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Pigment Composition of Prehistoric Pictographs of Gatecliff Shelter, Central Nevada

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ABSTRACT

X-ray diffraction and electron microprobe analysis reveals the minerals used as base and pigments in prehistoric paints from Gatecliff Shelter, an archeological site in central Nevada. Goethite, hematite, and lepidocrocite were mixed in varying proportions to obtain red, orange, and yellow paint. The combination of aragonite, gypsum, and halotrichite-pickeringite (an alum) formed both the white paint and also the base used to bind the other colors. This mineral assemblage is probably from a local hot-spring deposit. Not only is the paint composition a potential indicator of prehistoric interaction networks and an aid for rock art classification, but pictograph paint may even prove significant as a cultural and/or temporal index in certain regions.

INTRODUCTION

As a cultural product, prehistoric rock art has at least three analytical dimensions: style, technique, and provenience. In studying western North American rock art, scholars have generally concentrated on stylistic aspects of both petroglyphs and pictographs. Steward (1929) in a pioneering study recognized four stylistic areas within California and adjoining

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states. Somewhat later Cressman (1937) divided Oregon into two styles: naturalistic designs common throughout most of the Great Basin and the more complex Klamath Basin polychrome style. More recently, styles have been isolated in much smaller geographic units. Grant, Baird, and Pringle (1968), suggested, for instance, that naturalistic rock art elements found in the Coso Range of eastern California may be the remnants of a local prehistoric mountain sheep cult.

To a lesser degree, investigators have also considered the specific provenience of rock art elements. Using such a strategy, Heizer and Baumhoff (1962) suggested that the locations of 99 Nevada rock art sites may indicate that the rock art may have been involved in hunting magic. Although this suggestion remains an untested hypothesis, the evidence clearly indicates a correlation between rock art localities and areas of potential hunting, especially migration routes and watering holes.

To date, analysis of the third analytical dimension—rock art technique—remains preliminary and perfunctory, tending to group all petroglyphs and pictographs into a single style without regard to mode of application, such as pecking, scratching, and painting. Pictograph composition has been too often dismissed with rather superficial descriptions; the existing literature generally alludes to pigments as ocher, charcoal, animal fat, or perhaps some more exotic, yet unidentified mineral (e.g., Steward, 1929, p. 175; Cressman, 1937, p. 48; Heizer and Baumhoff, 1962, p. 207).

We suggest that a more exacting analysis of both qualitative and quantitative aspects of pictograph composition is in order. In an earlier study of pigments taken from the walls of Toquima Cave in central Nevada (McKee and Thomas, 1973), it was determined that the paint consists of a gypsum binder, colored with hematite, goethite, and charcoal. These mineral phases were identified by X-ray diffraction techniques, but because of the masking effect of the cave-wall contaminants, the analyses were difficult to interpret quantitatively.

To obtain more conclusive results, a second site was selected for analysis, the Gatecliff Shelter (26-NY-301), situated 12 miles south of Toquima Cave (fig. 1). The cave walls are hard chert and dolomite, materials that produce a minimum of interference by contamination during the analytical work. The site was excavated in 1970 and 1971, and three occupation phases are recognized: Yankee Blade phase (*ca.* A.D. 1300 to historic era), Underdown phase (*ca.* A.D. 600–1300) and Reveille phase (*ca.* 1500 B.C.–A.D. 600). These dates are tentative and the deposits are currently being analyzed in detail. About 75 rock art elements, including circles, dots, quadruped, hand patterns, and human figures, are painted on the walls of Gatecliff Shelter in various colors, especially white, yellow, orange, red,

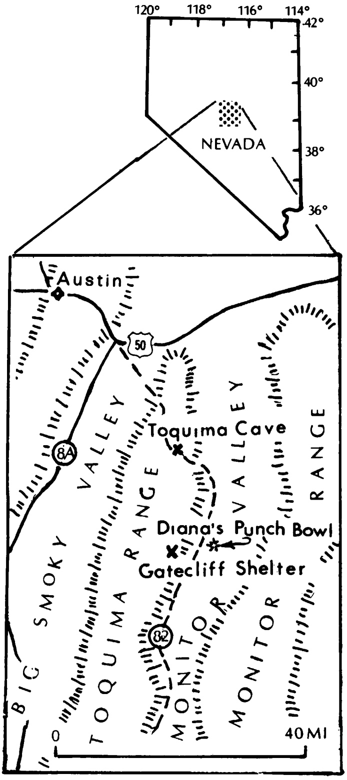

FIG. 1. Map of Nevada with enlargement of the area from which the petroglyph pigments were collected. Those analyzed for this report are from Gatecliff Shelter.

and dark red. The Gatecliff art can be tentatively classified as Great Basin Representational style (Thomas and Thomas, 1972) and is considered to have probably been produced sometime during the Reveille phase.

ANALYSIS

Samples were obtained by scraping the petroglyph paint pigments from the relatively smooth cave walls with a steel blade. At this point, we assume these samples are representative of all pigments of the four colors used at Gatecliff.

Mineral phases were then identified by X-ray diffraction and electron microprobe methods at the United States Geological Survey in Menlo Park, California. Diffractograms were obtained from a Picker biplane diffractometer using copper radiation and scintillation detector. Mineral identifications were obtained by reference to the American Society for Testing and Materials (A.S.T.M.) powder Data File and the Fink index.

The X-ray analyses show that each color sample contains several

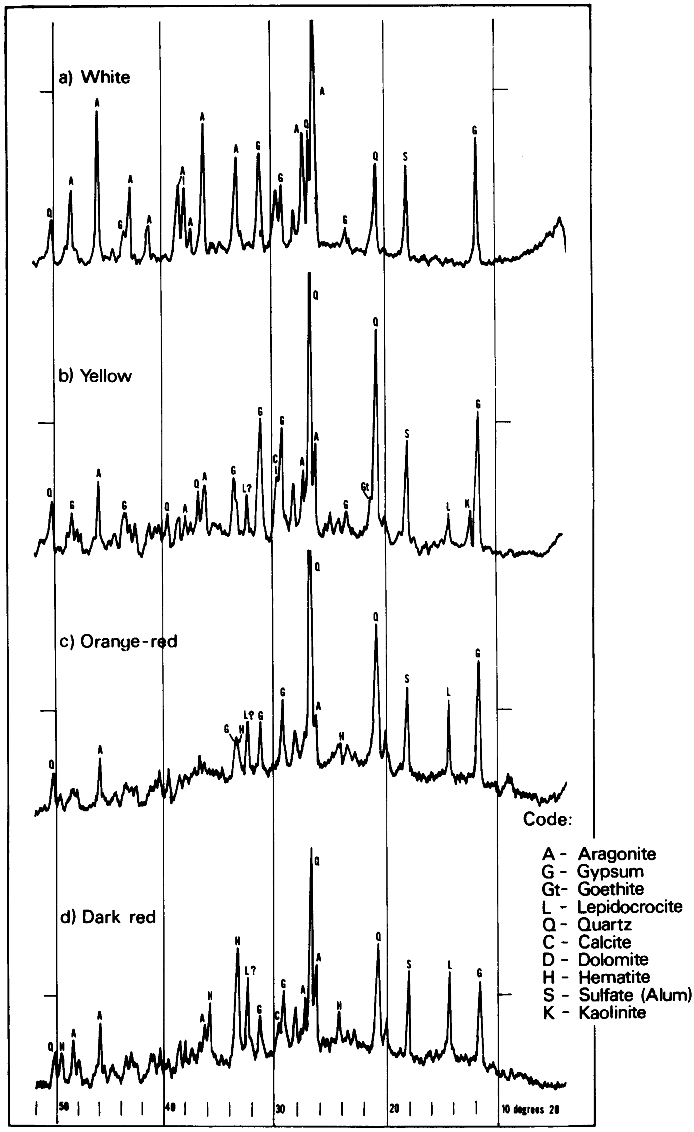

FIG. 2. Diffractograms of four paint samples.

dominant mineral phases, producing a multitude of large-scale reflections (peaks) on the diffractograms (see fig. 2). To resolve the identity of minor phases, which might have hidden reflections, the samples were immersed

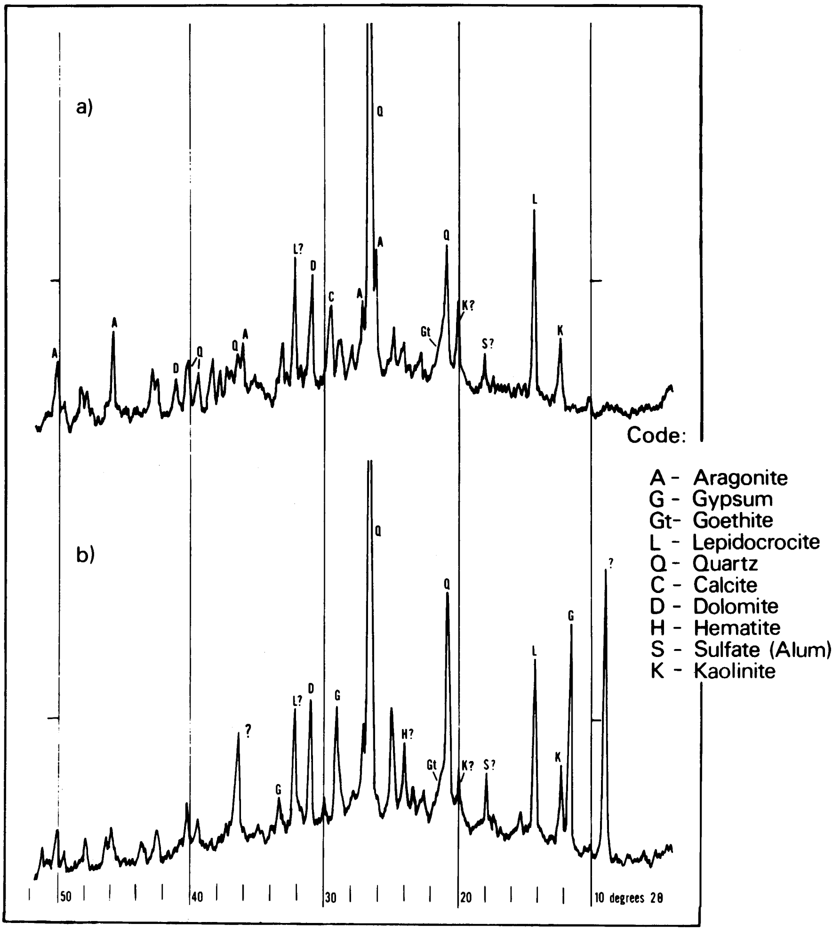

FIG. 3. Diffractograms of (a) water-treated, and (b) acid-treated yellow paint sample.

in distilled water and in dilute HCl, and the residues X-rayed. Diffraction patterns for the four paint samples are shown in figure 2. For diagram reproducibility, the scan speed during diffraction was 2 degrees 2θ per minute, with a chart speed of 2 inches per minute, resulting in the compressed diffraction patterns seen in figures 2 and 3.

X-ray analyses reveal that aragonite, gypsum, and an alum mineral form the binder (paint base) in all the samples. Quartz is probably a contaminant from the cave wall, and small amounts of kaolinite and calcite are thought to be impurities brought in with the binding constituents. The unpigmented binder also served as the white paint. Coloring agents consist of lepidocrocite ($FeO(OH)$), and possibly goethite ($HFeO_2$) for yellow, and hematite (Fe_2O_3), lepidocrocite, and goethite for red.

To demonstrate how variations in relative mineral proportions from one sample to another can affect hue, the major peak for various minerals in the three colored samples is scaled relative to the major reflection of quartz (26.6° 2θ), which is given a constant value of 100 (see fig. 4). Thus the ratio of lepidocrocite to sulfate is greater in the orange-red paint than in the yellow and is highest in the red, and the amount of hematite relative to other mineral components is greatest in the red paint.

Diffraction patterns of the residues from distilled H_2O-treated and dilute HCl-treated yellow paint samples are shown in figure 3. These patterns show that samples immersed in water lost sulfate components because peak heights for dolomite and calcite were enhanced greatly. Conversely, acid-treated yellow paint (fig. 3b) lost carbonate components, as would be expected. Gypsum remained as the major sulfate; the alum was partially soluble in the acid solution.

Identification of the type of alum mineral was accomplished by electron microprobe analysis in which certain cationic species were determined in coexisting groups of three elements. Because of the soft granular texture of the material, polishing was not attempted, and the microprobe results are qualitative. Analysis was done on carbon-coated grain mounts with an ARL-EME-SE electron microprobe operated at 15 kv. accelerating potential, 0.025 μ amp. specimen current, and beam diameter of about 2 μ. Of the combinations of elements searched for—S, Fe, Mg: S, Fe, Al; S, Cu, Mg—only Fe, Mg, and Al in some combination with sulfur were found. It is concluded that the sulfate mineral is an intermediate member of the halotrochite ($FeAl_2(SO_4)_4.22H_2O$)-pickeringite ($MgAl_2(SO_4)_4.22H_2O$) solid solution series, which is a member of the alum group (Dana, 1948, p. 764).

CONCLUSIONS

Various mixtures of iron oxide minerals added to the white base were used to produce the yellow, orange, and red paints. These minerals are common forms in the Great Basin. The minerals include lepidocrocite ($FeO(OH)$) and goethite ($HFeO_2$), which are yellow to reddish brown, and hematite (Fe_2O_3), which is red. Orange hues were produced by mixing red and yellow minerals in varying proportions, as would be expected and as shown by variations in the iron oxide peak heights (fig. 4). Specific collecting sites for the ocher minerals near Gatecliff Shelter are not known,

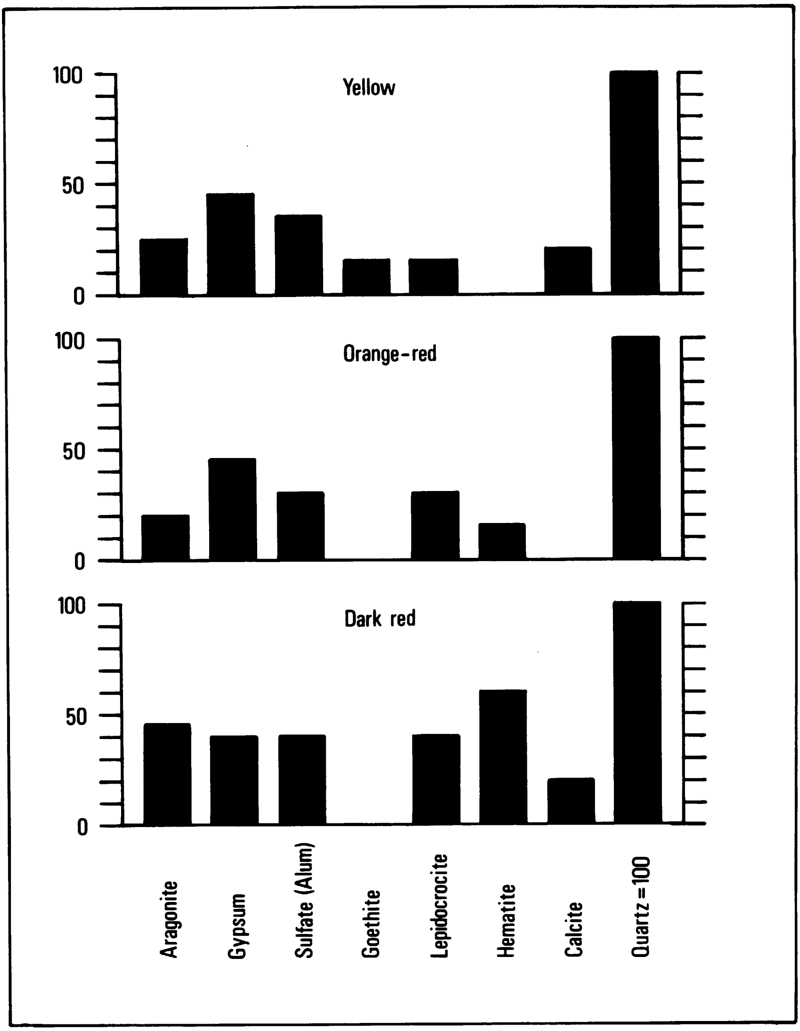

FIG. 4. Major peak heights of various minerals relative to quartz (=100).

but as noted, these minerals are common in small amounts throughout the region. The coloring agents were probably collected when found and stored, although large seams may have been mined over a long period. Prehistoric ocher mines have not been identified in central Nevada to date.

All the mineral phases recognized by X-ray diffraction, with the possible exception of the alum (halotrichite-pickeringite), are common in central Nevada. The alum may be common as well (e.g., Hewett, 1924, p. 83) but is usually overlooked because it is difficult to identify.

Because the white paint and the base for the other ochers are composed of the same mineral ingredients in the same proportions, it is assumed that they were collected from a single source of white material and are not a mixture of ingredients from different places. The constituents of aragonite, gypsum, and alum (halotrichite-pickeringite) suggest a hot-spring deposit. The occurrence of aragonite and not the more stable calcium carbonate (calcite) in association with gypsum and alum (halotrichite-pickeringite) reflects the rather restricted physical and chemical conditions characteristic of deposits from hydrothermal waters. Although these minerals individually form in several material environments present in the arid Great Basin, hot springs are one site common to all. Such springs occur in almost every valley in the Great Basin, and an especially large one (Diana's Punch Bowl) lies about 5 miles from the Gatecliff Shelter.

IMPLICATIONS

Although the present study is primarily descriptive, we believe that such work may aid research in anthropological archeology. It is possible, for example, that detailed pictograph pigment analysis could help to establish the extent and duration of prehistoric trade networks; exotic minerals could help to confirm the interregional trade suggested by the presence of clam shell disk beads and other diagnostic Californian trade items known from some prehistoric Great Basin sites (Bennyhoff and Heizer, 1958). Like obsidian source analysis, rock art pigments might also outline detailed intra-Great Basin interaction networks. It is even possible that localized residential groups ("bands") could have used distinctive minerals. The analysis of paints from several sites might point toward territorial size, or perhaps ethnic boundaries, such as that between the historic Northern Paiute and Western Shoshoni.

Another potential value lies in solution of the lingering problem of rock art classification. Most typologies are based on common stylistic elements (e.g., Great Basin Curvilinear, Great Basin Rectilinear). Because of the considerable overlap in rock art elements—almost all ethnographic groups paint concentric circles, cross-hatched grids, wavy lines, and so forth—it may be that pigment composition could provide a better "social fingerprint" than amorphous styles. We now know, for example, that the Gatecliff and Toquima pigments were made by mixing gypsum with the appropriately colored mineral. Yet Steward (1941, p. 298) reported that the historic Shoshoni mixed their paints from animal fat and ocher. The Australian aborigines of the Gibson Desert, in contrast, used saliva and kangaroo dung for their paint (Gould 1969, p. 147). Conceivably, distinctive binders such as minerals, fat, water, vegetal matter, might prove significant as cultural and temporal indexes in certain regions.

We suggest that unrecognized cultural and temporal distinctions may well exist in prehistoric rock art, and pigment analysis might be a useful tool in bringing these to light. Unfortunately, comparable data from the Great Basin and nearby areas are not currently available.

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