SnRI
Technical Notes
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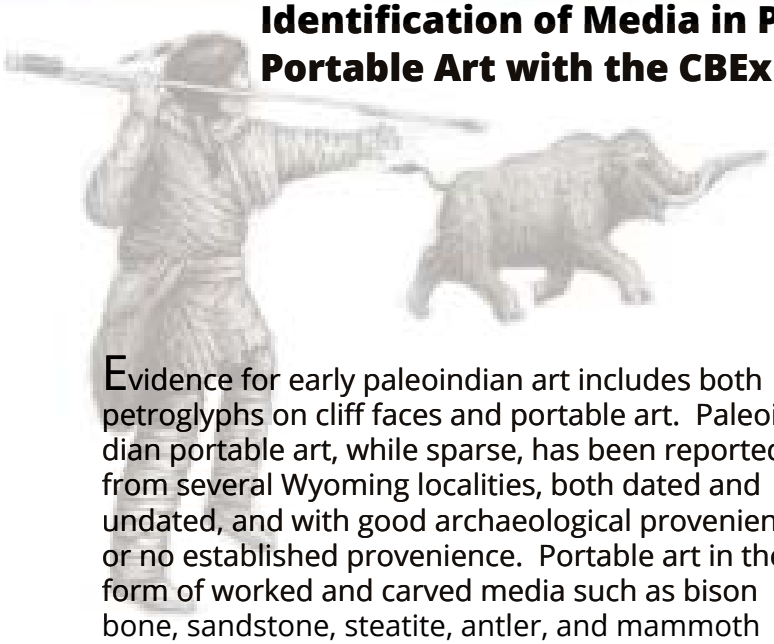
Art and Archeology Series

Identification of Media in Paleoindian Portable Art with the CBEx 1064



Evidence for early paleoindian art includes both petroglyphs on cliff faces and portable art. Paleoindian portable art, while sparse, has been reported from several Wyoming localities, both dated and undated, and with good archaeological provenience or no established provenience. Portable art in the form of worked and carved media such as bison bone, sandstone, steatite, antler, and mammoth ivory objects has been excavated at several Paleoindian campsites dating before 8,000 years. Taken by themselves, these are often some of the rarest objects recovered from the sites, but they are consistently present when campsites are excavated.

Lightweight at 1.2 lbs - Non-destructive - No Consumables - Portable Power with Common AA Batteries -Reduce & Eliminate Fluorescence

Our Authors

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The CBEx 1064 is the worlds smallest and most portable SWIR (short wave infrared) handheld Raman system and is ideal for Art and Archeology applications. The measurement is non-destructive and does not require any consumables. Its ruggedized and lightweight (1.2 lbs) field design can handle those long and arduous pack trips. Field portable power is supplied by two AA batteries so you don't have to worry about AC power when in remote locations. The power variable 1064 nm laser allows you to identify more samples because it reduces interfering fluorescence found in many artifacts that are caused by most cellulosic fibers, pigments and dyes.

Barns Tusk One of the most intriguing Paleoindian portable art piece from Wyoming, the Barnes tusk, was found about five years ago. This is assumed to be an incised segment of mammoth ivory that was collected by an avocational archaeologist in the Big Horn Basin of Wyoming not far from the Legend Rock. The photographs at right show an artifact fragment of what appear to be ivory, based on its herring bone surface texture, and even more intriguing are the geometric incisions which appear to encircle its circumference. We now have reason to doubt the Pleistocene antiquity of the site where it was found, but we still believe the artifact is of at least Clovis age, and therefore has the potential to inform us about early Paleoindian art technologies. We initially believed the tusk to be mammoth ivory, but it is certainly possible it could be mastodon. We used the handheld Raman CBEx 1064 by SnRI to assist in identifying the media and to authenticate it as archeological ivory.

Figure 1. Rotational displays of the Barns Tusk found near the Big Horn Basin. The tusk fragment has a mass of 434 g, or close to one pound, and is 14.9cm in length

The CBEx 1064 Fights Interfering Fluorescence One-Handed

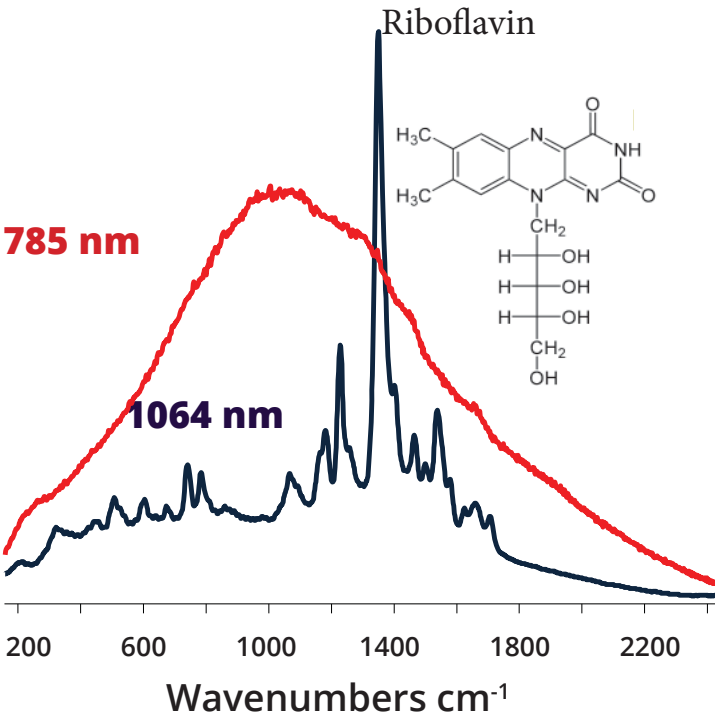

Figure 2. Raman spectra illustrating the 1064 nm system reducing intefering fluorescence in Riboflavin. A major problem associated with the Raman spectroscopic analysis of ivories is the onset of fluorescence emission, which can occur in the more common 785 nm laser excitation systems. This fluorescence emission is several orders of magnitude greater than the Raman effect, generated through the laser excitation of low energy excited electronic states of impurities or other associated materials in the sample. The adoption of long wavelength laser radiation such as 1064 nm laser excitation is insufficient to probe these electronic energy levels and an answer to this problem for the recording of Raman spectra from archaeological ivories.

Is the Barns Tusk Archeological Ivory?

Teeth are highly mineralized and comprised of over 96 % weight inorganic mineral primarily in the form of hydroxyapatite , $[Ca_{10}(PO_4)_6(OH)_2]$ which is a crystalline form of calcium phosphate. The top Raman spectrum in Figure 3 displays the primary phosphate band frequency ν1 (PO_4) at 960 cm^{-1}, which gives evidence of a modern Bison tooth that has not undergone mineralization (calcification).

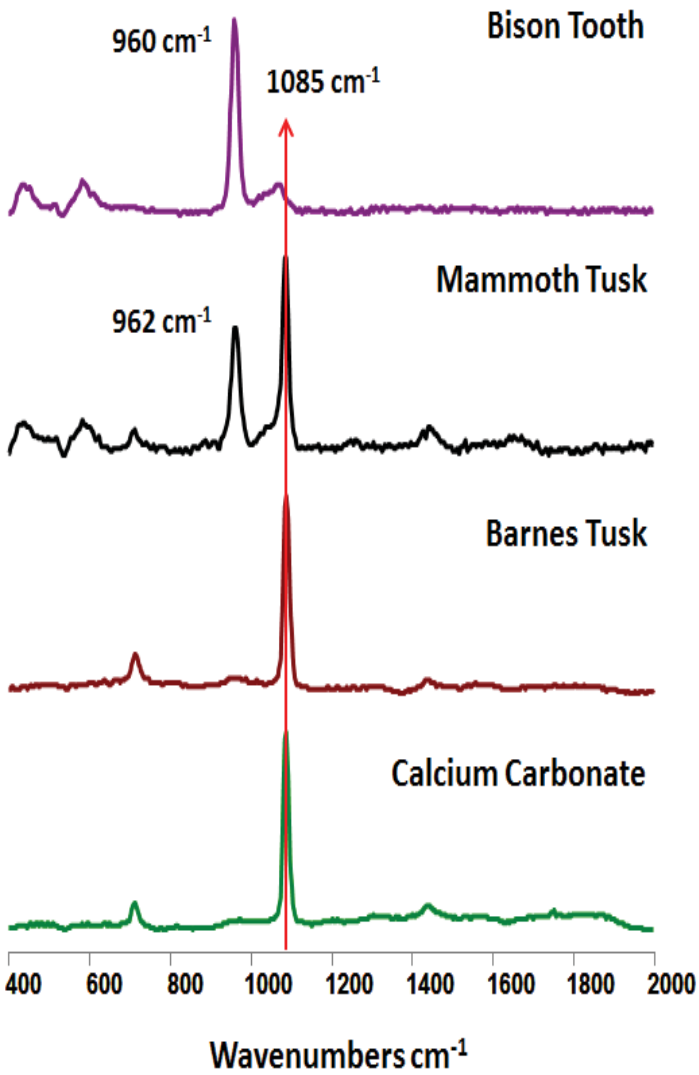

Figure 3. Handheld Raman spectra using the CBEx 1064 for Bison Tooth, Mammoth Tusk, Barnes Tusk, and Calcium Carbonate. In Figure 2 above we illustrate the Raman spectra acquired from a bison This hand-held spectrometer with a point and shoot attachment permitted non-destructive spectra to be acquired at multiple locations on the sample. The laser power was adjusted to 250 mW at the sample. The spectral resolution of this system is 16 wavenumbers.

A Mammoth tusk is derived from the modification of the upper incisor tooth; thus, ivory can vary with the enamel, dentin and pulp regions of the tusk and consists of osteons comprising a matrix of hydroxyapatite and proteinaceous collagen. Modern ivories can be distinguished using chemometric methods and plotting the ratios of hydroxyapatite and collagen.

As ivory ages, such as in mammoth tusks, the organic elements (collagen) tend to leach out and are subject to mineralization over time with the degree of substitution varying on the burial environment, and not indicative of the age of the specimen. This mineralization process can lead to substitution with calcium carbonate, and it has been observed that ivories buried in permafrost environments have less mineralization. However, literature suggests that hydroxyapatite is always present in archeological tusks. The mammoth tusk gives evidence of a mineralized (calcified) mammoth tusk comprised of a mixture of phosphate [ν1 (PO_4) at 960 cm^{-1}] and carbonate [ν1 (CO_3) at 1085 cm^{-1}] species. This mammoth tusk was likely buried in a non-permafrost environment or subject to mineralization over long periods of time.

To our surprise, the Barnes tusk is comprised entirely of calcium carbonate (calicite), with no hydroxyapatite present. The Raman spectrum of the Barns tusk indicates the base media is not derived from a mammoth or mastodon tusk or any other archeological ivory. The media appears to be a stalactite which is comprised entirely of calcite. Based on this evidence, the Barns tusk is not a Mammoth or mastodon tusk.

Conclusion: The CBEx 1064 has allowed us to collect quality Raman spectra in the field to identify and authenticate the base media for archeological artifacts. The higher wavelength laser diminished the amount of competing background fluorescence that would normally inhibit the measurement using visible or 785 nm (NIR) laser excitation.

We hope you enjoyed part of our Technical Note Series. For more information on Art and Archeological applications with the CBEx 1064 contact one of our application team members below.

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