

# DATING BCS ROCK ART AT THE GREAT GALLERY, CANYONLANDS, UTAH

## ABSTRACT

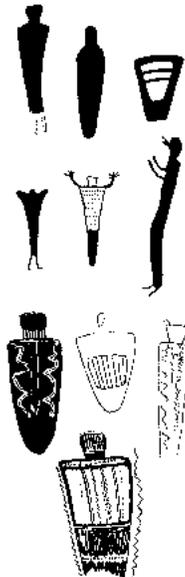
Dark red paint on a fallen block of sandstone at the Great Gallery site was sampled and dated. This test of the age of the Barrier Canyon Style of rock painting is part of a preliminary analysis of the antiquity of the style. Arising from this study are questions concerning the probable subcategories within the broad style because age estimates for various motifs range from Early Archaic to the Late Basketmaker periods. This paper describes the analysis of the paint and rock, and the steps necessary to remove contaminants prior to determining the age of the paint.

## PURPOSE

The purpose of this study was to use AMS radiocarbon techniques to determine the age of the painting on a section of paint from a fallen rock at the Great Gallery panel of Barrier Canyon Style rock art in Horseshoe Canyon. The hope was to obtain a reliable date for the painting of this section of panel, using only small chips of paint and not the underlying sandstone.

Polly Schaafsma (1971) classified the Great Gallery paintings as belonging to the Barrier Canyon Style, circa 1000- 8000 BP. The dominant motifs at this site are large, life-size, tapering anthropomorphic forms lacking appendages and facial features, and all of upright orientation. The figures at the Great Gallery appear front or back-facing, but without eyes and noses, and are in static poses. They range in size from approximately 1.7m to 1.1 m in height

with the exception being the “Holy Ghost” figure, which measures 2.13m. All figures were painted at least 2m above a rock platform which is much higher than the bottom of the canyon. The torsos of the large figures generally taper towards the ground whereas they are of uniform width in most of the smaller figures. This is consistent with the general variation of torso tapering seen in this style, which elsewhere ranges from long, thin tapers to broader triangular forms. None of the larger figures at the Great Gallery has arms or legs.



The figures vary considerably in decoration. Most figures are in solid red paint, the typical color of the style, but white and black are used for details. Intricate lines, stripes and zigzags are painted in the torsos, which are completely filled with red paint or divided into horizontal belts of vertical and horizontal red lines (broad belts), patterns or enclose other motifs (Figure 1).

*Figure 1* Various BCS figures. (drawings after P. Schaafsma 1971).

Two dog-like animals have been painted on the chest of one figure above a series of red vertical lines and double zigzag lines (Figure 2).



**Figure 2.** Great Gallery anthropomorphic figures. (photo by C. Patterson)

Another figure has two small, decorated anthropomorphic shapes within the central part of the torso (Figure 3). White dots, facial lines and linear markings are on some torsos. Vertical black bars have been painted on the chest of one of the larger figures. Incised zigzag lines are also observed in several of the large figures.



**Figure 3.** Close up on anthropomorph with smaller figures inside torso.(Photo by C. Patterson).

In the general style the heads of the large figures vary considerably including round, rectangular, wedge-shape, elongate, and oval shapes. Facial features are usually restricted to round eyes, “bug-eyes” or “goggle-eyes”, as in the largest figure of the “Holy Ghost” group of paintings. Heads are either plain or decorated. The decorations range from double line antenna-like projections at either side of the top of the head, straight lines either horizontal, vertical

or a combination of both in red or white, or bichrome. Some heads have what appear to be crowns made up of rows of dots or horizontal bands.

Permission was not obtained to remove in situ pigments from any pictograph or pictograph mural. Samples for dating could only be taken from spall and mural fragments that through natural attrition have fallen away from murals and were not located on discrete artifacts. Therefore to investigate the age of the rock painting of the Barrier Canyon Style at the Great Gallery the paint on a fallen slab at the floor of the panel was selected (Figures 4 and 5). Small sections of painted rock were removed under permit (#CANY-2002-SCI-0025).



**Figure 4.** The probable original location of the fallen slab.(photo by C. Patterson).

## FIELD METHODS

The Great Gallery site was visited three times in order to obtain sufficient paint material for dating from a fallen slab of painted rock measuring 40 x 20 cm (Figure 5). The paint came from a figure, which was on a portion of the rock face with other paintings, but it had collapsed in a major rock fall. The shape and size of the figure is unknown, but given the size of the piece of painted rock the painting would have been large, possibly as large as the other large anthropomorphic figures on the same rock

face. The remnant painting clearly shows a band or belt of unpainted rock divided by thin red lines, and surrounded by red paint. The monochrome red painting is consistent with other figures nearby as other figures on the panel have broad bands of stripes, both vertical and horizontal. White paint does not seem to have been used to outline or highlight any part of the fallen section of painting.



*Figure 5. Photograph showing the painted surface of the fallen slab of rock, Great Gallery, Horseshoe Canyon (scale bar is 10cm long). (Photo by C. Patterson).*

The painted sections of rock were removed and wrapped in aluminum foil before laboratory examination and preparation for dating. Photographs were taken of the fallen block in the field and details were also noted of the nature of the paint and surface conditions of the paint on the fallen block and of the remaining paintings on the wall of the cliff.

## ANALYTICAL METHODS

Mineralogical analyses were carried out on the paint sample to determine the inorganic composition of the paint. The non-destructive micro-analytical method chosen was the General Area Detector Diffraction System (GADDS), manufactured by Bruker AXS. Equipment used for this analysis is located at the Advanced Analytical Centre, James Cook University, Townsville, Australia.

The configuration of the equipment is an X-ray tube (copper target) and associated generator, a motorized specimen stage with movement in the XYZ directions mounted on a goniometer system, a Bruker-AXS HI-STAR<sup>TM</sup> area detector and a laser alignment system. A spot size for the X-ray beam of 800 microns was set using a series of collimators. With guidance from the video system the laser beam is used to illuminate the exact spot on the specimen where the diffraction measurement was obtained. Data acquisition is approximately one minute. The diffracted X-rays are detected by a parabolic series of detectors and the electronic signal arising from the detection is corrected for intensity and spatial aberrations. Integration of the diffraction rings produces a conventional XRD pattern.

The paint sample and rock was mounted onto a backing plate that forms part of the specimen stage using Blu Tac<sup>TM</sup>. The laser was used to align the specimen stage to analyze the desired part of the red paint. X-ray data were collected over 60 seconds at selected locations on the artifact. The corrected diffraction pattern was then automatically examined for identifying peaks and mineralogical identifications were undertaken using a computerized search-match routine.

The presence of hydrocarbons in the paint and rock were tested using combustion and gas chromatography. Carbon, hydrogen and nitrogen analyses were made using a Carlo Erba 1106 automatic analyzer. Gas chromatography - mass spectrometry was performed on a Hewlett Packard G1800A GCD series gas chromatograph with EI detector and controlled by an HP GC Top program installed on a Digital 5100 Pentium computer. An HP5 crosslinked phenylmethyl silicone of dimensions 30 m (L) x 0.25 mm (ID) x 25  $\mu\text{m}$  film thickness was selected as the column. The carrier gas was high purity helium, travelling at an average linear velocity of 48  $\text{cm s}^{-1}$ . An injector temperature of 250°C and detector temperature of 280°C were

used. The column oven had the following temperature program: initial temperature of 50°C (held 5 min), ramped at 5°C/min, final temperature of 200°C (held 5 min). Injection volumes of 1.0 µL were used, with splitless injection.

Dichloromethane was fractionally distilled before use and stored in a sealed, dark brown glass bottle. Flash liquid chromatography was performed on silica gel using Merck Kieselgel 60 (230-400 mesh ASTM). Concentration of solutions was performed using a Buchi rotary evaporator under vacuum supplied by a water aspirator. GCMS solutions were concentrated and contained in Pierce 1 mL Reactivials, sealed with PTFE-faced septa. Vials were cleaned in Aqua Regia, rinsed with distilled water, dried in an oven, then rinsed with distilled dichloromethane before use.

GCMS data was obtained for dichloromethane solutions of the standards of Shell kerosene, Caltex regular unleaded petrol, Glendale mineral turpentine and commercial dodecane. Each solution had a solute concentration of 1.0 µL per mL.

Finely divided samples of paint and/or rock were prepared for analysis by the following general method. All glassware was thoroughly cleaned, rinsed with distilled water, dried in an oven at 135°C, then rinsed with dichloromethane before use to minimize the possibility of introducing adventitious hydrocarbons. The sample (10 mg - 2 g) was weighed into a pear-shaped flask and covered with distilled dichloromethane (5 - 10 mL, depending upon the mass of the sample). The suspension was mixed thoroughly by drawing up into and squirting back out of a glass Pasteur pipette for about 1 minute in order to extract alkanes. A short column (2 - 3 cm) of silica gel was prepared in a disposable Pasteur pipette, using a small wad of cotton wool to hold the stationary phase in place. The column was rinsed thoroughly with distilled dichloromethane prior to filtering the extract suspension down it, with the

aid of further dichloromethane. The filtrate was reduced to 400 - 500 µL on the rotary evaporator in a pear-shaped flask, then transferred to a 1 mL Reactival. The volume was reduced further on the rotary evaporator to approximately 20 µL by placing the vial inside a Quickfit test tube. Care was taken to avoid the use of grease on any of the ground glass joints close to the solution. The Reactival was capped with a PTFE-faced septum (prewashed with dichloromethane) and 1 µL of this solution was injected into the GCMS instrument.

### TESTING PROCESS

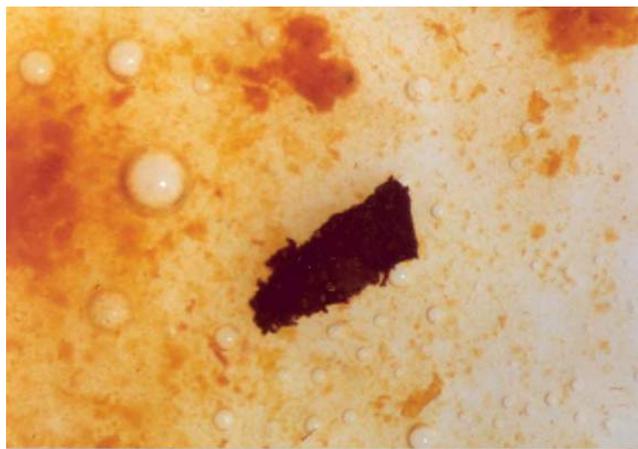
Radiocarbon analyses were carried out using the NOSAMS accelerator mass spectrometer (AMS) at Woods Hole Oceanographic Institute, Massachusetts, and at the Rafter Radiocarbon Laboratory, Lower Hutt, New Zealand. Analysis by AMS requires a sample that is orders of magnitude smaller than that for a conventional radiocarbon analysis (1 mg. vs 5 g). While this greatly increases the scope of radiocarbon studies, it also means that a much smaller amount of contaminant can ruin a sample.

The initial examination and radiocarbon analysis was made on a portion of the paint particles that were scraped from the rock and treated with 80% hydrofluoric acid to remove quartz grains and carbonate, and then 10% hydrochloric acid. The dry residue was hydrated and then 10% potassium hydroxide was added to neutralize the acidified sample. One small flake of cellular material (Figure 6), five short strands of reddish fiber and many small organic particles were observed in the resulting residue (Figure 7). Several short thin fibers, possibly fragments from the brush used to apply the paint to the rock, were observed while the components were in clear liquid suspension.

The test sample of a small portion of paint indicated that the quantity of carbon present in the paint was approximately 3.3 µg/cm<sup>2</sup> and so to obtain sufficient carbon for a radiocarbon

measurement a much larger surface area of painted rock was needed for dating. This piece, obtained by Dick Reed and Nancy Simon in collaboration with Gary Cox (NPS) measured approximately 100 cm<sup>2</sup> in surface area, with paint occupying about 55 cm<sup>2</sup>. Almost the entire paint sample was scraped to ensure that a radiocarbon age determination and a stable carbon isotopic measurement could both be measured. About 1% of the paint was retained on the rock for organic analyses.

At the AMS laboratories the scraped paint powder was considered a small sample and therefore was registered in the 'small sample preparation schedule'. Samples containing between ~120 and 300 µg C are considered small samples, require special handling and are likely to have reduced precision depending on the amount of carbon and its <sup>14</sup>C content (or age).

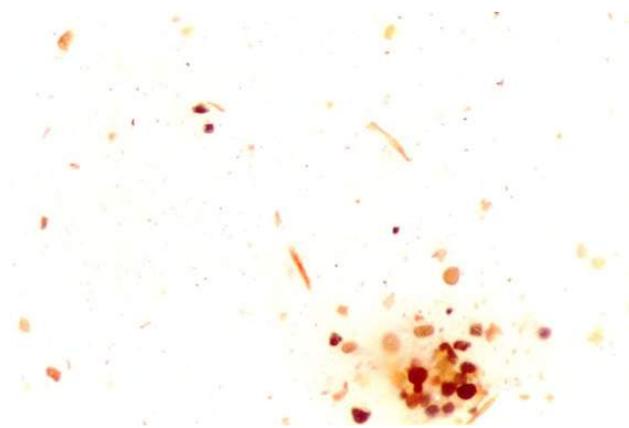


**Figure 6.** A photograph showing one of the relatively large fragments of cellulose-like plant material extracted from the paint on the fallen slab, Great Gallery, Horseshoe Canyon (70X magnified).

The paint was regarded in a similar manner to the usual plant or wood samples and these undergo an *acid-base-acid* pretreatment procedure to remove any inorganic carbon and certain mobile humic materials before conversion to CO<sub>2</sub>.

All materials (such as beakers, syringes, tweezers) used to pre-treat and combust organic car-

bon samples were rigorously cleaned. Apparatus was washed with Sparkleen soap, rinsed with organic-free distilled water (MilliQ H<sub>2</sub>O), rinsed with 10% HCl then given five more rinses with the MilliQ H<sub>2</sub>O. All apparatus that can be safely heated was baked in a muffle furnace at 550 degrees C for two hours to remove all traces of organic contamination. Gloves were used during all handling steps.



**Figure 7.** Three small fibrous strands presumably from the brush that was used for painting the rock face, Great Gallery, Horseshoe Canyon (90X magnified).

The chemical pre-treatment to remove inorganic carbonate involved the following procedure and chemical reagents. Five milliliters of 10% organic free hydrochloric acid was added to the paint residue in a cleaned centrifuge tube. It was capped and placed in 60°C shaker-water bath for 3 hours. After centrifuging the acid was decanted using a disposable pipette. This was repeated three times using organic free water to rinse the sample well.

To remove humic substances and alkali soluble materials approximately 20 ml of 2% NaOH was added. The solution was covered and placed in the 60°C water bath for 1 hour. Any brown discoloration was removed by decanting from the base of the tube after centrifugation. The sample was rinsed at least 3 times with organic free water, centrifuged and decanted until the solution remained clear. Another 5-10 ml of 10% organic free hydrochloric acid was added. The tube was capped and placed in the 60°C

water bath for 1 hour. The sample was then poured onto a pre-baked quartz filter (Whatman 4.7 cm QM-A ultrahigh-purity SiO<sub>2</sub> microfiber filter) over a vacuum-pump filtration unit. The filter was rinsed three times with organic free water. The clean sample on the filter was removed from the apparatus with pre-baked tweezers and placed on cleaned aluminum foil. It was left in an oven at 60°C to dry.

Some preliminary work was necessary before combusting the sample. Two grams of cupric oxide was weighed into a quartz combustion tube (Vycor) and this was pre-baked at 850°C in pure oxygen for 5 hrs. The tube and contents were allowed to cool before 100mg of silver powder was added. The dry filter and sample was then rolled into a tube and placed within the prep-prepared combustion tube. The combustion tube was attached to a vacuum line and gently pumped down to a vacuum of less than 5mTorr. A flame was used to seal the Vycor tube containing the components about 2 cm from the vacuum fitting. The sealed tube was then placed in a muffle furnace and combustion was initiated at 850°C for 5 hours to generate the CO<sub>2</sub> (carbon dioxide) sample.

The automated process of converting CO<sub>2</sub> to graphite occurred overnight using a catalytic reduction method at high temperature. A precise and uniform amount of catalyst (Fe) was measured and loaded into a Pyrex graphitization tube. It is then placed on the graphite vacuum-line system and leak-checked. The carbon dioxide from the sample was transferred to the reactor tubes containing the catalyst, and hydrogen (the reducing agent) was added in a proportion of 2.5x the measured amount of CO<sub>2</sub>, and an oven heated to 625°C was positioned over the tube.

In order to assess and assure sample quality and consistency, an automated computer program is used to control the operation of valves and the oven temperature, and to log a number of parameters such as temperature and pressure of

each graphitization reaction over time into the NOSAMS relational database. Each graphitization process is numbered and tracked in the relational database with an OSG number. Once a sample has been reduced to pure carbon, the graphite-iron catalyst mixture is pressed mechanically to form a solid pellet, which in turn becomes the sputter target for the AMS ion source. The graphite is pressed into aluminum cartridges and mounted in a sample wheel or carousel. Samples are arranged on the carousel and analyzed in a pattern of 5 unknowns to 1 standard and there is at least one process blank included for each type of sample loaded. A similar process was used at the Rafter Laboratory to prepare graphite targets.

The graphite derived from the target of the paint sample was inserted into the cathode of the ion source of the mass spectrometer. After acceleration and removal of electrons, the emerging positive ions were separated and the C-12 and C-13 ions were measured in Faraday Cups where a ratio of their currents was recorded. Simultaneously the C-14 ions were counted in a gas ionization counter so that instantaneous ratios of C-14 to C-13 and C-12 were recorded. These raw signals are ultimately converted to a radiocarbon age.

Although one can simply measure old samples for long times, the targets are constantly being consumed by the ion source, so there are practical limits to the minimum sample activity that can be measured, depending on how much material is present in the target. The present limiting age is ten half-lives, or 55,700 years, set not only by the sample size but also by measurements of the blanks (no C-14). The blanks contain small but measurable amounts of C-14 from contamination introduced during chemical preparation or other handling techniques during sample collection. Organic materials, which require the most processing, are limited to younger ages by their corresponding blanks. Since it is always necessary to subtract the counts due to blanks from the counts due to samples and

standards, it becomes a statistical problem of measuring the differences between small numbers.

The fraction-modern is computed from the expression:  $F_m = (S - B) / (M - B)$

In the equation, B, S and M represent the C-14/C-12 ratios of the blank, the sample and the modern reference, respectively. When the statistical error in the fraction-modern begins to exceed the fraction-modern value itself a limiting age is obtained. Standard practice is to limit reporting ages to fraction-modern, which are at least two standard deviations from the blank, or background levels.

Aside from the normal statistical errors intrinsic to the counting of C-14 events, there are additional statistical errors from the several corrections and adjustments that are necessary for us to arrive at a reportable result. The delta C-13 value is measured, both on the AMS machine and off-line on a stable isotope mass spectrometer for each sample. This is necessary to correct the result for natural fractionation to the customary value of -25 per mil. The correction, which varies between zero and 5%, has its own uncertainty of 0.1%. The added benefit of measuring the delta C-13 online during AMS C-14 measurements is that correction can be made for any machine fractionation effects. The overall AMS system stability contributes about 0.2% and the sample preparation contributes 0.25% to the error. As an example of a typical analysis, consider a case where the counting statistics is 0.35%.

The radiocarbon age is calculated by taking the natural log of the fraction modern ( $F_m$ ):

$$\text{Age} = -8033 \ln (F_m)$$

The error in the age is given by 8033 times the relative error in the  $F_m$ . Therefore a 1% error in fraction-modern leads to an 80-year error in the age. The reported error is the larger of the in-

trinsic counting statistics or the total error as measured by the standard deviation among the several measurements made on each sample.

## RESULTS

### Mineralogy

The X-ray diffraction analysis using the GADDS revealed a rock mineralogy consisting of quartz ( $\text{SiO}_2$ ), mica ( $\text{KAl}_3\text{Si}_3\text{O}_{10}(\text{OH})_2$ ), rutile ( $\text{TiO}_2$ ), diaspore ( $\text{AlO}(\text{OH})$ ), and ankerite ( $\text{Ca}(\text{Fe},\text{Mg})(\text{CO}_3)_2$ ). The iron-rich carbonate mineral, ankerite, contains carbon and this is a possible contaminant in the rock which will affect the age of the surface paint unless removed. In addition, a thin calcite ( $\text{CaCO}_3$ ) film covers the red painting providing another contaminating component. Both these carbonate minerals can be removed using acid.

The mineralogy of the red paint at the Great Gallery consists of quartz, potassium feldspar ( $(\text{K},\text{Na})\text{AlSi}_3\text{O}_8$ ), hematite ( $\text{Fe}_2\text{O}_3$ ), gypsum ( $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$ ), kaolinite ( $\text{Al}_2\text{Si}_2\text{O}_5(\text{OH})_4$ ), and calcite. This analysis confirms the presence of carbonate contamination in the paint itself. The presence of quartz is not surprising considering that the painting was applied to the sandstone rock the primary component of which is quartz. Potassium feldspar may have been added to the paint as a colorless component. Kaolinite, gypsum and potassium feldspar could have been used as 'fillers' to increase the bulk of the paint without changing the color. Adding these components, while not affecting the color (they are colorless or white), increases the bulk of the paint material and therefore extends the area that the paint covers. The colorant is hematite, the only red mineral in the paint.

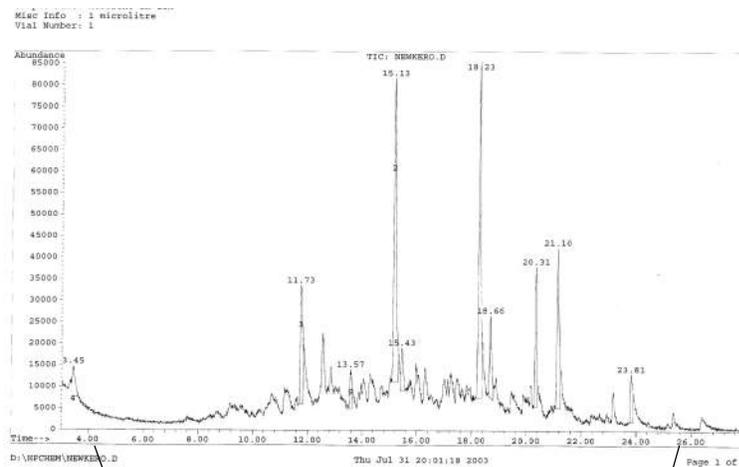
Calcite may also have been used as a 'filler' or an extender to enable the spreading of a small quantity of colorant across a large painted area, but carbonate was also observed as a matrix component in the rock and as a thin film over the painting. Whether a rock component or fill-

er, it has the disadvantage of providing carbon to the paint unless it is removed. The chemical pre-treatment of the sample using acid ensures that this form of contamination is eliminated prior to combustion of the paint.

## Hydrocarbons

Chaffee et. al (1994) reported the presence of hydrocarbons in their samples of rock from this site, and they inferred that kerosene or some other chemical had been thrown over the paintings to improve the photogenic qualities of the paintings. It was therefore necessary to test the paint on the fallen slab for the presence of contaminating hydrocarbons. This was done using combustion and gas chromatography (Figure 8).

Kerosene



Paint -  
kerosene  
deliberately  
added

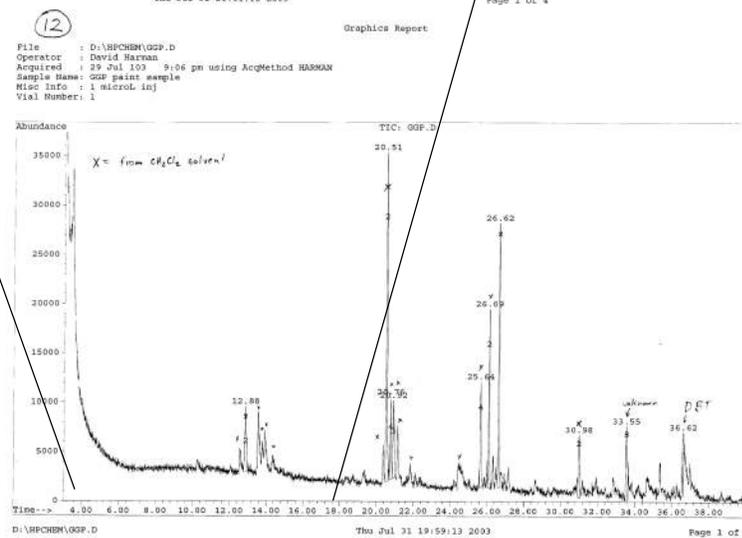
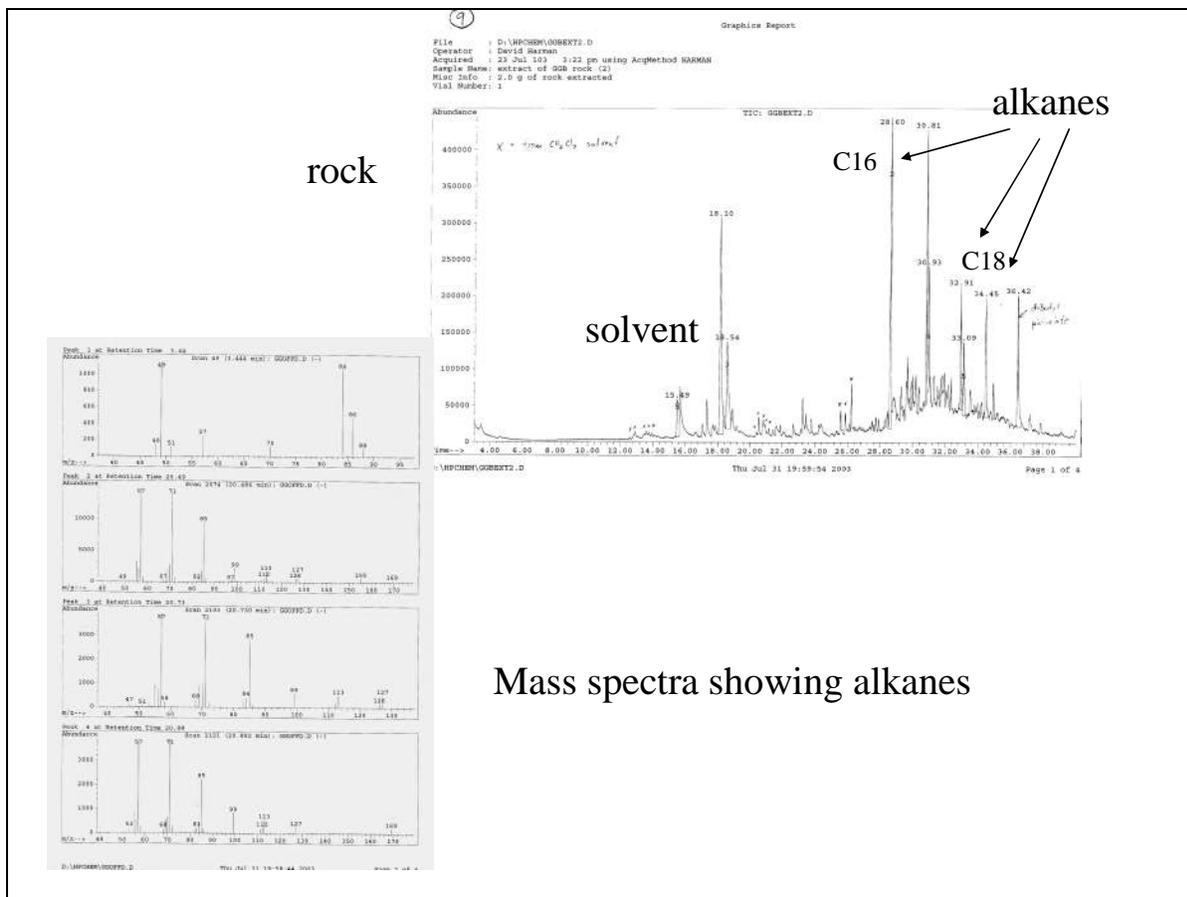


Figure 8 Chromatograms from a sample of paint that had been deliberately contaminated with kerosene.



**Figure 9** Chromatograms and mass spectra showing the presence of trace levels of alkanes in the rock at the Great Gallery site.

Generally, the total volume of alkanes in the paint/rock samples varied from 0.65 - 2 nL per gram of sample. In other words, if 0.1% of the sample mass was carbon from paint, then the mass of carbon present in the whole sample as hydrocarbon would be in the order of one millionth that of the carbon in the paint. Therefore, initial indications are that the amount of carbon present in the form of alkanes in the Great Gallery paint is insignificant in terms of affecting AMS  $^{14}\text{C}$  age determinations (Figure 9).

While no alkanes were found in the Great Gallery red paint several unidentified non-alkane peaks were found. These are presumably traces of the original organic material present when the paint was originally prepared.

The AMS  $^{14}\text{C}$  age determinations are listed in Table 1 below. Comparison is also made with published results obtained by Chaffee et al (1994) and with those reported by Dr Marvin Rowe to Nancy Coulam (unpublished letter 3 March 1993). The previous results indicated that the rock contained dateable carbon and that the paint they sampled was likely affected by hydrocarbons.

The rock sample under the paint contained carbonate and when this was dated using acid to generate carbon dioxide an age for the carbonate was  $8160 \pm 270$  years BP (-26.0%). When the rock was deliberately treated with hydrocarbons and reanalyzed an age was measured of  $24,600 \pm 280$  years BP (OS-43387; -26.4%).

An untreated (no acid used to remove carbonate) paint sample gave a misleading young age of  $1040 \pm 40$  years BP ( $-9.10\text{‰}$ ). The best approximation to the age of the Great Gallery paint sample was determined from the acid treatment of the paint, followed by combustion of the residue. The age of the carbonate (Fe-rich dolomite) filler in the paint obtained from acid hydrolysis was  $8370 \pm 190$  years BP ( $-16.5\text{‰}$ ). This chemical attack left residual paint, quartz and acid insoluble organic matter. When this carbonate-free residue was combusted in the two dating laboratories it provided age estimates of  $8630 \pm 310$  years BP ( $-29.9\text{‰}$  NOSAMS) and  $8680 \pm 110$  years BP ( $-27.9\text{‰}$  RAFTER).

These results indicate that the major carbon-bearing components in the paint, the dolomite

filler and organic matter have approximately the same age of 8500 years ago. While their stable carbon isotopic ratios are different,  $-16.5\text{‰}$  compared with  $-28\text{‰}$  to  $-29\text{‰}$  it indicates that they formed in different ways. The gas chromatographic analyses indicate that the non-alkane compounds in the paint are clearly of organic origin whereas the dolomite is of mixed origin (organic-inorganic). From these analyses it appears that the red paint components could have been derived from a single source, a shallow volume of water containing algal and other organic growths which presumably aided in the deposition of dolomite-rich red (hematite-bearing) mud, which was a naturally available pigment ideal for use as paint.

Sample identity	Painted area (cm <sup>2</sup> )	AMS <sup>14</sup> C age (years BP)	Lab. Number	δ <sup>13</sup> C ‰
GG3 untreated paint	55	$1040 \pm 40$	NOSAMS-37581	-9.10
GG3 acid treated rock	Carbonate age in rock	$8160 \pm 270$	RAFTER	-26.0
GG3 acid treated paint	Carbonate age in the paint filler	$8370 \pm 190$	NOSAMS	-16.5
GG3 acid residue combusted	Organic residue, no carbonate	$8630 \pm 310$	NOSAMS	-27.9
GG3 acid residue combusted	Organic residue, no carbonate	$8680 \pm 110$	RAFTER	-29.9
<b>Chaffee et al. (1994)</b> 42WN418-1a	6.21 g rock and paint	$32\,900 \pm 900$	AA-8747	-36.0
<b>Rowe (1993)</b> 42WN418-2a	6.08 g rock and no paint	$3\,400 \pm 65$	AA-8625	-26.1
42WN418-2d	5.84 g rock and no paint	$4\,010 \pm 55$	AA-9177	-25.7

**Table 1.** Summary of the details of the samples and analyses in this project and previous studies of Barrier Canyon Style rock paintings at the Great Gallery, Horseshoe Canyon.

## CONCLUSIONS

The AMS  $^{14}\text{C}$  age determination for the residual organic matter in the painted rock surface on the fallen slab at the Great Gallery is  $8655 \pm 210$  radiocarbon years BP (calibrated interval  $2\sigma$  8286 BC – 7295 BC). This puts the painting of a presumable large, red monochrome Barrier Canyon Style figure in the Early Archaic period.

Is the new age determination reliable? As the fallen slab was lying with its painted side downwards there is little chance that modern grasses became incorporated in the paint, and therefore the carbon in the paint represents the original content. Modern contamination is therefore probably not very great because the age determination and the stable isotopic readings are consistent with each other. The critical issue regarding the age determination and its reliability is that chemical pretreatment of the paint is absolutely necessary before dating the residual carbon so that the carbonate contaminants are removed from the red colorant.

The stable carbon isotope value for the paint obtained in this study differs considerably from that obtained by Chaffee et al. (1994) for another painted rock sample from the same site. The more negative value obtained by those researchers for the paint is thought to indicate contamination of the paint by a fossil fuel derivative (Chaffee et al. 1994:166), possibly kerosene or some other straight-chain hydrocarbon. The conclusion from the age and the stable isotopic value is that the sample from the fallen block is not contaminated with fossil fuel derived products. Though the rock does contain naturally occurring alkanes and some paintings may have been sprayed with hydrocarbons to enhance their visual aesthetics the paint sampled from the fallen rock does not.

An age estimate has been obtained for the red paint on the fallen slab of painted rock at the

Great Gallery location in Horseshoe Canyon. The painting, probably in the form of a large anthropomorphic figure in a style generally known as the Barrier Canyon Style, was painted in the Early Archaic period. Such large anthropomorphic figures typical of the early paintings in this style are reminiscent of similar monochrome forms at the Black Dragon site ( $8520 \pm 970$  years BP) and slightly younger polychrome motifs painted in rock shelters in Baja California, Mexico (Watchman et al. 2002). These large anthropomorphic figures are of a different style and age to the much younger polychrome figure in Salt Creek known as Paiyatiamo (dated to  $925 \pm 80$  years BP), and to the Lower Pecos rock art.

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