
New Insights into Missouri Pictographs

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We conducted radiocarbon dating and portable X-ray fluorescence analyses at four rock art sites in Missouri. At the White Rock Bluffs site (23TE01), our data and results confirm the presence of Early/Middle Woodland paintings where multiple images of atlatl hunters are portrayed; the most prominent image dates to 420 to 120 B.C. based on a single radiocarbon date. A single figure with an atlatl at the DFS site (23WN85) dates to the Early/Middle Woodland period based upon a date of 365 to 50 B.C. The presence of Middle/Late Woodland pictographs at the Deer Run site (23MO1380), based on two similar radiocarbon dates of ca. A.D. 375, is interesting because one of the dated images has been proposed as a bow-tie atlatl weight. The Deer Run site also yielded a C-14 date of A.D. 1425 to 1635, indicating that pictographs were being created in Missouri as recently as the Terminal Mississippian into the Protohistoric period. The Groeper site (23WN1177) is in close proximity to Picture Cave (23WN79) and they share many similarities in terms of motifs and pigment chemistry, which make the three newly obtained radiocarbon dates from Groeper of particular interest. The C-14 dates at the Groeper site are statistically indistinguishable from one another with a weighted average of A.D. 1045 to 1225. The DFS site, also in close proximity to Picture Cave, indicates that artists were actively painting caves in Warren County over several centuries.

Missouri archaeological research has focused for over a century on stone tools, pottery sherds, animal bones, and seeds; sadly, only a few attempts have been made to link pictographs to the cultural traditions spanning over ten thousand years. Marvin Rowe (2009:1732) summarized the dating of five C-14 samples from Picture Cave “ranging from 940 ± 80 to 1090 ± 90 years BP,” marking an important moment in the study of Missouri pictographs. Diaz-Granados et al. (2001) connected four of those dates with a specific period in Missouri, the Early Mississippian period, ca. 950 years ago. Subsequent dating of the fifth sample showed that all of the samples “are indistinguishable from one another, with a weighted average of 980 ± 30 years BP” (Duncan et al. 2015:130).

In January of 2023, Karen Steelman worked for three days to collect seven C-14 samples from four Missouri pictograph sites (Figure 1). Steelman lectured on her research techniques at the St. Louis Society of the Archaeological Institute of America and they funded the cost of four dates; a generous landowner funded the cost of three more dates. Michael Fuller collected portable X-ray fluorescence spectrometry (pXRF) readings on the pictographs (see Appendix), while Anthony Starr and Mike Chervinko provided invaluable assistance and photographic documentation during the fieldwork. The pXRF readings were made with a Niton instrument rented from EcoRentals in St. Louis.

Stelman collected very small samples of pigment using sterile scalpels, surgical gloves, and aluminum foil. Nearby background samples of unpainted rock were also collected. At the Shumla Archaeological Research and Education Center (in Texas) the samples were powdered with a mortar and pestle, then examined for any contaminants such as rootlets. Each sample was washed in a base, filtered, and dried. Each individual sample was loaded into a plasma oxidation instrument that extracts organic material from paint samples for accelerator mass spectrometry (AMS) radiocarbon dating. Elec-

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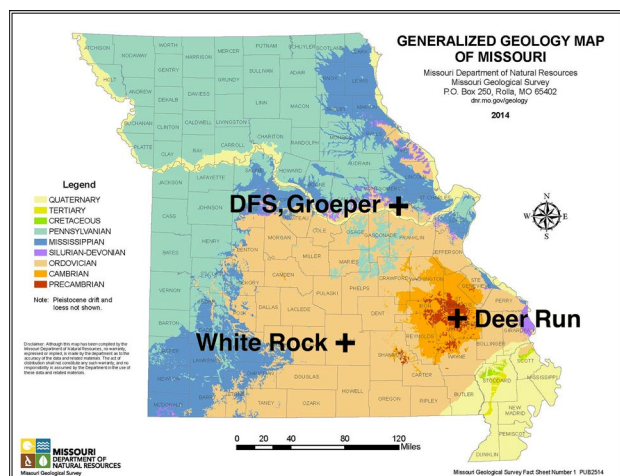


Figure 1. General location of four pictographs sites on the Missouri Geological Survey surface geology map. The sites are on private property and not open to the public.

trically excited oxygen converted the organic material into carbon dioxide and water. The carbon dioxide was converted into graphite for AMS isotope measurement. This process allows for the dating of painted rock art by isolating the charcoal in black charcoal pictographs, and by isolating the organic binders or other additives used in paints made from red ochres or other inorganic materials.

White Rock Bluffs Site (23TE01)

The White Rock Bluffs site is situated near the watershed of the Gasconade River (a south-to-north-flowing tributary of the Missouri River) and the Northfork River (a north-to-south-flowing tributary of the White River). The pictographs at White Rock Bluffs are painted on Roubidoux sandstone. The site was reported to the Archaeological Survey of Missouri before 1955, but there is good reason to believe that the site was known to at least one citizen archaeologist as early as the 1930s. The White Rock Bluffs site was nominated to (and listed on) the National Register of Historic Places (NRHP) in 1969 by Phil Born, a research archaeologist with the Missouri State Park Board; he was assisted by Frank Magre (a citizen archaeologist) in preparation of the

nomination. Unfortunately, a written manuscript by Magre about the site cannot be relocated in any of the public or private archives. Magre noted that the pictographs are clustered in small groupings across a space of approximately 250 feet; GPS readings by Fuller in 2021 measured the dispersed panels over a distance of 284 feet. Magre characterized the colors as red, brown, and purple. Thirty-nine outline sketches were included in the NRHP nomination but no photographs were included. The sketches attached to the nomination missed several important pictographs including the atlatl figure (Figure 2) and the dog (Figures 3 and 4); sketches in the NRHP registration did include the deer painted in yellow ochre (Figure 5).



Figure 2. DStretch image of the atlatl figure with segmented ritual hat at the White Rock Bluffs site (23TE01). The atlatl figure holds a bag in his/her left hand and another bag hangs from the waist.

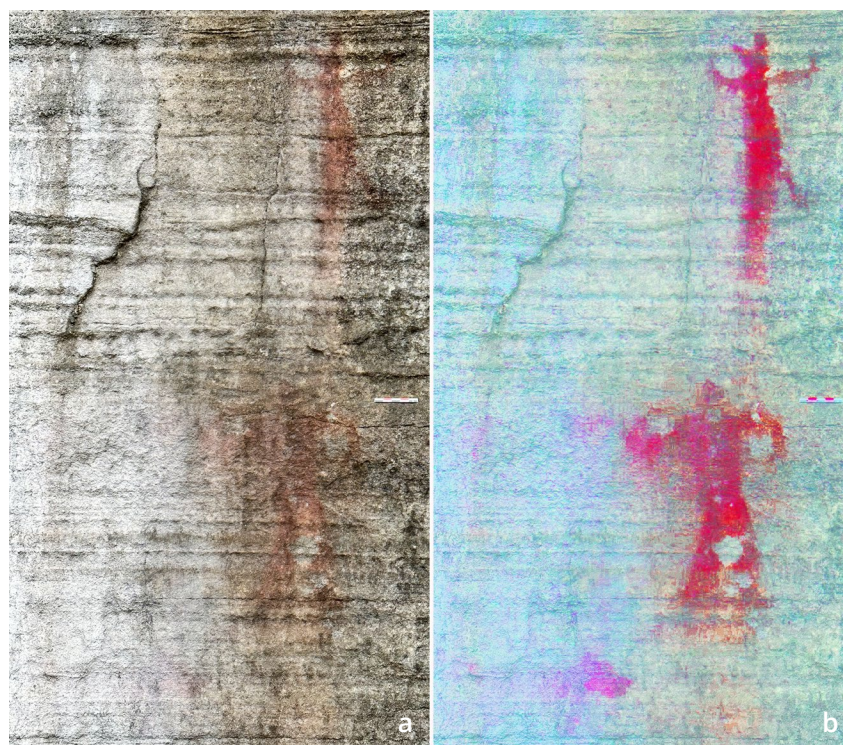


Figure 3. (a) Conventional and (b) DStretch images of a dog (lower left) following behind two human figures at White Rock Bluffs. They are located 7.2 meters to the left of the atlatl figure; the dog and all three human figures move in the same direction. All anthropomorphs appear as if in position to launch javelins with their atlatls.

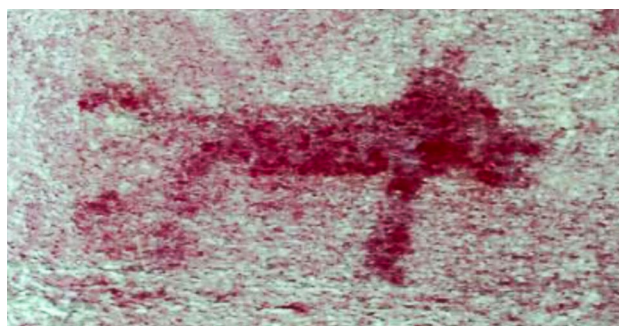


Figure 4. The dog accompanying the two human figures at White Rock Bluffs. The dog measures 20 cm in length from tip of the tail to the nose. DStretch YWE.

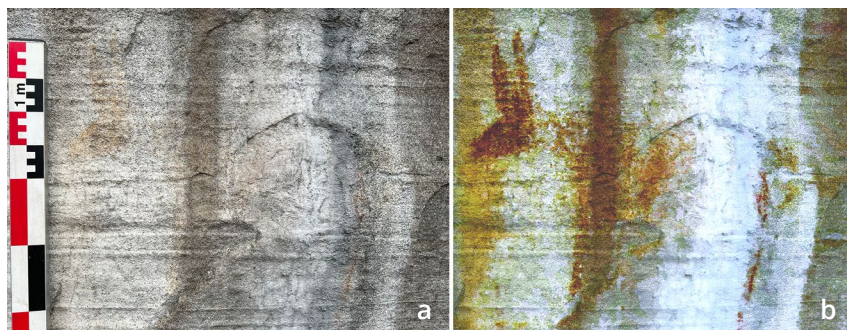


Figure 5. (a) Very weathered yellow ochre image painted approximately 13 meters to the right of the atlatl figure at White Rock Bluffs. This pictograph faces left towards the approaching atlatl figure, other humans, and dog, as if confronting a hunting party. It could also be seen as a totemic spirit watching the migration of the atlatl figure and his/her band. (b) DStretch YWE enhancement.

Carol Diaz-Granados visited White Rock Bluffs on 29 February 1992 during fieldwork for her dissertation. She was guided to the site by a local resident of Texas County. Diaz-Granados recognized the significance of the atlatl figure and discussed it in her dissertation (Diaz-Granados 1993:242, 293, Illustration 70.5.d) and subsequent publication with Jim Duncan (Diaz-Granados and Duncan 2000:171, 191, Figure 5.43a). She also recognized and sketched the “deer with large ears” (Figure 5). The atlatl figure resembles many examples in both New World and Old World rock art. Harry Allen (personal communication 9 June 2024), an expert in the archaeology of Australia, noted that the similar atlatl figures made by the First Australians would carry a magpie goose wing fan in their free hand. If the object held in the outstretched arm of the atlatl figure at the White Rock Bluffs site is holding a fan made of a bird’s wing, then there are many possibilities: bald eagle, golden eagle, red-tailed hawk, etc.

Atlatls are rarely preserved in the archaeological record of the Midwest. Baker and Kidder (1937:Figure 5) illustrated an example from Cimarron Cave near Boise City, Oklahoma. Pettigrew (2018) illustrated several

examples from the Ozarks of Missouri and Arkansas; he notes that in all cases the “mixed stratigraphy context make artifact relationships hard to assess.”

Documentation in the 1969 NRHP nomination for White Rock Bluffs is very “thin” and the nature of the site, even its exact location, was not clarified until Michael Fuller visited the site on 22 May 2012; Dean Belshe, a citizen archaeologist and former sheriff of Texas County, arranged permission and directions to assist Fuller in reaching the site. Fuller returned to White Rock Bluffs in conjunction with a Missouri Archaeological Society field school on 9 June 2021 when he conducted pXRF analysis of 14 pictographs. The majority of pictographs are red pigments, one is a brown pigment, and two are a crimson red (called purple by Magre). Steelman and Fuller visited the site on 13 January 2023 and collected a C-14 pigment sample of the atlatl figure.

Stelman’s (2023) sampling and analysis of the atlatl figure at the White Rock Bluffs site yielded a date of 420–120 cal B.C./2260 ± 60 RCYBP (95.4% probability; Shumla ID N85; CAMS ID 191212). That age range belongs to the last half of the Early Woodland period (700–200 B.C.) and first quarter of the Middle Woodland period (200 B.C.–A.D. 450) in the chronological sequence currently proposed by Lopinot and Ray (2023:Table 1).

The pXRF analysis demonstrated that the red pigment of the head of the atlatl figure is composed of iron with other elements, and that the amount of iron is slightly higher in the lower part of the body of the figure. The unpainted sandstone bedrock near the atlatl figure contains iron in a value significantly below that of the atlatl figure.

The variation in iron within the pigment between the head and lower body part most likely represents the imperfect mixing of the pigment and binder. The trace elements (beside the iron) are simple bleed-through elements in the bedrock; they are not in values large enough to represent one or more additives to the red ochre.

pXRF analysis was not carried out on the yellow ochre deer because of the very faint nature of the pigment. The nearby red pictograph of a dog following the two humans was tested and proves also to be an iron pigment. Measurement of the background bedrock associated with the dog pictograph shows that the value

of barium appears to be significantly higher than the surrounding bedrock, suggesting that a small amount was added to the red ochre during mixing of the red pigment. Barium does occur in trace amounts in several examples of hematite (both raw samples and artifacts) found in Missouri, so it most likely was a natural additive in the red pigment.

There are many engaging pictographs at the White Rock Bluffs site, including examples that may represent an individual carrying a totem, an owl, and examples of pregnant or birthing women. The overall impression of this panel is that it does not represent either war or hunting, but that it could represent migration and re-settlement. The motifs at White Rock Bluffs are similar to a modern piece of art entitled “Migration” drawn by Lance Foster, a professional archaeologist and Tribal Historic Preservation Officer for the Ioway Nation. The Early/Middle Woodland period date for the atlatl figure is not surprising as there is Middle Woodland period lithic associated with the petroglyph panels at the Washington State Park site (23WA1) situated on a hilltop overlooking a tributary of the Meramec River (Fuller 2023; Fuller et al. 2019).

DFS Site (23WN85)

The DFS site is included in this study because it also has a pictographic representation of an atlatl (Figure 6), executed in black pigment. Most of the pictographs at this site are in red pigment including a large projectile point attached to the shaft of a spear (Figure 7a). In the



Figure 6. Black-pigment atlatl figure on the ceiling of the DFS site (23WN85). The figure holds an atlatl/throwing paddle in his/her left hand, a fan or handful of darts in the other, and has a spear across the waist. DStretch LBK.

field, Mike Chervinko recognized the projectile point type as resembling examples he had seen at two sites in Illinois. Wagner (2002:64) identified a very similar rock art pattern in Illinois as representing a Middle Woodland period diagnostic projectile point, the Ross point. The possibility that the red pigment projectile point was meant to represent a Ross point is intriguing even though that point type is not represented in published reports from Missouri (Jack Ray, personal communication 16 June 2024). Ironically, the projectile point painted with the atlatl figure at the White Rock Bluffs site (Figure 7b) also resembles a Ross point.



Figure 7. (a) Red-pigment hafted dart point at the DFS site. Length from tip to base approximately 7 cm. DStretch LW. (b) Detail of the projectile point shown in Figure 2 from White Rock Bluffs. DStretch YRD.

The DFS site has been known in the community for many years and has suffered significant vandalism and looting. Fuller looked at the site through binoculars and registered it with the Archaeological Survey of Missouri in 1986. Artifact collectors had shown him Woodland and Mississippian period artifacts unearthed from the site. Diaz-Granados and Duncan were taken to the site by a neighboring property owner in May of 1991; they published their observations, including the fact that Woodland period pottery was found there, in Diaz-Granados (1993:87, 170, 471, Illustration 14.1 and 14.2) and Diaz-Granados and Duncan (2000:30, 111, 266). Neighboring property owners worked out an agreement in 2023 that allowed Fuller, Steelman, and Chervinko to visit the site in order to make pXRF measurements and take a single C-14 sample.

The atlatl figure at the DFS site is situated on the ceiling of the cave; it measures approximately 15 cm in length; it is fortunate that the vandals overlooked it. Steelman's (2023) analysis of the atlatl figure at the site yielded a date of 365–50 cal B.C./2160 ± 40 RCYBP (95.4% probability; Shumla ID N91; CAMS ID 191215). That date range falls in the last half of the Early Woodland period (700–200 B.C.) and first quarter of the Middle Woodland period (200 B.C.–A.D. 450) as currently proposed by Lopinot and Ray (2023:Table 1). The C-14 dates from the atlatl figures at White Rock Bluffs and DFS considerably overlap (Figure 8).

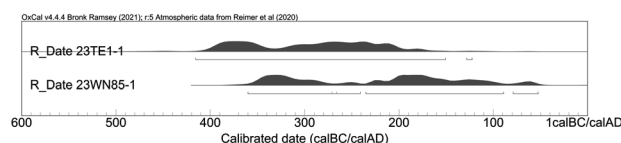


Figure 8. Radiocarbon dates for the White Rock Bluffs and the DFS atlatl figures.

The pXRF measurements of the atlatl figure at the DFS site revealed the absence of manganese, suggesting that the black pigment is created out of carbon, an element not detected with the Niton pXRF spectrometer. Measurement of an undecorated portion of the ceiling near the atlatl figure at the DFS site returned the interesting result that the amount of iron is significantly higher in the image versus the bedrock; it is also interesting to note a very faint trace of gold. Gold was only detected in this one pictograph and was not detected in any of the background readings.

The measurement of the red pigment Ross point pictograph revealed a high level of iron as compared to a nearby unpainted section of bedrock, showing that the red pigment at the DFS site is clearly an iron pigment.

Deer Run Shelter (23MO1380)

Deer Run Shelter is a south-facing sandstone rockshelter in the foothills of the St. Francois Mountains of southeast Missouri. A perennial rocky stream runs 30 meters from the dripline before turning north to meet the rock face just beyond the rockshelter's western end. According to local lore, 125 meters west of the known rock art area, the creek undercuts the bluff; turbulent water flow under the bluff would make it "sing." Columns of intrusive granite 80 meters to the east towered over the sandstone bluff. Both natural features were destroyed in historical times. The singing stopped when upstream impoundments slowed water flow. The granite columns were felled by drill and dynamite.

These peculiarities would have added to the site's special character in prehistoric times. The site is on private property, and is closed to the public.

Diaz-Granados made the first documentation of the site in 1990, identifying 40 glyphs in one day (Diaz-Granados 1993:538–544). She classified the site as "Deer Run Shelter Limited Style." Under her system, based on her investigation of 134 rock art sites in Missouri, Limited Style denotes "a singular site that is obviously significant in regard to size, complexity, and content, but for which there are no known related sites in the state" (Diaz-Granados and Duncan 2000:ii, 109–110). The advent of DStretch image-enhancement technology has facilitated the identification of additional glyphs and more detail in previously known glyphs. Known rock art includes one black and 101 red pictographs and one petroglyph across 75 meters of rock face, and one petroglyph on a detached boulder (Starr 2023). The site has the largest known collection of pictographs in a rockshelter in Missouri.

Fuller (2023) analyzed 28 red pictographs using pXRF, obtaining results suggesting a paint derived from iron-rich minerals, as was expected. Surface deposits of iron ores are common throughout the Southeast Missouri Iron Metallogenic Province (Missouri Geological Survey 2020), and were used in prehistoric red pigments (Diaz-Granados and Duncan 2000:104). Chunks of hematite have been found at Deer Run Shelter, and limonite, used as a flux agent in metallurgical furnaces, was quarried within 2 kilometers of the shelter during the early 1800s.

Deer Run Shelter Glyph 89 (Figure 9), approximately 9 cm wide, is seen as a filled bow-tie shape surrounded by dots. Diaz-Granados and Duncan (2000:171, 191) suggest that Glyph 89 might repre-

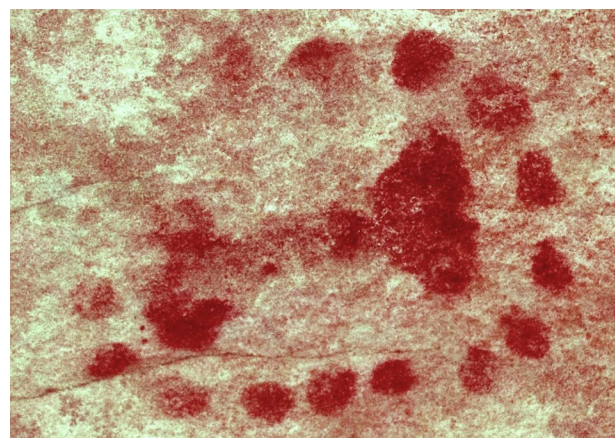


Figure 9. Deer Run Shelter, Glyph 89, bow-tie shape surrounded by dots. DStretch YRE.

sent a bow-tie bannerstone. The pXRF analyses were conducted on the red pigment of the pictograph and a nearby section of unpainted bedrock.

The principal component of Glyph 89 pigment is iron and the C-14 sample yielded results of cal A.D. 230–530/1710±50 RCYBP (95.4% probability; Shumla N92; CAMS 191213). That date places the glyph in the second half of the Middle Woodland period into the beginning of the Late Woodland period (Lopinot and Ray 2023:Table 1). Estimates for when the atlatl gave way to the bow and arrow vary widely but mostly fall within the Late Woodland period (Blitz 1988:131; O'Brien and Wood 1998:232). Diaz-Granados and Duncan (2000:171, 191) note that “the atlatl and bannerstones, considered typical of the Archaic period, were also utilized in subsequent periods.” If the bow-tie pictograph at Deer Run Shelter depicts a bannerstone, then its inspiration was probably a utilitarian object, but could have been an anachronistic or ceremonial one.

Deer Run Shelter Glyph 99 (Figure 10), approximately 20 cm in length, is a handprint with nested open loops in the palm. A high level of iron in the pXRF analysis of the red pigment as compared to a nearby section of unpainted bedrock shows that the red pigment of Glyph 99 is based on iron. The radiocarbon analysis of Glyph 99 resulted in a date of cal A.D. 260–540/1650±40 RCYBP (Shumla N93; CAMS 191217). That date places the glyph in the Middle to Late Woodland period and is very close to the date for Glyph 89 at the Deer Run site.

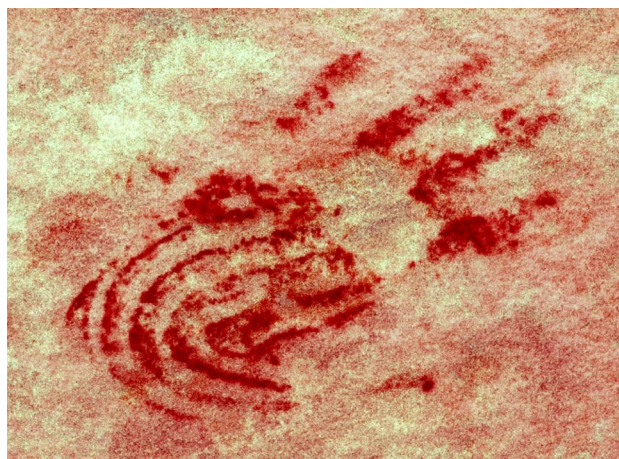


Figure 10. Deer Run Shelter, Glyph 99, handprint with nested open loops. DStretch YRE.

Diaz-Granados and Duncan (2000:164) note that “this treatment of the palm with concentric ovals is seen in graphics of the Southwest.” One such example is illustrated by Feest (1980:54) where an Arapaho Ghost

Dance dress shows hands styled as “protective designs.” Similar pictographs of handprints with nested open loops can be found throughout the American Southwest, e.g., Fate Bell Shelter, Seminole Canyon State Park, Texas, and Many Hands Panel, Escalante Grand Staircase National Monument, Utah (Alvarez n.d.). Closer to Missouri, examples are known from at least two sites (3CN325, 2CN425) in the Petit Jean Mountain area of Arkansas (Higgins 2014:Figure 12; Higgins personal communication 2 June 2024). The Native American open-hand design is famous in art history literature based upon the evocative mica right-hand cutout excavated from Mound 25 at the Hopewell site in Ross County, Ohio (Seeman 2004). Another Middle Woodland hand representation, an open left hand design carved into the surface of a micritic limestone circular palette, was found in Winchester Mound 3 in the Naples Archaeological District, Scott County, Illinois; its age is estimated to be between 100 B.C. and A.D. 300 (NMNH/Smithsonian catalog number A43126-0). Mark F. Seeman (personal communication 9 May 2024) notes that the hand image is widespread in North American and can have many possible meanings including pushing through to another dimension, trophy-taking, and protection.

Deer Run Shelter Glyph 10 (Figure 11), approximately 10 cm tall, is an anthropomorph holding a spear with a large point. The red pigment’s pXRF results show a high level of iron and an elevated level of strontium relative to levels in a nearby spot of unpainted bedrock. The pigment of Glyph 10 is clearly based on iron with a trace of strontium. It is likely that the hematite/ochre sample used to create the pigment contained the trace of strontium.

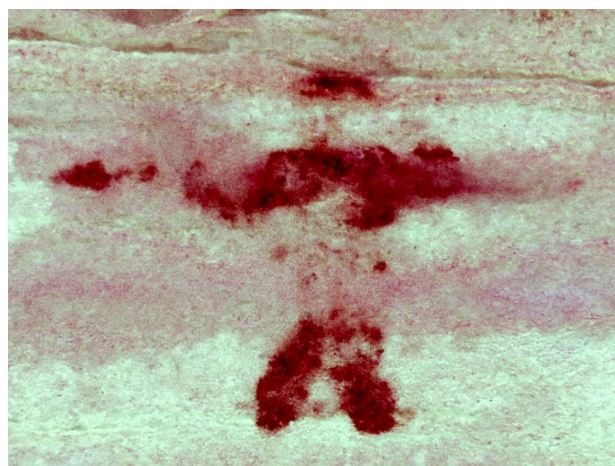


Figure 11. Deer Run Shelter, Glyph 10, anthropomorph with spear. DStretch YRE.

A crescent boatstone from 23GR341 in the Pearson Creek Archaeological District contained strontium in levels of $495 \text{ ppm} \pm 32.28$. Elevated levels of strontium were detected with pXRF analysis in samples of a calcite from the Denton Mine ($332.07 \text{ ppm} \pm 15.77$) and from Cave-In-Rocks ($246.3 \text{ ppm} \pm 25.44$), both in Illinois. It has also been detected in a sample of ram's horn selenite gypsum ($473.97 \text{ ppm} \pm 21.97$), a rare mineral found in a handful of cave sites such as Mammoth Cave, where it was harvested by Native Americans during the Early Woodland period and possibly later (Crothers 2012; Munson et al. 1989). A sample of celestine from Indiana has a very high ppm of strontium ($228253.36 \text{ ppm} \pm 678.45$), which is not unexpected as celestine's chemical formula is SrSO_4 .

The radiocarbon sample from Glyph 10 yielded a date of cal A.D. 1425–1635/400 \pm 45 RCYBP (Shumla 90; CAMS 191213). That date places the glyph in the Late Mississippian to Contact period. This also coincides with the hypothesized “Vacant Quarter” period, circa A.D. 1400–1650, during which all known permanent settlements were abandoned in the riparian zone centered on the mouth of the Ohio River, upstream to the Wabash River, up the Tennessee and the Cumberland rivers as far south as modern-day Nashville, and down the Mississippi River from Cahokia into northeast Arkansas (Williams 1983:77–78). This is not interpreted to mean that the land was empty of people. “Abandonment of southeast Missouri, for instance, did not seem to have interrupted the continued exploitation of the [St. Francois] Mountains for critical natural resources including salt, basalt for heavy edged tools, copper for ornaments, galena and hematite for paint, and cherts for a variety of edged tools” (Morse and Morse 1983:280–282). John E. Kelly (2010:210) notes that archaeological digs near St. Louis show that “there is a clear and strong link between Cahokia and the St. Francois Mountains in the form of basalt axe heads manufactured in the American Bottom. The nature of the journeys probably involved a landscape with sacred locations that extended not only into mother earth but also pushed upward into the heavens.” While evidence of quarrying is largely absent from the area, probably having been destroyed by historical-period mining, a site interpreted as an Early Mississippian seasonal lithic workshop has been documented that includes diabase tools and blanks that are also found in Cahokia (Crow 2014:33–34). Galena (lead sulfide) from the northern St. Francois Mountains has been found in sites dated from the Archaic to Contact pe-

riods, although no tested samples have been linked to the eastern and southern parts of the region (Walthall 1981:29, 36–41). Whether the painter of the spearman glyph traversed the area to extract minerals, hunt, tend to spiritual matters, or conduct ordinary business in his home neighborhood, remains unknown.

The millennium-long interval between the bowtie and hand glyphs and the spearman glyph (Figure 12) is the first radiocarbon evidence of a significant temporal gap in image-making episodes in a single rock art site in Missouri. Diaz-Granados and Duncan (2000:250)

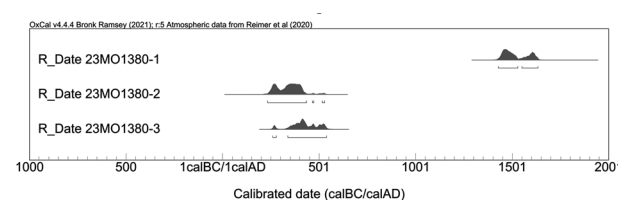


Figure 12. Three radiocarbon dates from the Deer Run site.

said, “We believe that several of the larger, complex panels were rendered to convey a group’s rich oral traditions—but not entirely oral, because of the wonderful graphics that they left behind for us to contemplate. The faintness of the upper rattlesnakes at Rattlesnake Bluff, the layers of graphics at Picture Cave, and the unidentifiable faint areas of pigments at Deer Run Shelter and at many other sites suggest that these areas of rock art activity were used over successive generations.” Continued research in Missouri pictographs will probably reinforce the fact that large panels were used repeatedly over millennia.

Groeper Site (23WN1177)

The Groeper site is situated in an isolated hollow within a half day’s walk of three other important pictograph sites: Picture Cave, Cactus Cove, and DFS. Stone tools and pottery sherds associated with these sites strongly suggest that they were contemporaneous. The Groeper site has been known to the local community for many years, and fortunately the rock art (both pictographs and petroglyphs) has not been vandalized; poorly controlled amateur excavation has removed all the loose sediment from below the overhang of the shelter. Duncan visited the site with the property owner on 31 January 1993; Diaz-Granados and Duncan published their observations in Diaz-Granados (1993:176, 220, 476, Illustrations 21.2 to 21.4), Duncan and Diaz-Granados (2004:201), and Diaz-Granados and Duncan (2000:111, 114, 115, 202, 209, Figure 5.39). Michael Fuller visited the site with the property

owner on 18 April 2021, registered the site with Missouri Department of Natural Resources, and returned to conduct pXRF analysis and collect radiocarbon samples on 15 January 2023.

Most of the pictographs at the Groeper site are discreetly hidden on the ceiling of the shelter, but one is prominently painted on the back wall as if it is a totemic pictograph: an undulating, horned serpent executed in red pigment. The property owner had mistaken the image as “teepees” because it is difficult to scramble across the boulders for a close inspection. Duncan photographed the pictograph and recognized it as a horned serpent (Figure 13).

Careful examination and DStretch photography demonstrate that the undulating horned serpent is a more complex composition of six red pigment horned serpents hunting in a pack—each carrying a black pigment chick in its mouth while a black pigment mother bird flies helpless overhead (Figure 14). The red pigment was applied first, then the black pigment was painted on top of it after the red was completely dry. The last red-pigment horned serpent has a prominent wing and rattle (Figure 13). Radiocarbon analysis of the red-pigment serpents yielded a result of cal A.D. 1030–1255/890 ± 45 RCYBP (Shumla ID N87; CAMS ID 191218). Radiocarbon analysis of the black-pigment mother bird above the undulating line of red serpents yielded a result of cal A.D. 1045–1270/860 ± 40 RCYBP (Shumla ID 89; CAMS ID 191219). The two radiocarbon dates are essentially contemporaneous.

The chemical analysis by pXRF of the red pigment shows a very high level of iron compared to the sample of nearby unpainted rock, demonstrating that it is an iron oxide pigment with traces of other elements. The analysis of the black-pigment bird flying above the undulating red serpents yielded very interesting results: it is a mineral-based black pigment containing manganese, lead, and iron. The pXRF results for the black-pigment bird shows a manganese trace element value of 70.8 ppm, which does not seem high enough to consider it as the sole color-producing component of the pigment. Precontact black pigments made out of manganese in Texas range from 400 to 110,000 ppm. The black-pigment bird and the chicks are very faint in color density.

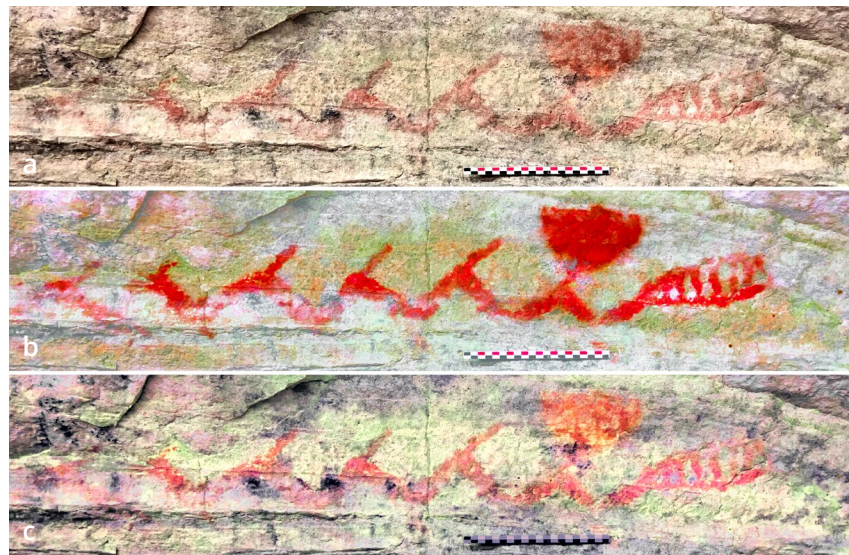


Figure 13. (a) Six horned serpents as an undulating pack moving right to left at the Groeper site; a prominent open wing and rattle are attached to the last serpent. (b) DStretch YWE to highlight red pigment. (c) DStretch YDT to highlight black pigment.



Figure 14. Black-pigment chick in the mouth of each red serpent with a black-pigment mother bird helplessly watching, Groeper site. DStretch YBK.

Radiocarbon and pXRF analyses were conducted on a red-bodied figure with outstretched arms or wings with a black-pigment head or mask (Figure 15a and b) on the ceiling of the shelter. The radiocarbon age of cal A.D. 1030–1225/900±45 RCYBP (Shumla ID 86; CAMS ID 191214) was obtained for the red figure. As shown in Figure 16, this and the two dates from the undulating snakes (cal A.D. 1030–1255) and bird (cal A.D. 1045–1270) are congruous with dates obtained by Rowe (2009; Diaz-Granados et al. 2001; Duncan et al. 2015) on black charcoal pictographs in nearby Picture Cave, all generally falling between cal A.D. 1000 and 1225.

Three pXRF measurements were taken on the red/black pictograph on the ceiling of the Groeper site, with separate measurements on the upper half of the red-pigment body, the lower half of the body, and the



Figure 15. (a) Red-pigment torso of a human with outstretched arms and black-pigment oversized head (mask or transforming head) at the Groeper site. (b) DStretch LDS enhancement.

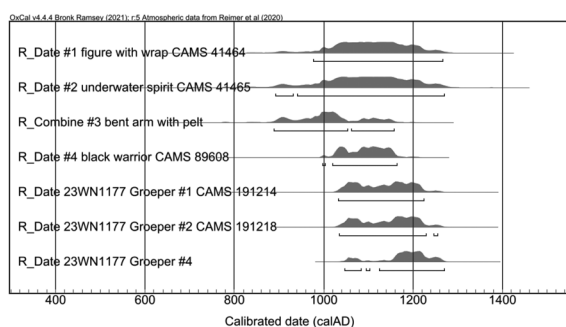


Figure 16. Comparison of the four C-14 dates from Picture Cave with three C-14 dates from the Groeper site.

faint black-pigment head/mask, with a nearby unpainted portion of the ceiling for background readings.

The red pigment is clearly based upon iron while the faint black pigment can be assumed to be charcoal as all mineral components are within the range of the unpainted bedrock.

A remarkable aspect of the Groeper site is that a moderate-sized collection of material culture, assembled from near-surface deposits by a previous landowner, clearly demonstrates occupation during the Woodland (700 B.C.–A.D. 950) and Mississippian (A.D. 950–1600) periods. The most unique artifact in the assemblage is a lightning whelk (*Sinistrofulgur sinistrum*) columella that has been cut and snapped (Figure 17a). The shell originated in the Gulf of Mexico and probably was obtained by trading/raiding at Cahokia. Columellae like this were found at Tick Creek Cave (23PH145), the Fierce Owl site (23SL18), the Big Mound in downtown St. Louis, and the Herrell site (23JE55) in Jefferson County. Many examples are known from Cahokia and the American Bottom area of Illinois.

Many examples of Mississippian projectile points (Figure 17b–d) and pottery sherds were also found by the landowners in near-surface sediments at the Groeper site. Interestingly, Middle Woodland projectile points (Figure 18a), Late Woodland projectile points (Figure 18b), and Late Woodland/Early Mississippian period sherds (Figure 19a–c) are well represented in the material culture from the Groeper site.

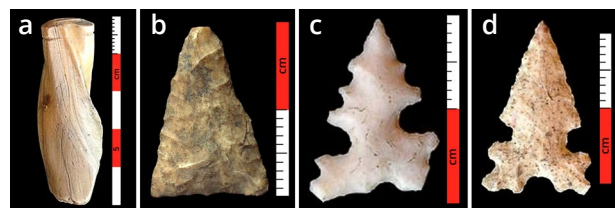


Figure 17. Mississippian artifacts from the Groeper site. (a) Lightning whelk columella; (b) Madison, (c) Cahokia serrated, and (d) Cahokia multiple-notched projectile points.

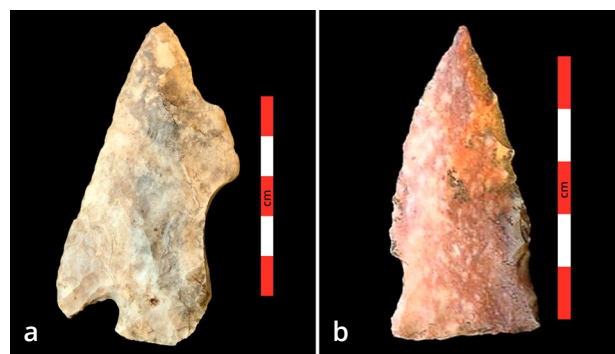


Figure 18. Woodland period projectile points from the Groeper site. (a) Snyder and (b) Rice Side-notched points.

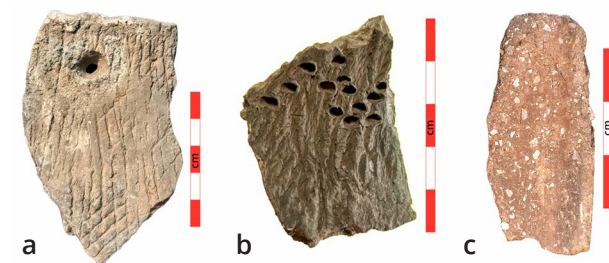


Figure 19. (a and b) Grit-tempered Late Woodland sherds and (c) shell-tempered Mississippian sherd from the Groeper site.

Summary

Based on radiocarbon dating, two sites in Missouri have Early/Middle Woodland period pictographs of atlatl figures. These direct dates are not surprising considering the indirect evidence for petroglyphs dating back to the Early/Middle Woodland period at Washington State Park (23WA1). The red-pigment pictograph of a handprint with nested open loops at Deer

Run Shelter, dating to the Middle Woodland period, is an exciting discovery that raises interesting questions about the continuity of artists' representations of open hands from the Woodland into the Mississippian period art canon. The radiocarbon-dated Early Mississippian period art in Picture Cave is now established as contemporaneous with the panels at the Groeper site. The pXRF analysis has demonstrated that the majority of red-pigment pictographs are red ochre and the black-pigment pictographs are carbon-based. A few examples have been discovered of pigment formulations that involved the addition of iron and manganese to black pigments. The young (cal A.D. 1425–1635) Late Mississippian to Contact period radiocarbon date for Glyph 10 at Deer Run Shelter requires us to reconsider the common perception of the area being nearly devoid of settlements during this time.

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Appendix: pXRF Sample Measurements

White Rock Bluffs Site (23TE01)

Red pigment, head of the atlatl figure

- antimony = 67.12 ppm \pm 14.79
- tin = 34.57 ppm \pm 11.46
- cadmium = 26.08 ppm \pm 11
- silver = 19.61 ppm \pm 7.7
- zirconium = 38.64 ppm \pm 9.12
- iron = 593.71 ppm \pm 56.55
- barium = 481.31 ppm \pm 53.74
- strontium = 18.8 ppm \pm 3.34
- rubidium = 3.72 ppm \pm 2.05

Lower part of body of atlatl figure

- antimony = 74.4 ppm \pm 14.75
- tin = 47.28 ppm \pm 11.52

- cadmium = 28.13 ppm \pm 10.95
- silver = 14.17 \pm 7.52
- zirconium = 75.97 ppm \pm 7.52
- iron = 651 ppm \pm 58.11
- barium = 456.95 ppm \pm 53.14
- strontium = 22.61 ppm \pm 3.44
- rubidium = 5.6 ppm \pm 2.15

Unpainted sandstone bedrock near atlatl figure

- antimony = 49.07 ppm \pm 12.11
- tin = 29.69 ppm \pm 9.45
- cadmium = 19.05 ppm \pm 9.04
- silver = 10.15 ppm \pm 6.22
- zirconium = 21.85 ppm \pm 7.35
- iron = 338.25 ppm \pm 38.55
- manganese = 75.27 ppm \pm 35.33
- barium = 359.87 ppm \pm 43.87
- strontium = 19.85 ppm \pm 2.8
- rubidium = 4.02 ppm \pm 1.72

Red pictograph of dog following two humans

- zirconium = 19.9 ppm \pm 8.16
- iron = 581.82 ppm \pm 51.6
- barium = 210.78 ppm \pm 47.9
- strontium = 14.8 ppm \pm 2.96
- rubidium = 3.68 ppm \pm 1.9

Background bedrock associated with dog pictograph

- zirconium = 15.33 ppm
- iron = 202.92 ppm \pm 35.68
- barium = 96.49 ppm \pm 45.84
- strontium = 17.35 ppm \pm 2.96

DFS Site (23WN85)

Atlatl figure

- antimony = 57.96 ppm \pm 13.57
- tin = 33.95 ppm \pm 12.2
- zirconium = 42.15 ppm \pm 8.48
- gold = 14.88 ppm \pm 8.63
- iron = 905.67 ppm \pm 60.95
- barium = 422.7 ppm \pm 48.88
- strontium = 20.41 ppm \pm 3.28

Undecorated portion of ceiling near atlatl figure

- antimony = 55.91 ppm \pm 12.57
- tin = 24.25 ppm \pm 11.17
- zirconium = 23.74 ppm \pm 7.63
- iron = 337.78 ppm \pm 39.49
- barium = 340.22 ppm \pm 44.84
- strontium = 23.38 ppm \pm 3.12

Red pigment Ross point pictograph

- antimony = 72.04 ppm \pm 13.69
- tin = 58.27 ppm \pm 13.34
- cadmium = 22.83 ppm \pm 10.7

- zirconium = 40.88 ppm \pm 9.02
- iron = 908.44 ppm \pm 65.42
- barium = 491.46 ppm \pm 52.82
- strontium = 10.65 ppm \pm 3.17

Unpainted section of bedrock near Ross point

- antimony = 48.79 ppm \pm 12.33
- tin = 31.43 ppm \pm 11.09
- zirconium = 32.2 ppm \pm 7.62
- iron = 222.33 ppm \pm 34.48
- barium = 410 ppm \pm 44.69
- strontium = 17.95 ppm \pm 2.93

Deer Run Shelter (23MO1380)

Filled bow-tie shape (Glyph 89)

- barium = 463.00 ppm \pm 40.33
- antimony = 62.94 ppm \pm 10.81
- cadmium = 17.33 ppm \pm 7.91
- silver = 19.08 ppm \pm 5.65
- zirconium = 102.30 ppm \pm 7.74
- strontium = 19.54 ppm \pm 2.38
- copper = 23.35 ppm \pm 10.19
- iron = 678.09 ppm \pm 41.66

Unpainted section of bedrock near bow-tie glyph

- barium = 398.26 ppm \pm 40.51
- antimony = 51.79 ppm \pm 10.86
- tin = 28.88 ppm \pm 8.58
- cadmium = 20.43 ppm \pm 8.04
- silver = 12.87 ppm \pm 5.63
- zirconium = 331.84 ppm \pm 9.83
- strontium = 30.11 ppm \pm 2.65
- rubidium = 3.67 ppm \pm 1.51
- zinc = 13.13 ppm \pm 5.06
- copper = 23.83 ppm \pm 10.29
- iron = 417.28 ppm \pm 35.16

Handprint with nested loops (Glyph 99)

- barium = 471.45 ppm \pm 40.34
- antimony = 62.73 ppm \pm 10.81
- tin = 35.38 ppm \pm 8.52
- cadmium = 26.03 ppm \pm 8.00
- silver = 11.94 ppm \pm 5.54
- zirconium = 46.31 ppm \pm 7.05 ppm
- strontium = 8.13 ppm \pm 2.09
- zinc = 8.31 ppm \pm 4.74
- iron = 552.93 ppm \pm 38.49

Unpainted section of bedrock near handprint

- barium = 453.06 ppm \pm 41.29
- antimony = 69.80 ppm \pm 11.15
- tin = 31.03 ppm \pm 8.72
- cadmium = 30.80 ppm \pm 8.26
- silver = 23.16 ppm \pm 5.85

- zirconium = 58.54 ppm \pm 7.38
- strontium = 12.20 ppm \pm 2.25
- iron = 290.42 ppm \pm 31.75

Anthropomorph holding spear (Glyph 10)

- antimony 95.04 ppm \pm 12.97,
- tin = 68.97 ppm \pm 12.97,
- cadmium = 37.13 ppm \pm 9.52,
- silver = 30.33 ppm \pm 10.36,
- zirconium = 61.36 ppm \pm 8.83,
- strontium = 120.18 ppm \pm 4.83,
- lead = 37.87 ppm \pm 7.29,
- zinc = 13.63 ppm \pm 6.04,
- copper = 39.55 ppm \pm 13.57, and
- iron = 907.85 ppm \pm 55.03.

Unpainted spot of bedrock near anthropomorph

- barium = 422.49 ppm \pm 31.12
- antimony = 55.22 ppm \pm 11.02
- tin = 35.12 ppm \pm 8.74
- cadmium = 19.95 ppm \pm 8.14
- silver = 14.53 ppm \pm 5.72
- zirconium = 91.16 ppm \pm 7.80
- strontium = 36.66 ppm \pm 2.83
- lead = 16.75 ppm \pm 5.49
- zinc = 22.94 ppm \pm 5.82
- copper = 122.59 \pm 14.02
- iron = 290.62 ppm \pm 31.74

Groeper Site (23WN1177)

Red pigment serpents

- antimony = 47.68 ppm \pm 13.53
- tin = 33.58 ppm \pm 12.23
- zirconium = 30.8 ppm \pm 8.32
- gold = 13.2 ppm \pm 8.52
- nickel = 37.49 ppm \pm 24.91
- iron = 1318.4 ppm \pm 71.78
- barium = 467.03 ppm \pm 49.44
- strontium = 10.03 ppm \pm 2.95

Black pigment bird above serpents

- antimony 51.88 ppm \pm 13.42
- tin = 46.14 ppm \pm 12.2
- zirconium = 34.26 ppm \pm 8.29
- lead = 22.63 ppm \pm 7.41
- iron = 298.05 ppm \pm 41.05
- manganese = 70.8 ppm \pm 39.88
- barium = 371.81 ppm \pm 48.27
- strontium = 10.53 ppm \pm 2.94

Unpainted rock near serpents

- antimony = 47.79 ppm \pm 11.96
- tin = 30.97 ppm \pm 10.77
- cadmium = 13.45 ppm \pm 8.74

- zirconium = 22.4 ppm \pm 7.24
- iron = 182.3 \pm 31.83
- barium = 357.28 ppm \pm 43.03
- strontium = 9.97 ppm \pm 2.6

Upper half of red pigment body of anthropomorph on ceiling

- antimony = 57.93 ppm \pm 13.46
- tin = 37.67 ppm \pm 12.1
- zirconium = 33.45 ppm \pm 8.31
- nickel = 42.04 ppm \pm 24.48
- iron = 5526.28 ppm \pm 137.58
- barium = 402.65 ppm \pm 48.37
- strontium = 27.46 ppm \pm 3.46

Lower half of the red-pigment body

- antimony = 62.19 ppm \pm 13.22
- tin = 40.7 ppm \pm 11.89
- cadmium = 29.09 ppm \pm 9.77
- zirconium = 29.2 ppm \pm 8.08
- iron = 7334.08 ppm \pm 154
- barium = 498.45 ppm \pm 47.91
- strontium = 34.51 ppm \pm 3.58.

Faint black-pigment head/mask

- antimony = 38.99 ppm \pm 12.41
- tin = 26.2 ppm \pm 11.17
- zirconium = 15.65 ppm \pm 7.54
- iron = 229.28 ppm \pm 35.2
- barium = 306.33 ppm \pm 44.66
- strontium = 27.72 ppm \pm 3.25

Unpainted portion of ceiling near anthropomorph

- antimony = 54.05 ppm \pm 13.21
- tin = 27.66 ppm \pm 11.91
- cadmium = 11.91 ppm \pm 16.62
- zirconium = 27.23 ppm \pm 8.15
- iron = 201.47 ppm \pm 36.15
- barium = 411.52 ppm \pm 47.66
- strontium = 45.93 ppm \pm 3.9

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