MAKING PAINTINGS IN SOUTH CENTRAL CALIFORNIA: A QUALITATIVE METHODOLOGY FOR DIFFERENTIATING BETWEEN IN SITU RED ROCK ART PIGMENTS USING PORTABLE XRF

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Five Chumash rock art sites in the Wind Wolves Preserve, California, were examined using portable X-ray fluorescence analysis in order to compare red pigments used, differentiate between pigments and painting events, and discuss the implications of this information. The results showed that the technique was successful in identifying different pigments and that multiple pigments were used within each rock art panel and within individual elements. These results indicate the presence of multiple artists or episodes of retouching over time, and potentially a less exclusive role for rock art than some have suggested previously.

This paper assesses the potential of using portable XRF (pXRF) analyses to examine and compare in situ rock painting materials in order to establish variation in pigments and minimum numbers of painting events. To achieve this assessment, a multi-site pXRF analysis was performed on five pictograph sites located in the San Emigdio Hills on the Wind Wolves Preserve, Kern County, California (Figure 1). The results show that this technique has applications for rock art study around the world. Portable XRF is a method which uses temporary irradiation by X-rays to identify the chemical elements that make up a material, and which has been applied to a wide range of archaeological materials, such as obsidian (Craig et al. 2007; Jia et al. 2010; Nazaroff et al. 2010), other lithics (Jones et al. 1997; Williams-Thorpe et al. 1999), ceramics (Papachristodoulou et al. 2010; Terenzi et al. 2010), glass (Kato et al. 2009), bronze (Dungworth 1997), and iron (Mentovich et al. 2010), as well as pigment materials (Nuevo et al. 2011; Olivares et al. 2013; Roldan et al. 2010). Portable XRF has developed from lab-based XRF devices but does not need the sample preparation that is required by lab-based instruments. The portable devices can therefore be used in situ without causing any damage to the material being examined.

Previous studies by d'Errico, McGil, Jercher, and Gialanella have already characterized the chemical composition of ochre and have established that it is a complex material which occurs in pockets of varying quality (Jercher et al. 1998:386). It is predominantly iron oxide but contains a number of trace elements, such as arsenic, lead, copper, and zinc, which could provide a chemical fingerprint for different ochre samples (McCall et al. 2007:728). It has also been established that the appearance of ochre can be affected by heating and that red ochre may have been produced by heating yellow ochre (d'Errico et al. 2010; Gialanella et al. 2011).

Studies by Roldan et al. (2010), Nuevo et al. (2011) and Olivares et al. (2013) have shown that pXRF is effective for examining the composition of in situ rock art, and they have used the technique to characterise the materials present. These studies have established that the red pigment used is iron oxide and that black pigments tend to be either charcoal or manganese-based (Nuevo et al. 2011:4; Olivares et al. 2013). Roldan et al. (2010) also presented the idea that fluctuating trace levels of manganese may allow the identification of different preparation techniques, and that the absence of manganese in some pigments may indicate different ochre source materials (Roldan et al. 2010:248). Nuevo et al. (2011) also noted that the relatively high level of iron in one pigment may indicate a different material (Nuevo et al. 2011:4).

Figure 1. Map showing the location of the Wind Wolves Preserve in California.

The papers mentioned above touch on the possibility of differentiating between in situ pigments but do not follow the idea with a systematic comparison of the rock art elements within a panel or site. However, Nuevo et al. (2011:4), Olivares et al. (2013), and Roldan et al. (2010) demonstrate that there is potential for pXRF to be used for such a comparison. The following study looks at all the rock art elements within five rock art sites at the Wind Wolves Preserve in south-central California. Each site is examined thoroughly using portable XRF to establish its chemical composition and compare it with the other rock art elements present. This allows the identification of different pigment materials, leading to the establishment of minimum numbers of painting events at each site. This is important because it informs interpretation of social aspects in the making of and visual consumption of rock art.

PICTOGRAPHS OF SOUTH-CENTRAL CALIFORNIA

South-central California is home to many fine examples of rock art, the exact nature, purpose, and chronology of which are not known with any certainty, and as such are the subject of great debate (Blackburn 1977; Hyder 1989; Hyder and Oliver 1986; Insoll 2012; Lee and Hyder 1991; McCall 2007;

Quinlan 2000; Robinson 2010; Whitley 1987). These analyses have largely focused on typology and cultural affiliation (Blackburn 1977; Lee and Hyder 1991), the establishment of chronologies (Hyder 1989; Hyder and Oliver 1986), aspects of sorcery and shamanism (Keyser and Whitley 2006; Quinlan 2000; Whitley 2000), and, more recently, rock art relationships to land-use and ideology (Keyser and Whitley 2006; Robinson 2010, 2011). Current research by the authors is investigating deposits associated with pictographs found in the San Emigdio Hills (Robinson and Sturt 2008a, 2008b; Robinson et al. 2009, 2010) to further investigate the chronology and range of activities associated with pictographs. This pXRF study likewise moves to more fully understand the social context for rock art by examining the art itself.

METHODOLOGY

Initially, the five rock art sites of Pinwheel, Pond, Three Springs, Los Lobos, and Santiago on the Wind Wolves Preserve in south-central California were previously examined using a Bruker Tracer III handheld XRF spectrometer (see Bedford 2013). This project laid the groundwork for a next stage of examination. In the original investigation, it became clear that greater numbers of readings would need to be taken in order to be confident about any conclusions drawn relating to painting events and pigments, in light of greater variation than originally anticipated. Therefore, the site of Three Springs was revisited to accumulate further readings and perform a more thorough analysis.

Following rock art documentation conventions (see Bury et al. 2003), painting groups were classified as panels, each of which was comprised of one or more individual rock art elements. The term “element” here describes a particular image or motif within a panel. In this article, these will be described as “rock art elements” in order to make them distinctive from chemical elements.

The analysis was undertaken using a Bruker Tracer III handheld X-ray fluorescence spectrometer. S1PXRF software was used to gather the spectra, and the device was set at 40 kV and 3.4 uA and was run for one minute for each reading. The analysis compared the relative number of counts per second of particular elements at this voltage setting by using ARTAX software to calculate the net area under each elemental peak and convert to total counts, which were examined using Microsoft Excel. This analysis is a study of relative iron percentages but not of absolute element concentrations.

SAMPLING METHODS

Approximately 150 readings were taken from rock art elements within Three Springs, a large number of which were from the larger and more complex rock art elements known as Blueboy and the Zoomorph (Figure 2). These 150 readings include those from the rock around each rock art element. These were taken to check for chemical variation in the rock, as it is possible that such variation could affect the readings from in situ pigments. Each reading contained numbers of counts for a range of chemical elements, as shown in Figure 3.

These results were then converted into Excel spreadsheet format using ARTAX software. The readings for individual chemical elements could then be examined and compared. As these results have not been calibrated to provide absolute quantities of chemical elements, the relative levels of iron were examined by looking at them as a proportion of the total number of counts, presented as a percentage.

These percentages were plotted on a scatter graph as shown in the following section in order to establish groups of similar readings. Any groups established this way were then tested for statistical validity using a one-way ANOVA test.

THREE SPRINGS

The Zoomorph results show readings between 20 and 35 percent, which are the background rock, and two other groups of readings, one between 35 and 50 percent, and a smaller group between 50 and 60 percent.

Blueboy similarly has a large number of readings in the lower range which are from the background rock, and then readings from different parts of the rock art element that occupy different

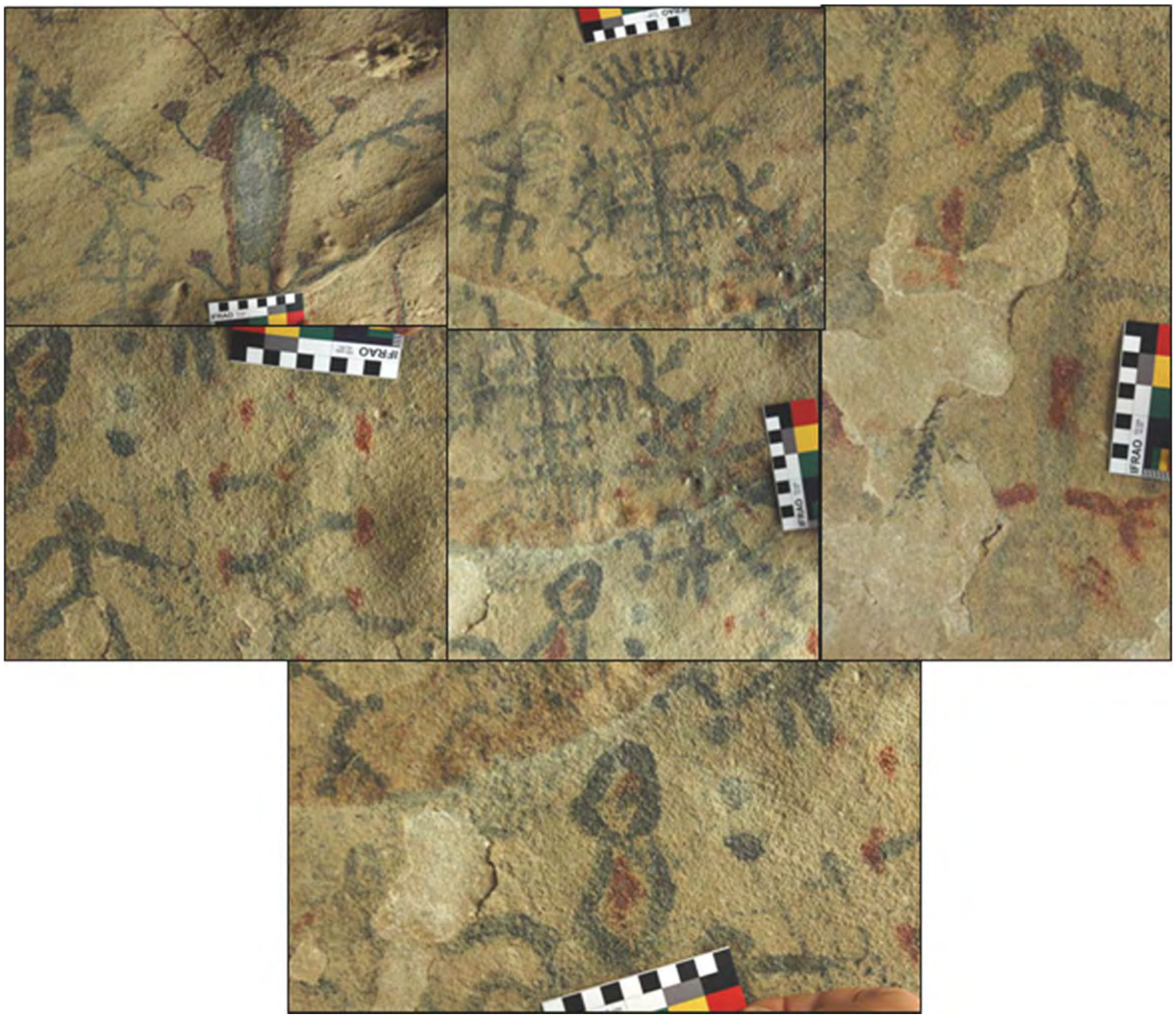

Figure 2. Rock art elements at Three Springs, including Blueboy (top left), Zoomorph (top right), Zig-zag (mid left), Fig 8 (bottom), and Bird (middle and mid top).

percentage ranges. These different parts are identified with the letters A, B, C, and G. Notably, group G potentially has two different groups within it.

The aquatic motifs are smaller rock art elements in red or black, which are located around the zoomorph. The results from these aquatic motifs show readings falling between 50-60 percent and the usual background range. However, in this case there are some readings below those from the background rock. These are the black aquatic motifs.

When these data are plotted, it is apparent that groups of readings with different percentage readings can be seen, representing different pigment materials. At Three Springs, background readings tend to be between 20 and 35 percent iron, and in the pigment results three separate ranges of readings can be seen:

a. 35-50 percent - present in Blueboy and the Zoomorph;

b. 50-60 percent - present in all elements; and

c. 60-70 percent - only present in Blueboy.

Figures 4, 5, and 6 show the distribution of pigments within these elements at Three Springs. This distribution gives an indication of stages of production within elements; for example, the "hands" in Blueboy are different from the pinwheel and aquatic motifs which accompany it, indicating different

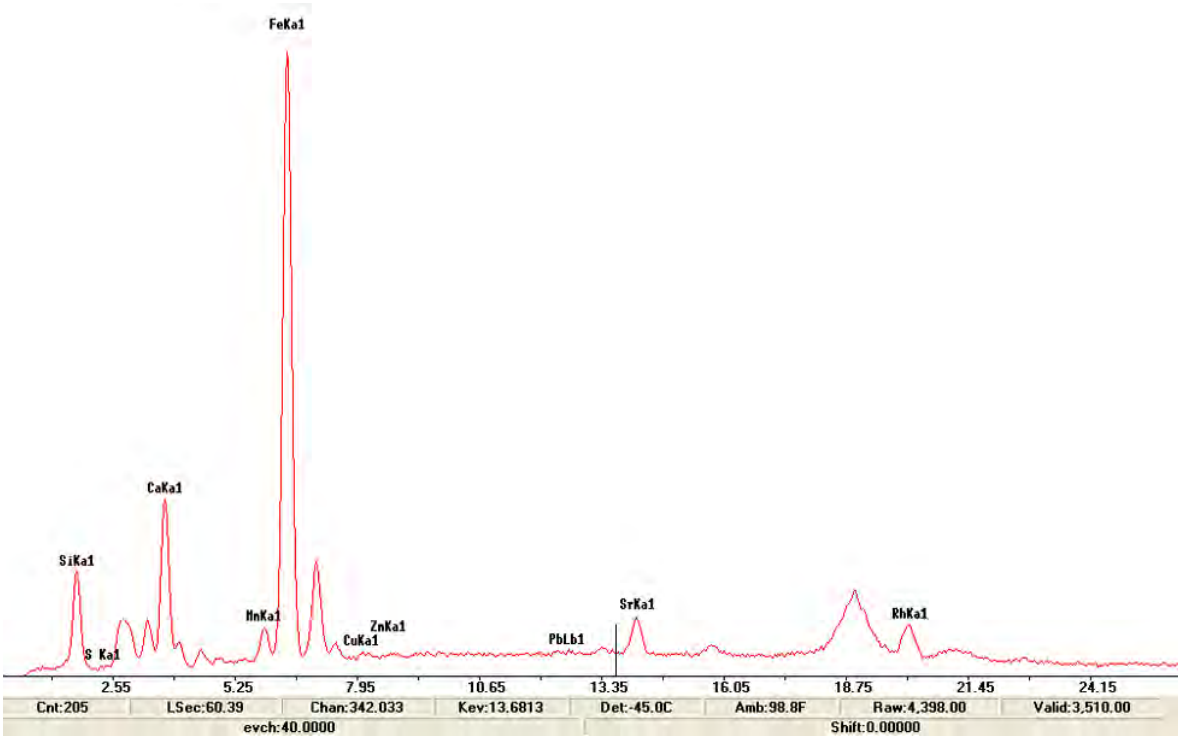

Figure 3. XRF spectrum as viewed in S1PXRF software.

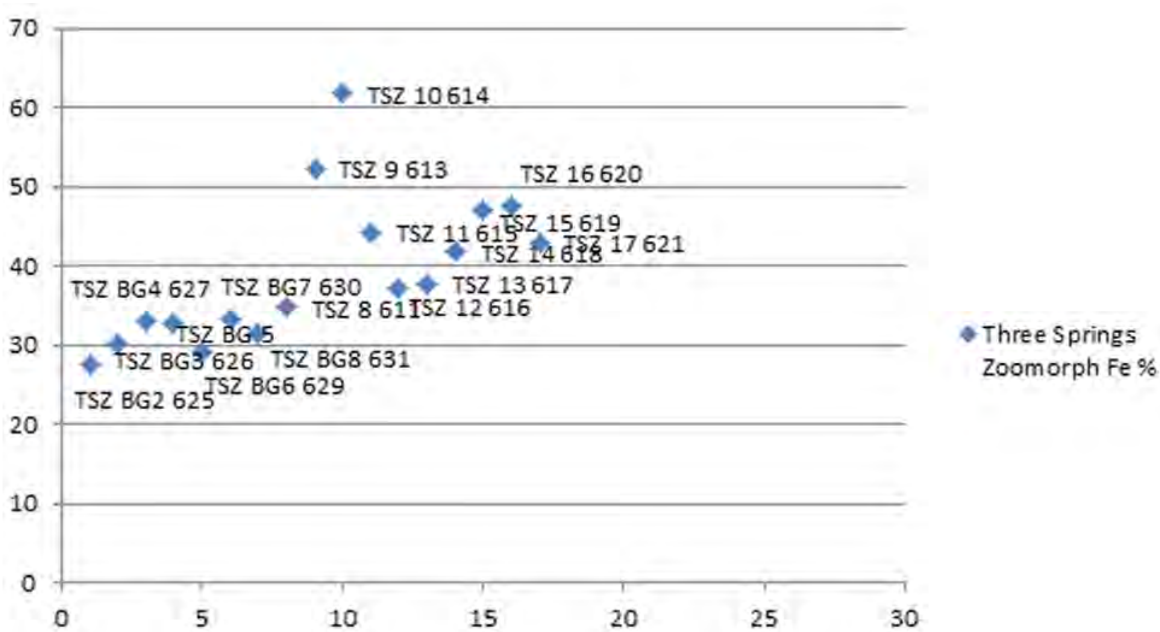

Figure 2. Chart showing iron percentages in Three Springs Zoomorph.

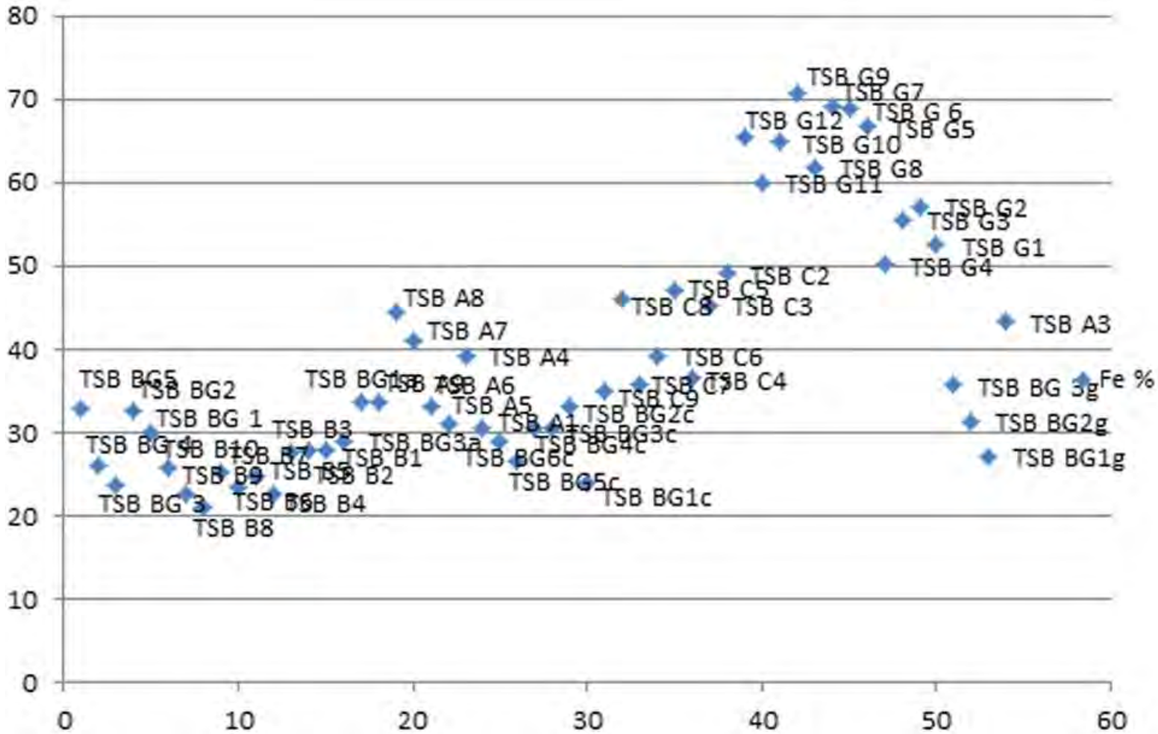

Figure 3. Chart showing iron percentages in Three Springs Blueboy.

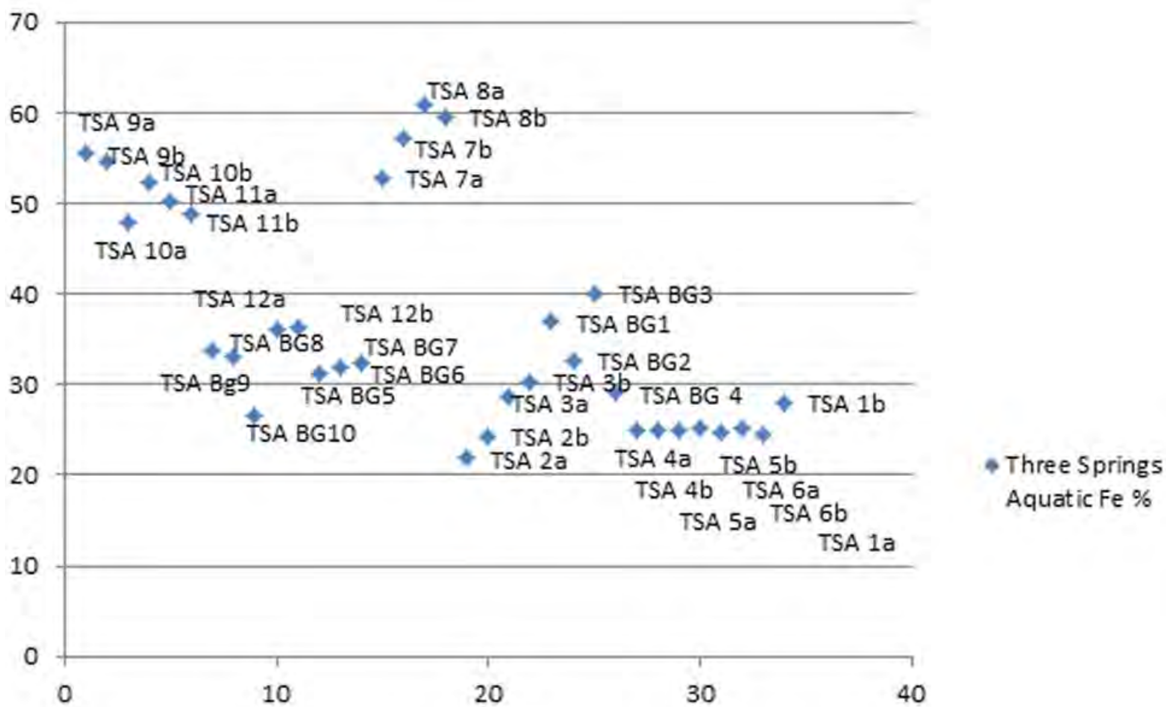

Figure 4. Chart showing iron percentages in Three Springs aquatic motifs.

Figure 5. Distribution of pigment groups at Three Springs.

periods of production. However, the pinwheel and aquatic motifs are similar to the Zoomorph, which may indicate that they were produced at the same time. Figure 7 shows the distribution of different pigment materials at Three Springs.

DISCUSSION: THE USE OF XRF TO INFORM ON PIGMENTS AND PAINTING EVENTS

Different pigment materials are present within rock art elements, and between elements within a panel. This can be explained in a number of ways. One explanation is that there is natural variation within the ochre. However, if this were the reason for these results, we would expect such variation within all areas of the rock art elements and not the clear clustering of readings such as group G in Blueboy. Another explanation is that different pigments, potentially used by different artists, were applied on one occasion to produce these rock art elements.

A further, related interpretation is that different pigments have been added to rock art elements at some point after they were first produced, either to touch up an existing element or to add elements to the panel. However, the common pigment among all three suggests that pigment was applied to all three at the same time at least once, potentially indicating that the elements were created at different times but added to over time, and eventually all added to at the same time on one occasion.

The presence of different red pigments at Three Springs is consistent with the range of dates discovered in excavation. Using the distribution of different red pigments at Three Springs, we can infer an order of production. For example, we could argue that Blueboy was created first, as it contains a red pigment which is not present in the others. This was followed by the Zoomorph, at which point Blueboy was also added to, thereby explaining the presence of Pigment A in both Blueboy and the Zoomorph. The aquatic motifs therefore were created third, and on this occasion further red pigment was added to the other elements.

XRF results can only show similarities and differences between pigments rather than directly providing dates, and as such a different order of production could also be argued. For example, it could be argued that all the rock art elements were produced together, but that the Zoomorph and Blueboy were selected for additions later on. When XRF is combined with studies of superimposition, it can be used to link elements and panels, and therefore has the potential to establish more comprehensive chronologies within sites.

THE IMPLICATIONS FOR SOUTH-CENTRAL CALIFORNIA ROCK ART

The site included in this study contains multiple pigment materials. As mentioned earlier, there are a number of possible explanations for these different materials. The physical variation in materials may result from a number of factors. These include the raw materials, the method of application, and the processing and preparation techniques. For example, the presence of binders would affect the final reading obtained from a pigment, particularly if an iron-rich binder such as blood were used. The thickness of the pigment on the rock may also affect the XRF data, as thinner pigment layers may allow greater penetration of the background material. Different pigments may result from the use of material from different sources. By linking or contrasting pigment materials within a panel, it may be possible to enhance chronologies which have already been established by studies of superimposition (Hyder and Oliver 1986). Excavations near the rock art at Three Springs revealed multiple dates of occupations, which is consistent with the different pigment materials found in situ.

The presence of different red pigments may indicate that elements were produced by different people, or that sites were revisited and pigment added at this point to “retouch” preexisting rock art or add to panels at a later date. Importantly, this may therefore indicate the involvement of multiple individuals in rock art production or a continuing relationship between rock art and either individuals or communities.

Three Springs is positioned close to a bedrock mortar (BRM), and BRMs are known to be predominantly female workspaces (Robinson 2010:802). It is therefore reasonable to suggest that some of the rock art next to the BRMs was being produced by the women working there. As Robinson (2010) points out, the majority of members of the community would have been in the area of these BRMs and therefore would have been close to the rock art while acorns were being processed (Robinson 2010:804). It is possible therefore that these other members of the community were also involved in the production of rock art at such sites. It is likely that, far from being a restricted ritual phenomenon, rock art was actually an integral part of life, in which many people, including women, were actively involved.

THE CONTRIBUTION OF PXRF TO ROCK ART ANALYSIS

To summarize, it is clear that pXRF is valuable in characterizing the elemental composition of rock art pigments and that pXRF data can be used to differentiate between materials that look identical to the naked eye and therefore have never previously been identifiable. It was able to estimate the number of painting events at each site and to show a minimum of three red pigments, as well as black, blue, and white pigments, giving a total minimum of six painting events at Three Springs.

These results suggest that rock art production is a complex process which does not necessarily have one single explanation. It is clear that these examples of rock art were not produced in single events, nor does it seem that they were exclusive to one individual. The results indicate that rock art was revisited, reused, and preserved, as if it held cultural importance to a number of people over time.

There is great potential for more work to be done in this area. Portable XRF has shown itself to be a very useful tool in the examination of in situ rock art, and the method employed here has allowed a swift analysis of many rock art elements. This analysis has revealed a greater number of painting events than are apparent to the naked eye.

The analysis performed here has also raised a number of questions relating to the specific effects of particular factors such as processing techniques, heating of pigments, and the addition of binders, on the end results. Such questions can be addressed both by performing further pXRF and by employing other analytical techniques such as X-ray diffraction or Raman spectroscopy (Olivares et al. 2013) which would enhance the depth of knowledge gained from pXRF work and assist in addressing questions which may not be answerable with a single device (McGlinchey 2013).

Further, experimental reconstruction of methods of rock art production and intentional manipulation of particular factors such as the selection of ochre material, processing of ochre, and the addition of binders, would allow analysis of the individual effects of these factors and greatly enhance our understanding of the spectra produced by pXRF analysis. As McGlinchey (2013) notes, the superimposition of layers of pigment can affect the readings obtained from lower layers. The effect of this superimposition in rock art could be investigated further with experiments.

To conclude, pXRF analysis has provided a great amount of valuable information regarding the production of Chumash rock art and provided a valuable and original contribution to core debates in Chumash rock art research, including the social role, production circumstances, and technology involved in the production of rock art. This work has demonstrated the potential of pXRF to contribute to research both in Chumash rock art and the many rock art panels that are being examined around the world, and it has also opened up further questions and revealed the global potential for many more exciting directions in rock art study.

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