SUPPLEMENTAL TEXT

Near-Infrared Spectrometry of Stone Celts in Precontact British Columbia, Canada

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Near-Infrared Spectrometry (NIR) is the study of the interaction of light with matter and is most commonly used in pharmaceutical and food research for confirming the identity of unknown materials or the composition of compounds (Kemper and Luchetta 2003). Spectrometry is the practical application of the science of spectroscopy. The fundamental principle underlying the use of NIR in raw material analysis is that most molecules, including many minerals, produce unique infrared spectra based on their chemical content and crystal structure (Bokobza 1998; Kemper and Luchetta 2003; Ostrooumov 2009; Wisseman et al. 2002). NIR spectroscopy is being increasingly used for archeological applications (Beck 1986; Curtiss 1993; Emerson et al. 2005; Emerson et al. 2013; McGinity 2007; Ostrooumov 2009; Parish 2011, 2013; Wisseman et al. 2002; Zhang et al. 2007). The most complete description of an NIR application to archaeological research questions is provided in Wisseman et al. (2002), and I direct interested readers to that publication for greater detail.

To identify the material from which stone celts were made, I used a TerraSpec® NIR spectrometer produced by Analytical Spectral Devices, to collect spectra from the artifacts (ASD 2006). TerraSpec® is specifically designed for field analysis of geological samples. It is a high-resolution instrument that measures both the visible near infrared (VNIR) and NIR spectra with a spectral range of 350–2500 nm (ASD 2006). For collecting spectral data from artifacts, I used TerraSpec® with the contact probe attachment and the following procedures. I took at least two and as many as six spectral readings from artifacts and samples depending on their size (Morin 2012:193–198). I always tried to take readings from opposite faces and ends of celts. At set up, and every half hour thereafter, TerraSpec® reminds the operator to take white reflectance measurements of provided sample to control for instrument drift. These spectra were treated (interpreted/classified) separately, not averaged. I set the spectrometer to average 25 readings per derived spectrum, resulting in 1/5th the noise present in a single spectrum. My primary goal in obtaining these spectral data was to use it to interpret the mineralogy of each celt and sawn core in my sample. To do this, I used SIMIS-FeatureSearch 1.6 software designed for mineral identification (Mackin 2006). SIMIS-FeatureSearch contains a spectral reference library of 1,200 common minerals compiled by the U.S. Geological Service and allows one to create their own reference libraries (Mackin 2006). SIMIS-FeatureSearch hierarchically sorts the spectral library to provide the best matches to the identified spectral features of interest. The user then plots the spectra of those minerals to qualitatively decide which provides the "best fit." "Best fits" are achieved by matching multiple features (usually 3–6) along the wavelengths or X-axis.

Using this feature matching routine, I looked for "best fits" for my unknown celt spectra to known mineral spectra. Many minerals of interest to this research have been thoroughly investigated comparing NIR spectroscopy to chemical analysis including serpentines (lizardite and antigorite), chlorites, actinolite, and tremolite (Supplemental Figure 1) (Clark 1999; King and Clark 1989). Determining artifact mineralogy using the methods and spectral libraries described above was relatively straightforward for the majority of samples. The spectra from some artifacts, namely very black grainy celt stones (that would probably be described as basalt by most local archaeologists) and a variety of igneous rocks used for making splitting adzes, are either extremely noisy and not interpretable, or contain too few features to match to a known spectrum. Artifacts with spectra such as those described above were described as “unknown.” An issue of major importance in mineral identification was differentiating nephrite from seminephrite (Beck and Mason 2010:186; Morin 2012:202–205; Simandl et al. 2000). While there is some overlap in the physical appearance of these two groups, their NIR spectra consistently differ and can be distinguished. Although nephrite is made of actinolite/tremolite, the nephritic texture of nephrite appears to capture additional water in between the structural units of the actinolite/tremolite crystals (Zhang et al. 2007). For a full discussion of this topic see Morin (2012:193–208).

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