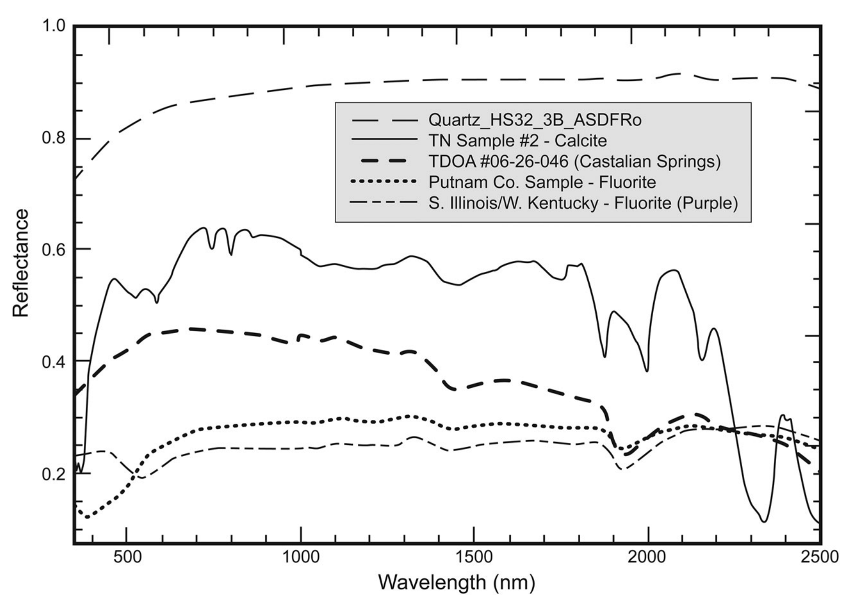

Figure 2. FORS spectral overlays of calcite, fluorite, and quartz.

Table 1. FORS-examined Middle Cumberland Region worked and unmodified crystal artifacts.

Site No	Site Name	Context/Cat No.	Artifact Type	FORS Result
40DV195	Cheyenne Trace	Stone-box, Burial 19	Earplug	fluorite
40DV8	Logan	Stone box, Burial 159	Earplug	fluorite
40CH69	Patterson	Surface collection	Earplug	fluorite
40SU14	Castalian Springs	Midden, Test Unit A5	Bead	fluorite
40SU14	Castalian Springs	Mound 3, N1169E790	Earplug	fluorite
40SU14	Castalian Springs	Mound 3, N1169E774	Earplug	fluorite
40SU14	Castalian Springs	TDOA #05–01–005	Unmodified	fluorite
40SU14	Castalian Springs	TDOA #05–01–008	Unmodified	fluorite
40SU14	Castalian Springs	TDOA #05–01–014	Unmodified	fluorite
40SU14	Castalian Springs	TDOA #05–01–015	Unmodified	fluorite
40SU14	Castalian Springs	TDOA #05–01–019	Unmodified	fluorite
40SU14	Castalian Springs	TDOA #05–01–021	Unmodified	fluorite
40SU14	Castalian Springs	TDOA #05–01–027	Unmodified	fluorite
40SU14	Castalian Springs	TDOA #05–01–037	Unmodified	fluorite
40SU14	Castalian Springs	TDOA #05–01–056	Unmodified	fluorite
40SU14	Castalian Springs	TDOA #05–01–057	Unmodified	fluorite
40SU14	Castalian Springs	TDOA #05–01–073	Unmodified	fluorite
40SU14	Castalian Springs	TDOA #06–26–008	Unmodified	fluorite
40SU14	Castalian Springs	TDOA #06–26–012	Unmodified	fluorite
40SU14	Castalian Springs	TDOA #06–26–017	Unmodified	fluorite
40SU14	Castalian Springs	TDOA #06–26–030	Unmodified	fluorite
40SU14	Castalian Springs	TDOA #06–26–033	Unmodified	fluorite
40SU14	Castalian Springs	TDOA #06–26–043	Unmodified	fluorite
40SU14	Castalian Springs	TDOA #06–26–046	Unmodified	fluorite
40SU14	Castalian Springs	TDOA #06–26–050	Unmodified	fluorite
40SU14	Castalian Springs	TDOA #06–26–052	Unmodified	fluorite
40SU14	Castalian Springs	TDOA #06–26–054	Unmodified	fluorite
40SU14	Castalian Springs	TDOA #06–26–061	Unmodified	fluorite
40SU14	Castalian Springs	TDOA #06–26–083	Unmodified	fluorite
40SU14	Castalian Springs	TDOA #06–26–092	Unmodified	fluorite
40SU14	Castalian Springs	TDOA #06–26–093	Unmodified	fluorite
40SU14	Castalian Springs	TDOA #06–26–148	Unmodified	fluorite
40SU14	Castalian Springs	TDOA #07–07–012	Unmodified	fluorite
40SU14	Castalian Springs	TDOA #07–07–034	Unmodified	fluorite
40SU14	Castalian Springs	TDOA #08–21–144	Unmodified	fluorite
40SU14	Castalian Springs	TDOA #08–21–152	Unmodified	fluorite
40SU14	Castalian Springs	TDOA #08–21–212	Unmodified	fluorite
40SU14	Castalian Springs	TDOA #08–26–050	Unmodified	fluorite
40SU14	Castalian Springs	TDOA #09–09–229	Unmodified	fluorite
40SU14	Castalian Springs	TDOA #11–04–114	Unmodified	fluorite
40SU14	Castalian Springs	TDOA #11–04–156	Unmodified	fluorite
40SU14	Castalian Springs	TDOA #11–04–160	Unmodified	fluorite
40SU14	Castalian Springs	TDOA #11–04–164	Unmodified	fluorite
40SU14	Castalian Springs	TDOA #11–04–181	Unmodified	fluorite
40SU14	Castalian Springs	TDOA #11–04–329	Unmodified	fluorite

2000 nm, 2150 nm, and 2350 nm. Spectral features can also be present between 550 and 800 nm if the specimen contains any visible color.

Fluorite, on the other hand, lacks many spectral features in the VNIR and SWIR regions as compared to calcite (Figure 4). Apart from the water bands at 1400 and 1900 nm, fluorite does not exhibit features 2000 nm, 2150 nm, or 2350 nm. Again, depending on the color of the fluorite crystal, additional features may be present beginning at 700 nm indicating visible red to violet colors.

Recently defined worked crystalline objects

Castalian Springs (40SU14)

The Castalian Springs mound complex was established on a northern terrace of Lick Creek in Sumner County (see Figure 1). Late nineteenth- and early twentieth-century investigations by William E. Myer yielded records of several crystal earplugs from the site area (Ball 2014; Myer 1923). Middle Tennessee State University (MTSU) later conducted a series of archaeological field schools between 2005 and 2011, recovering two small crystal earplugs, one partially ground crystal, and 21 raw crystals (TDOA 2013). It is this density of worked and raw crystal items that led the authors to suggest the likelihood of crystal production at Castalian Springs (Moore et al. 2014b:36).

MTSU initiated a new program of work at Castalian Springs in the summer of 2017. The 2017 project focused on the southern site area to evaluate the mineral springs vicinity for evidence of prehistoric salt manufacturing and processing. Among the artifacts recovered from Test Unit A5 in a midden zone was a very small,

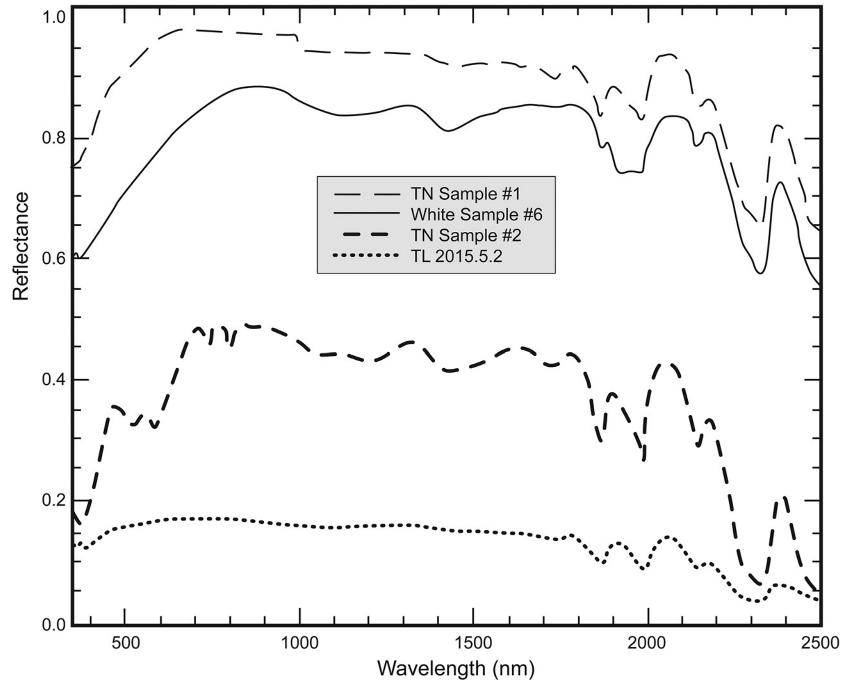

Figure 3. Calcite variability.

clear crystal bead measuring 7.5 mm in diameter and 3.7 mm in width (Figure 5). FORS analysis identified the specimen as fluorite. In addition, MTSU performed an EDS (Energy-Dispersive X-ray Spectroscopy) analysis on the bead with the result suggested as fluorite (Eubanks 2017).

Logan (40DV8)

The Logan site represents a Mississippian town on a low ridge overlooking Vaughn's Gap Branch just southwest of its confluence with Richland Creek in Davidson County (see Figure 1). The site was officially recorded in the early 1970s but had long been a popular location for people to

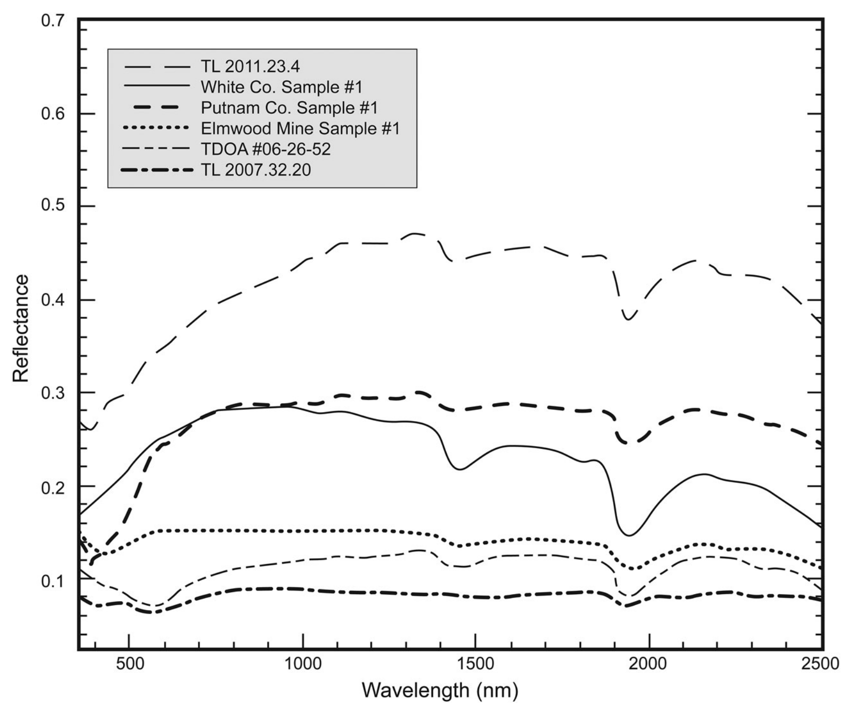

Figure 4. Fluorite variability.

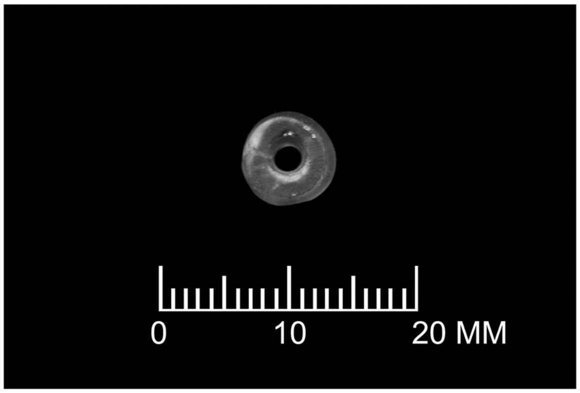

Figure 5. Fluorite bead recovered in 2017 from a midden at the Castalian Springs Mound site, 40SU14.

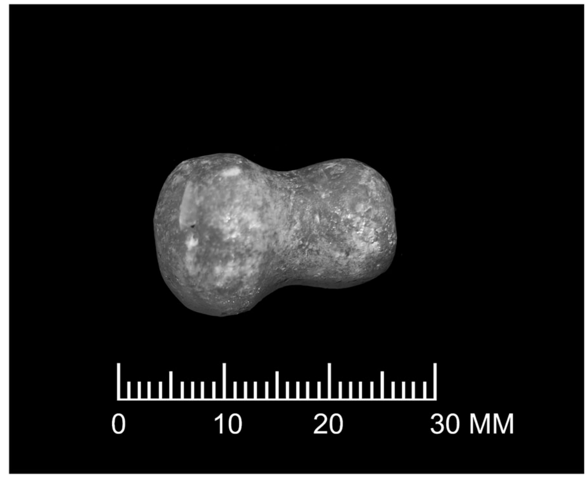

Figure 6. Yellow fluorite earplug recovered from site surface at the Patterson site, 40CH69.

surface collect as well as dig stone-box graves in search of artifacts. Retail construction starting in 1972 curtailed much of this activity. However, a 1990 utility trench dug across the house lot adjacent to the retail construction disturbed several stone-box graves (TDOA 2015).

A 2016 proposed private construction project for that same house lot raised red flags that additional burials would be disturbed. Based upon the 1990 documentation of graves, the landowner obtained a Davidson County chancery court order to define, remove, and rebury all burials within the proposed construction footprint.[3] A private consultant conducted the work in 2017, and one of the exposed stone-box graves contained a purple, dumbbell-shaped crystal earplug. An examination of the specimen using FORS determined it to be fluorite. This earplug measured 23 mm long with a maximum diameter of 12.8 mm and represents the only purple color artifact documented for the study area so far.

Patterson (40CH69)

Patterson comprises a relatively unknown Mississippian site near the confluence of the Cumberland River and Big Bartons Creek in Cheatham County. This site was recorded in the mid-1970s based on shell-tempered ceramics and a few Dover chert items collected from the surface.

In 2016 the division was notified that a private artifact collection from this site included a crystal earplug picked up during a surface hunt (Figure 6). Subsequent analysis of this specimen using FORS defined it as fluorite. This yellow, dumbbell-shaped artifact measured 22.7 mm long, with a maximum diameter of 15.7 mm.

Concluding remarks

A primary objective following the 2014 work was to use available and future technology to accurately identify the minerals used to manufacture the crystal artifacts found in the Middle Cumberland Region. Fiber Optic Reflectance Spectroscopy analysis provided the precise means to accomplish this goal. Through this invaluable technique, we can confidently correct our initial assessment to say the Middle Cumberland Region artifacts recovered to date are made of fluorite rather than calcite.

Why is this distinction between fluorite and calcite important? The obvious answer is to correctly identify the parent material acquired and worked by the prehistoric artisans. Scientific inquiry should strive for accuracy whenever possible. While visual techniques were able to broadly define the project materials from other crystal minerals (such as quartz), they did not prove reliable for a more sensitive identification. Visual identifications of fluorite/calcite in the future should be considered provisional until verified by FORS or other discriminating technology.

The reasons behind fluorite seemingly being preferred over calcite (or other crystalline sources) are not obvious. For example, how could one mineral crystal be easily distinguished over another if native inhabitants were indeed acquiring materials from local caves using torches? It is tempting to offer that a variety of crystals were initially collected while below ground and later sorted after reaching the surface. But, the result of such sorting should leave some trace of non-fluorite crystals visible in the archaeological record, whether as small discrete features or in refuse pits. No such evidence has been found to date.

The 2014 research noted fluorite and calcite are relatively soft minerals with similar properties and colors (Moore et al. 2014b:25–26). Fluorite is a bit harder than calcite, 4.0 vs. 3.0 on Mohs hardness scale. Fluorite also has an octahedral cleavage whereas calcite displays a rhombohedral cleavage. Perhaps clues to mineral choice lie within these slight differences. Could it be the harder fluorite, with an octahedral cleavage, is simply more reliable to work than the softer calcite with a rhombohedral cleavage? Whatever the reason, the revised data supports fluorite as the mineral crystal of choice for Mississippian inhabitants of the Middle Cumberland Region.

FORS analysis also allows the potential of finding original locations for the raw materials used to manufacture these artifacts. This possibility is especially important as we further evaluate the increasing likelihood that the Castalian Springs mound site (40SU14) was a center for the production of fluorite crystal artifacts. The bead discovered in 2017 by MTSU only adds to that intriguing notion. We know resources were available as the site was established within an area rich in mineral vein deposits (see Figure 1).

Nondestructive technology such as FORS now allows researchers to better understand the material culture. While reflectance spectroscopy has not been a common method for pursuing archaeological material research, a notable exception has been the study of chert sources (Parish 2011; 2016; Parish and Werra 2018; Sherman et al. 2023). The authors encourage future scholars using FORS and other technology to create open-access databases that would allow for comparison of various material types and source locations. Continuing analyses of crystalline specimens from various mines and other sources across the study area will hopefully, one day, yield that moment where a particular crystal artifact can be precisely traced back to its original source location.

Finally, another important project goal continues to be documenting additional worked crystal artifacts from study area sites. By 2014 we had, literally, a handful of defined items for review from four sites (Moore et al. 2014b). Documents from mid-to-late nineteenth-century and early twentieth-century excavations provided evidence that other worked crystal artifacts had been previously recorded or observed (Ball 2014; Clark 1878; Moore et al. 2014b:29–30; Myer 1923). These clues worked in our favor that additional crystal specimens exist in private and museum collections or have yet to be discovered through additional explorations. Such expectations were confirmed by the end of 2017 with the discovery of three more worked crystal items. Confidence remains high that future discoveries await this ongoing research project.

Notes

1. A May 2023 review of the Tennessee Division of Archaeology site files affirmed that no crystal quarry or surface spoil sites have been recorded to date.
2. Two worked specimens mentioned in the 2014 research were not part of the FORS testing (see Moore et al. 2014b:28–29). As noted in the 2014 study, the Rutherford-Kizer (40SU15) bead was reburied in 1995 in accordance with Tennessee state law. The bird effigy figurine from an unspecified location in Williamson County, held in a private collection, was not available for this analysis.
3. Tennessee state law provides a mechanism for public and private landowners to relocate a cemetery from one piece of property to another. This mechanism is the Termination of Land Use as Cemetery statute (T.C.A. 46-4-101-104). A landowner has the legal right, through the termination statute, to seek a court order to remove and relocate a cemetery at the landowner's expense. The decision to remove graves is up to the landowner, and the law is used for both ancient and modern burials. The proposed construction project that impacted the Logan site area was a privately funded venture on private property (in other words, this was not a project that invoked NAGPRA). All skeletal remains and associated burial objects removed from Logan were held at the private consultant's office until they were reburied on the property in 2018 in accordance with the chancery court order and as mandated by Tennessee state law (T.C.A. 11-6-119).

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Our deepest appreciation goes to several individuals and organizations for sharing their discoveries with the project team. Dr. Paul Eubanks with the Department of Sociology and Anthropology at Middle Tennessee State University (MTSU) informed authors Moore and Smith of the worked crystal bead recovered during the 2017 MTSU Archaeological Field School. Tennessee Valley Archaeological Research (TVAR) alerted author Moore regarding the Logan site (40DV8) earplug. Mr. Maury Miller notified author Moore regarding a crystal earplug he picked up many years ago while surface-collecting site 40CH69.

Disclosure statement

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

Data availability statement

Site information, data, and materials used in this study are maintained at the Tennessee Division of Archaeology in Nashville, Tennessee.

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