

Chemistry as a Criterion for Selecting Pictographs for Radiocarbon Dating: Lost Again Shelter in the Guadalupe Mountains of Southeastern New Mexico

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Portable X-ray fluorescence spectrometry (pXRF) was used nondestructively to assay iron signals of more than 75 pictographs in Lost Again Shelter (LA 162411) in southern New Mexico. Some figures are similar to the Red Linear Style in the Lower Pecos River region of southwestern Texas. Figures of this fine-line style in Lost Again Shelter often show iron contents lower than usual for iron ochre paints; but some contain paints with significantly higher iron signal, suggesting multiple paint recipes, different painting episodes, and/or perhaps significantly different ages. These findings inform future scientific methodology for selection of individual pictograph images for radiocarbon dating.

One always enters rock art sites equipped with a very sensitive, perceptive instrument: human eyes. This tool has permitted much fundamental understanding of rock art. Over the past decade or so, portable X-ray fluorescence (pXRF) devices have become more available as nondestructive field instruments. By measuring the presence of metallic elements in pictograph pigments, these portable devices produce semi-qualitative information efficiently and rapidly. In several hours, we can accumulate hundreds of measurements on pictograph pigments and compare those with readings on the background rock. The data are quantitatively inexact and highly variable but can be used cautiously for intra-site, relative comparisons of pictographs and to describe zeroth-order inter-site differences in pigment recipes. Using pXRF chemical information as an additional method, we hope ultimately to shed new light on archaeological problems, such as cultural-historical origins and development of rock art styles.

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The Lost Again Shelter in the Guadalupe Mountains of New Mexico provided an appropriate location to apply this technique, since the small rockshelter is a multi-component pictograph site with elements and panels similar to Red Linear Style rock art in the Lower Pecos region of southwest Texas. If we can describe the body of rock art in the Guadalupe Mountains using pXRF, we may be able better to evaluate its stylistic attributes, determine whether creation of panels was multi-episodic, and perhaps support or negate definition of the imagery as an archaeological style.

We have seen the development of archaeological use of *styles* leading to a fuller, more detailed understanding of rock art prehistory at sites around the world. In this sense, we are using the art as *artifact*, trying to place it in an archaeological context that may, in turn, describe its age, regional relationships, ancient ways of life, and ancient artistic intent. Examples of the Red Linear Style around the mouth of the Pecos River were recorded as watercolors by Kirkland in 1939 (Kirkland and Newcomb 1967). The Red Linear Style was named and elucidated further by Gebhard (1960; Gebhard et al. 1965) and particularly by Turpin (1984, 1990a). This style is important to this study because of the similarity of some pictographs in the Guadalupe Mountains rock art sites, including Lost Again Shelter, to Red Linear Style motifs in southwest Texas.

The age of Red Linear Style paintings presently is not well known. Ilger et al. (1994) dated one Red Linear Style image at site 41VV162A in the Lower Pecos River region at 1280 ± 45 years B.P., and Rowe (2003) dated another Red Linear Style image in the same area at site 41VV75 to 1280 ± 80 years B.P. However, Turpin (2005:316) doubts that the bulk of Red Linear Style paintings are that young. She reported it more likely that the age range is 3100 to 2500 B.P. (Turpin 2005). And more recently, Boyd (Boyd and Rowe 2010) reported Red Linear images in multiple shelters in the Lower Pecos River region of Texas that underlie older Pecos River Style pictographs (dated to roughly 3000 to 4000 B.P., see Rowe 2005, 2009, and Turpin 1990b). If Turpin and

Boyd are correct, a long period of time may be indicated for the duration of the Red Linear Style: approximately 1280 to >4000 years old.

Thus, new evidence suggests that what has been called *Red Linear Style* may actually be a component of a *Pecos Miniature Tradition* suggested by Billo et al. (2011) that developed over thousands of years. As an anonymous *American Indian Rock Art* reviewer pointed out, "that means that the Red Linear Style needs to be differentiated into sub-styles or that the concept of style here is useless. If it has no temporal and geographic value it is not really a style." We do not attempt in this paper to solve the uncertainties that are currently arising with the Red Linear Style in Texas. The style is mentioned here only because of the similarity of the paintings at the Lost Again Shelter with those of the Lower Pecos River region of southwest Texas discussed more fully by Gebhard (1960), Gebhard et al. (1965), Kirkland and Newcomb (1967), and Turpin (1984, 1990a, 2005). Our working hypothesis is that some relationship exists between the artist's paint production and the iron measurements, and our data collection is part of the process of providing temporal value to the art in Lost Again Shelter.

Chemical Studies on Rock Paintings

There have been relatively few studies of rock paintings using chemistry as a technique to understand them better. Rowe (2001) summarized chemical studies done through 2000. Three such studies will be described briefly here for illustration.

Clottes et al. (1990) used proton induced X-ray (PIXE) analyses that demonstrated that Paleolithic Niaux artists in southern France created complex paints by mixing pigments with mineral extenders and binders. They thought that quartz in the samples was likely a consequence of grinding, but that other minerals constituted additions to the paint. For Niaux Cave, painting materials were prepared according to well-defined recipes, minerals and pigments being ground to 5 to 10 μm to produce specific mixes. Clottes et al. identified four specific recipes, differing in the nature of the extenders added: (1) talcum

powder; (2) barite and potassium feldspar; (3) potassium feldspar alone (Nos. 2 and 3 are very similar); and (4) potassium feldspar mixed with an excess of biotite. This was taken to imply four artists made the paintings studied.

Watchman et al. (1993) found quartz plus kaolinite and quartz plus muscovite/illite made up two groups of white paints in the Laura region of Australia. It was shown in these studies that chemically distinctive paints were used at a given site.

More recently, with a totally different result, Newman and Loendorf (2005) were first to report the use of a hand-held X-ray fluorescence (pXRF) spectrometer to study rock paintings. They showed chemically that some green images were chromium-based, that yellow paint contained lead, zinc, arsenic and tin—all pigments used in modern paints. The conclusion was that they found both ancient patterns with chromium (green from fuschite) and modern paints with lead and zinc that were added to other figures they studied.

Chemical studies of this sort prompted us to see whether we could distinguish between paints used at the Lost Again Shelter site in the Guadalupe Mountains to provide information on Guadalupe Red Linear Style paintings that resemble the Lower Pecos Red Linear paintings. If different paints were used, it would imply different paint makers and potentially different times of manufacture.

Lost Again Shelter

The Lost Again Shelter, a multi-component rock art site (LA 162411) in the Guadalupe Mountains of southern New Mexico, contains paintings probably ranging from Late Archaic to Apache in age. The images have a variety of content, arrangement, application manner, and technological detail. But many are miniature red painted zoomorphic and anthropomorphic figures. There are similarities and differences between these images and other Guadalupe Mountain sites and localities further east to the Pecos River and south down the river into west Texas. As more sites were found during the ongoing work in the

Guadalupe Mountains, more diversity in kinds of themes has been noted. There remains uncertainty in interregional relations, artistic style, and associated cultural groups.

Bilbo and Bilbo (1991) first linked Red Linear Style rock art from the Lower Pecos River to the Guadalupe Mountain rock art, using data from Lost Again Shelter. Recently, Mark and Billo (2009) have also noted strong similarities in paintings in the Guadalupe Mountains at Hunters Shelter, White Oaks Spring Shelter, and now with Red Linear Style paintings of the Lower Pecos River region of southwest Texas. Since then, Mark and Billo have seen additional examples in the Lincoln National Forest (Mark, personal communication, 2011). As expected, these observations support the notion of a prehistoric corridor along the Pecos River for the movement of people or ideas between the Guadalupe Mountains region of New Mexico and the Lower Pecos region of southwest Texas.

Lost Again Shelter is located in Eddy County, New Mexico, in somewhat the central part of the Guadalupe Mountains on land managed by Lincoln National Forest (Figure 1). The site is just off the crest of the range, at the base of a canyon, and at an elevation of about 6000 feet. The age of the pictographs covering the shelter wall is of interest to this chemical recording and to separate radiocarbon studies in progress.

Lost Again Shelter is a limestone rock shelter 13.5 m long x 2.5 m high x 3.5 m deep (Figure 2). We did not analyze the dark stain that discolors the ceiling. Numerous pictographs, nearly all in shades of red, span nearly the entire shelter wall and cover about 12 meters of wall space (Figure 3). There are more than 100 elements, but only one has been found on the ceiling. Pictographs include fine-line representations of humans, their prey, and possibly their companion animals (dogs). Nets, animals, and weapon-holding hunters are shown in proximity. Three separate groups of fine-line paintings are of lines of people, perhaps dancing or engaged in other unknown communal activity. Only one image is bichrome, composed of both yellow and red pigments. The fine-line pictographs can be grouped into highly



Figure 1. Guadalupe Mountains (green shaded area) on Texas-New Mexico border. Outlined "X" is the location of Lost Again Shelter.

faded art and well-preserved art, with moderate differences in artistic content. Other pictographs are line drawings applied with a brush and / or finger, and these include zigzag lines and tree-like or snake-like abstract art. Dry, ochre pencils were also used to create some geometric images. The variety of techniques and images suggest that the pictographs at Lost Again Shelter were drawn in multiple episodes, potentially over a period of a thousand years. While the pictographs are not always separable by technique or content, most of the fine-line representational art appears to be related to



Figure 2. Looking through the trees toward the painted interior wall and ceiling of Lost Again Shelter.



Figure 3. Painted back wall of Lost Again Shelter.

the Guadalupe Red Linear Style (Dillingham and Berrier 2011). The shape of the shelter provides excellent protection to the pictographs (Figure 3). The ceiling overhang extends out a couple of meters and provides good protection from the weather, including direct sunlight and rain. Good preservation of the paintings is expected, and weathering is unlikely to be the cause of the observed low iron signal for so many of the pictographs at this site.

Experimental Procedure

We used a portable, hand-held, nondestructive pXRF device for *in situ* measurements of the iron signal of the red paints at the Lost Again Shelter. The device was a battery operated, Innov-X Systems Alpha Series spectrometer capable of making elemental abundance measurements on-site. The spectrometer works by irradiating the sample with an X-ray tube that emits primary X-rays that strike the target, in our case the pigment associated with individual pic-

tograph elements. These primary X-rays sometimes strike an orbital electron in an atom (e.g., iron) of the sample being analyzed with enough energy to knock out the electron from the inner electron shell of the element. The removal of such an electron from an element is accompanied by the emission of secondary X-rays in the atom's attempt to restabilize itself. It is the energies and numbers of secondary X-ray emissions that are measured. The energy of a secondary electron is specific for a given element, and essentially different from all others. Iron is thus isolated from manganese, for example, and iron and manganese can be distinguished from each other. Thus, the technique indicates what atoms are present in the pigment (and the underlying rock). Then, with proper calibration and software, the approximate (semi-quantitative) abundances of the elements can be calculated by measuring the intensities of the radiations of particular energies. Abundances in *uniform, homogeneous* samples as low as 10 parts per million (ppm)

are possible for some elements. In the situation here, we recorded measurable signals from the elements iron (from the pigment) and rubidium, strontium, and zirconium (present in the rock itself). But the method is not quantitative in the application to rock art pigment analysis—not even close. That is, we do not get even crudely accurate measures of the *abundance* (percentages, for example) of the iron for a number of reasons: (1) the pigment may not cover the entire area of the target primary X-rays; (2) the paint is not of uniform thickness; (3) no standards were used; (4) the pictograph surface is not completely flat; (5) the background amount of iron in the rock itself may not be completely uniform; (6) the paint may not be completely homogeneous (i.e., the iron in the paint may vary somewhat from one full paint brush to the next full brush); and (7) there may be differential degradation of the painting from image to image. All of these factors combine to make the method semi-quantitative at best. In our case, analyses within a particular pictograph may vary by a factor of two or more due to these effects. Nonetheless, we will see that the analyses may be useful in spite of these difficulties.

Our approach was simply to analyze each pictograph, some multiple times, and record the data for the iron, strontium, rubidium, and zirconium. Only the iron is of interest for this study; the strontium, rubidium, and zirconium are simply components in the rock itself. We then compared the analyses from pictograph to pictograph. Since some of the Guadalupe Red Linear pictographs had similar aspects and motifs to the Red Linear Style pictographs from the Lower Pecos region, we were primarily interested in whether the iron signals were different among the Guadalupe Red Linear pictographs and whether they were different from other pictographs on the panel. We followed that with analyses of the iron in pictographs that appeared similar to the Guadalupe Red Linear pictographs, but without any of the distinctively Red Linear like features to compare them with the Guadalupe Red Linear pictographs. Other, non Red Linear Style pictographs at the Lost Again Shel-

ter were also analyzed for comparison. Figure 4 shows the X-ray device being used to analyze a yellow pictograph.

The iron signal shown on the read-out screen in Figure 5 is quite low for a pictograph with red (iron ochre) pigment. The Guadalupe Red Linear pictographs, and in fact many other pictographs at the Lost Again Shelter, had very low iron signals, much lower than ordinarily seen in red and yellow pigments at other sites. For comparison, to demonstrate how low the iron signals are at Lost Again Shelter, the median iron signal is only twice the background iron signal. It must be emphasized that the units are not meaningful and are for rough, relative comparisons at best. In contrast, the median iron signal of all measurements we made at the Painted Grotto site, another painted rockshelter to the southeast, still within the Guadalupe Mountains, is seven times higher, at 15 times the background iron signal (Robert Mark, Marvin Rowe, and Evelyn Billo, unpublished data 2009).



Figure 4. Using portable pXRF device to analyze brownish-yellow paint in Painted Grotto, several kilometers to the southeast. The iron signal here was about six times higher than the reading in Figure 5.



Figure 5. Display of the pXRF device during measurement. The iron signal is quite low for red pigment, only about 1.5 times the background level in the rock, although concentration levels must be considered.

Results and Discussion: Iron Signals of “Guadalupe Red Linear” Pigments

The pXRF data may be useful in the following way for selection of samples for radiocarbon dating. Concentrating only on the Guadalupe Red Linear images for the moment, our procedure might be: (1) visually select those images that we agree are Guadalupe Red Linear Style; (2) measure the iron signals of the images selected as likely Guadalupe Red Linear images, but without the defining attributes to assign them with certainty; and (3) select images for consideration for dating that have widely different iron signals to get images with potentially distinct paint recipes and possibly different painting episodes, and we hope, significantly different ages.

We emphasize that the following are for illustrative purposes only. We have not taken into consideration in this discussion a most important attribute that we consider when sampling any

rock art: *its condition*. For the most part we are showing here images that are pristine. When we actually sample for radiocarbon dating, we try to find suitable images that are not necessarily as well preserved as those selected for illustrative purposes but have attributes we want to date. In our experience, we have been able to do so perhaps 95 percent of the time. Occasionally, however, the archaeologists involved have felt a date important enough to warrant the necessary damage to an unweathered painting. The reader should keep in mind this very strong caveat when looking at the figures that follow and the accompanying text.

Figure 6 shows several Guadalupe Red Linear images that have an iron signal <4 times the background iron signal. We would suggest that one of these would be informative for the radiocarbon date. This sample would represent many pictographs of the Guadalupe Red Linear Style that have a very low iron signal. Perhaps these constitute a single paint recipe, all being painted in a short time span. If these indeed constitute such a grouping, perhaps two or three dates would define the age closely enough for comparison with the ages of other groups.

The next higher iron signal group (5 to 20 times the background iron signal) is represented by the quadruped in Figure 7, with an iron signal 20 times the background iron signal. We assume that the paints used in Figures 6 and 7 are from different recipes and hence may have been painted at different times. Therefore, it would be useful to date these paintings to see if they are temporally distinct.

Similarly, Figure 8 is a Guadalupe Red Linear deer with a significantly higher iron signal 30 times the background iron signal. Again, we assume that the paint mixture is a different recipe from those in Figures 6 and 7. Although not necessarily universally true, we can see that the darker paintings (Figures 7 and 8) have increasingly more iron than the lighter colored ones (Figure 6). The pXRF measurements may remove uncertainty in defining color by eye in cases where color variation is more subtle than it is in these examples. If that is true, we might



Figure 6. Lost Again Shelter, small red figures with pXRF sample points marked with X. These elements have an iron signal of less than 4x the background reading of iron in unpainted rock.



Figure 7. Lost Again Shelter, small red long-tailed animal with pXRF sample point at the X. The iron signal was 20x the background reading of iron in unpainted rock.

anticipate a different age for the deer image from the others.

Figure 9 shows a meter long portion of the shelter wall with multiple images and figures sampled in this study. Interestingly, pictographs in this small area have widely different iron signals. The highest iron signal at the shelter was the small turtle in the upper-right with an iron signal >50 times the background iron reading. Another even smaller (though artistically similar) turtle just below also had a high iron signal just over 15 times the background iron reading. The anthropomorph on the left side of the photo has distinct features similar to the Lower Pecos Red Linear Style and produced a high iron signal 35 times the background iron reading. Other images have distinctly different iron signals ranging down to 3 times the background iron reading.



Figure 8. Lost Again Shelter, small red linear deer with pXRF sample point at the X. The iron signal was 30x the background reading of iron in unpainted rock and one of the highest iron readings for elements at the site. Rock art researcher Carolyn Boyd (personal communication 2009) suggested the missing body may once have been white pigment.

Conclusions

We used a nondestructive handheld pXRF spectrometer to measure the iron signals of pictographs at Lost Again Shelter. Images that resemble the Lower Pecos Red Linear Style, with sites about 300 km down the Pecos, exhibited widely differing iron signals. If, as we assume, differences in iron signal imply different recipes for the paints, it may follow that different artists are responsible for pictographs with widely differing iron signals. We hope that if the preceding is true, selecting pictographs with different iron signals may be an efficient means of finding pictographs of different ages and thus ascertaining the temporal range of Guadalupe Red Linear Style paintings at the Lost Again Shelter. An attempt is under way to confirm this inference of multiple recipes, different painters, and age differences by doing direct dating of the paintings in question. Samples have been taken by Karen Steelman and Eric Dillingham, and we look forward to those chronological results. Alternatively, our data could also mean that the same artist uses different hematite, and therefore data is needed on iron contents of potential hematite or other mineral sources.

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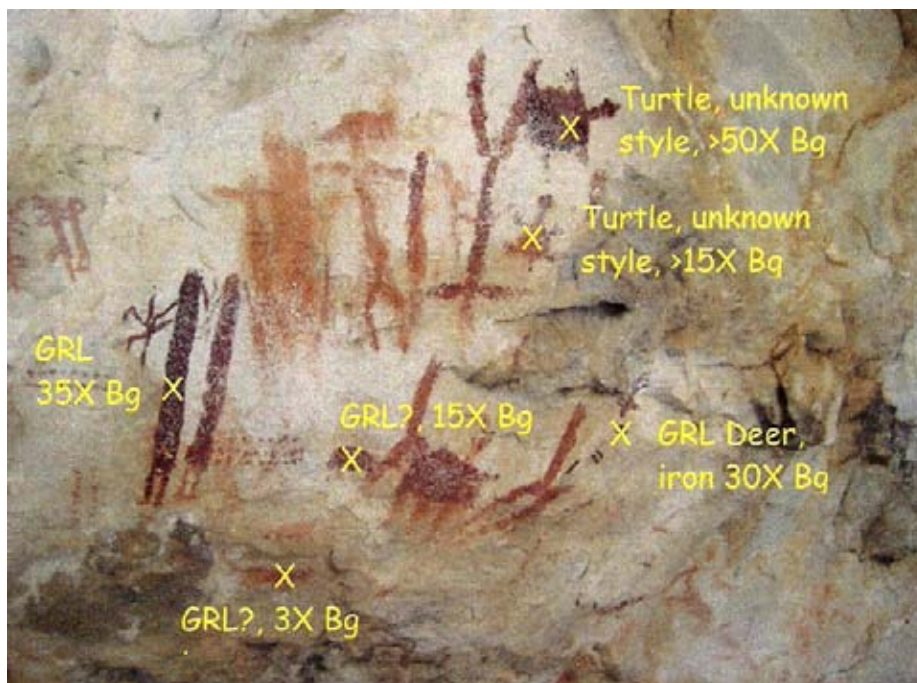


Figure 9. Lost Again Shelter, one-meter portion of painted wall showing approximate measurement locations (X). GRL is Guadalupe Red Linear Style. 3X Bg signifies the iron reading on the red figure is three times (3x) the background (Bg) reading for iron on adjacent unpainted rock. Figures have varying iron signals that are interpreted as indicating perhaps at least four different paint recipes, and thus implying different artists and potentially different ages.

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