Using Non-Invasive Technologies to Identify Multiple Paint Recipes on Hohokam Pottery

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Introduction

A single, pre-Classic Hohokam Red-on-buff sherd recovered from the surface of AZ T:12:243(ASM), a site in South Mountain Regional Park in Phoenix, Arizona, displays two distinct hues of red paint (see images at right). The sherd (FN 139.A.1) is a body fragment of a Santa Cruz-phase jar manufactured in the Middle Gila River Valley.[1] Though highly eroded, the sherd's surface exhibits seven parallel red lines, one of which (line "E") is noticeably lighter than the others.

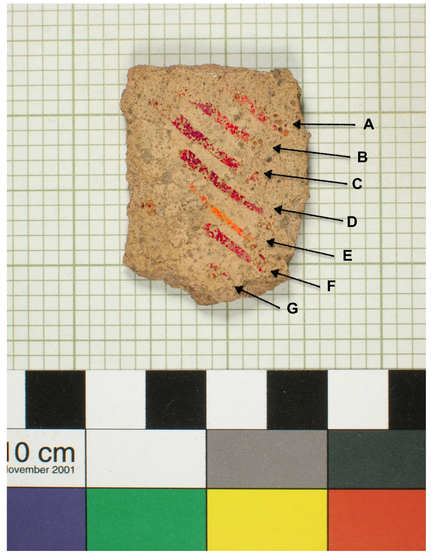
Are the lines' variable red hues indicative of different red paints applied to the same ceramic vessel or the differential weathering of a single paint across the vessel's surface? While a highly sensitive technique such as Laser Ablation Inductively Coupled Plasma Mass Spectrometry (LA-ICP-MS) can identify and quantify the paints' elemental compositions, sampling and analysis would result in irreversible damage to the sherd.[2] Alternatively, we seek to determine whether multiple paint recipes are represented by using non-invasive technologies, which will preserve the sherd for future research.

Methods

We used **Dstretch®** to enrich the colors of the red lines painted on the sherd. Applied most commonly in rock art research, Dstretch® is a software tool for enhancing ("stretching") color through an algorithm that decorrelates multispectral data in digital images.[3] The enhancement intensifies subtle differences in hues and can reveal colors that are nearly invisible to the naked eye. Here, the enhancement shows that the lighter red hue of line E is not a visual effect owing to a relatively greater exposure of the sherd's buff surface through the paint (i.e., weathering). Rather, the color of line E is indeed different from that of the other six red lines, implying that possibly two or more red paint recipes were used to decorate this vessel.

Due to the red hues, we assume that iron is the dominant element in each painted line. The iron most likely derives from locally available hematite that was pulverized and then mixed with a binder.[4] Variable concentrations of iron or the presence of particular trace elements deriving from either the hematite or the binder may indicate different paint recipes. Because the color of line E is distinct from the other painted lines, we suspect their elemental compositions differ.

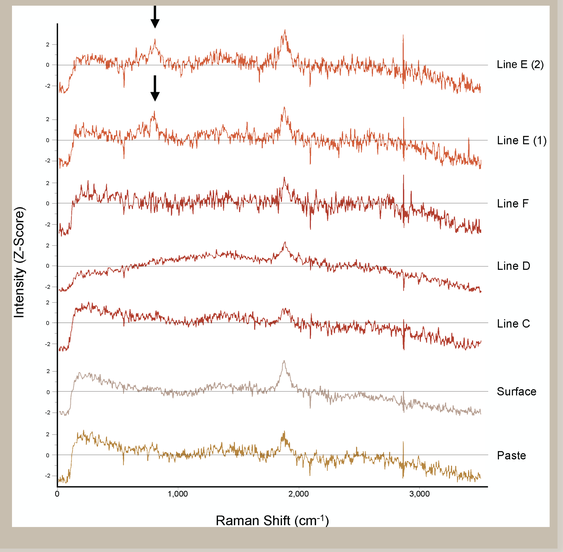
We chose two non-invasive techniques, **X-ray fluorescence spectrometry (XRF)** and Fourier-transform **Raman spectroscopy**, to analyze the composition of the red lines. We first used XRF to measure the relative levels of iron present in the painted lines, as well as the sherd's surface and interior paste.[5] We then relied on Raman spectroscopy to compare the spectra of compounds present in several painted lines, the surface, and the paste.[6]



Results

The XRF analysis was inconclusive. Low levels of iron in each painted line make them indistinguishable from each other, and we cannot differentiate the painted lines from the sherd's surface or paste using this method. We suspect that the XRF beam penetrated through the paint and into the paste, obscuring any elemental differences.

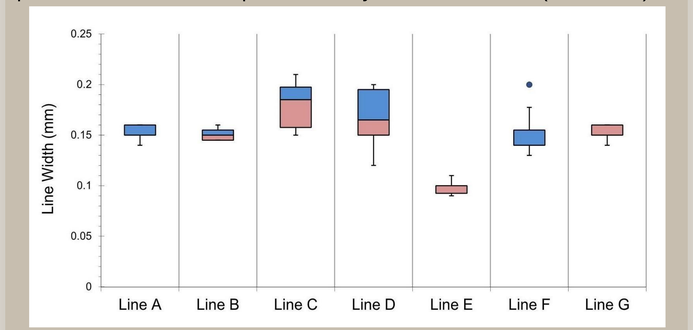
The Raman analysis, however, did reveal a compositional difference between the paints (see Raman spectra graph at right). The dips and peaks along each spectrum reflect the molecular compositions of lines C, D, E, and F as well as those of the sherd's surface and paste. We took two readings of line E in order to control for anomalous results. In both, a distinct peak occurs at wavelength no. 795 (noted with arrows). This peak is not mirrored in the other paints nor the sherd's body. This peak signals a unique molecular aspect of line E, suggesting it is chemically distinct from the other painted lines.



Discussion

The presence of chemically distinct red paints, as suggested by the Dstretch® enhancement, is supported by the results of the Raman analysis. This indicates multiple paint recipes were used to create red lines within a single design layout on this pre-Classic buffware jar.

We supplemented our investigation of the chemical composition of the painted lines with a comparative analysis of their widths (see below).



A Kruskall Wallis test demonstrates that line E is significantly thinner than the other painted lines (adjusted $H = 19.415$, df = 6, $p < .01$). This may imply that line E was made with a different brush, or by a different painter who applied less pressure.

Why a different paint, applied with a separate brush and/or by another painter, would be incorporated into an existing design layout remains in question. Previous research has shown that some children in the ancient Southwest learned to decorate pottery by painting vessels crafted by more experienced potters and by adding to existing design layouts.[7] Perhaps an apprentice using a different paint assisted in decorating this vessel, or line E was added after the other lines were painted. Regardless, the occurrence of multiple paint recipes on the same ceramic jar adds new insight into Hohokam ceramic production.

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