Rock-art image in Fern Cave, Lava Beds National Monument, California: not the AD 1054 (Crab Nebula) supernova

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The visual manifestation of the recent Hale-Bopp comet reminds us how telling are those rare objects which suddenly flare in the sky. One can suppose ancient people living by natural light were more compellingly struck by the sight of comets and supernovae, and understandably researchers seek images of them in the shapes of rock-art motifs. An absolute dating contradicts that supposition in respect of a presumed image of the visible supernova of AD 1054.

On 4 July AD 1054 a supernova brighter than Venus appeared in the sky, remaining visible for approximately 23 days and 650 nights. It was chronicled in five independent historic accounts, four from China and one from Japan (Duyvenduk 1942). Hubble (1928) suggested that the Crab Nebula is a result of the AD 1054 event, a view generally accepted (Clark & Stephenson 1977). For at least 40 years investigators have attributed certain distinctive rock paintings and carvings in the western United States as recordings of the AD 1054 supernova. More than 20 such depictions (circle or star-like symbols and a crescent) have been located (Brandt & Williamson 1979). In particular, two panels of rock paintings in Lava Beds National Monument, California (FIGURE 1), one at Fern Cave and one at Symbol Bridge, were listed as recording the AD 1054 supernova. Brandt *et al.* (1975: 52), noting that the orientation of the moon and su-

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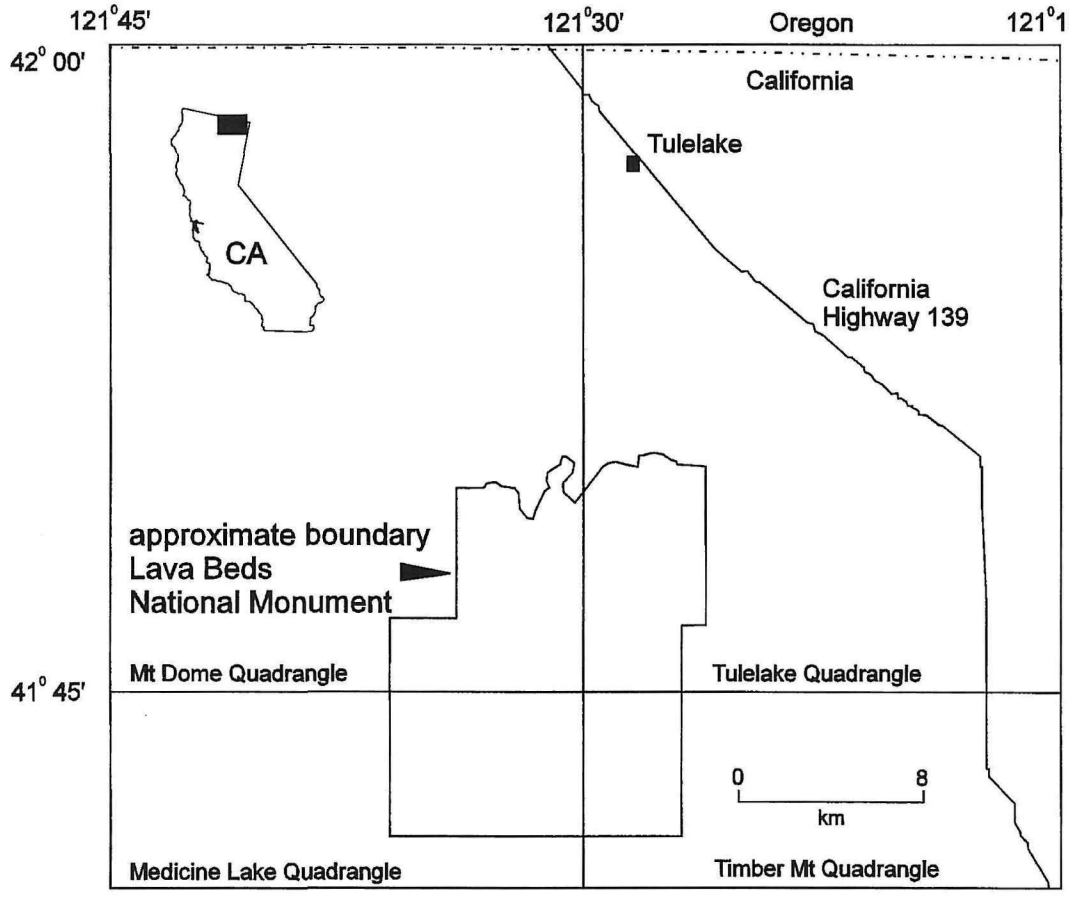

FIGURE 1. *Location of the Lava Beds National Monument, California.*

pernova are not correct in the Fern Cave rock painting, concluded that 'errors in recording the orientation of the crescent moon are common'. The only direct means of assessing the likelihood that a 'supernova' representation records the AD 1054 event is to date the rock painting or carving. In our laboratory at Texas A&M University, we developed a plasma-chemical extraction technique that permits analysis of ^{14}C in rock paintings, whether the pigments used were charcoal or inorganic iron- and manganese- oxides and hydroxides with organic binder/vehicles (Ilger *et al.* 1996). This paper presents direct ^{14}C age estimates on rock paintings that have been suggested to represent the AD 1054 supernova. The AMS ^{14}C analysis on each sample using our plasma-chemical extraction technique shows that these images do not represent the AD 1054 supernova.

Experimental procedure

We took charcoal pigment samples from three figures in proximity at Fern Cave: a crescent pointing downward and two near-by circles, one above and one below the crescent (FIGURE 2). Small amounts of charcoal were scraped from the crescent and two circles individually. Rubber gloves were worn to avoid contamination during sampling and all subsequent handling. Each charcoal sample was placed on aluminium foil, wrapped, and sealed in a plastic bag. The motif was photographed before and after sample collection. Damage incurred to the three paintings was so small that it was difficult to determine by visual inspection where the sample was removed.

The samples were treated with 1 M NaOH and sonicated at 50°C, a standard procedure used to remove possible humic and fulvic acids that might contaminate the charcoal to be

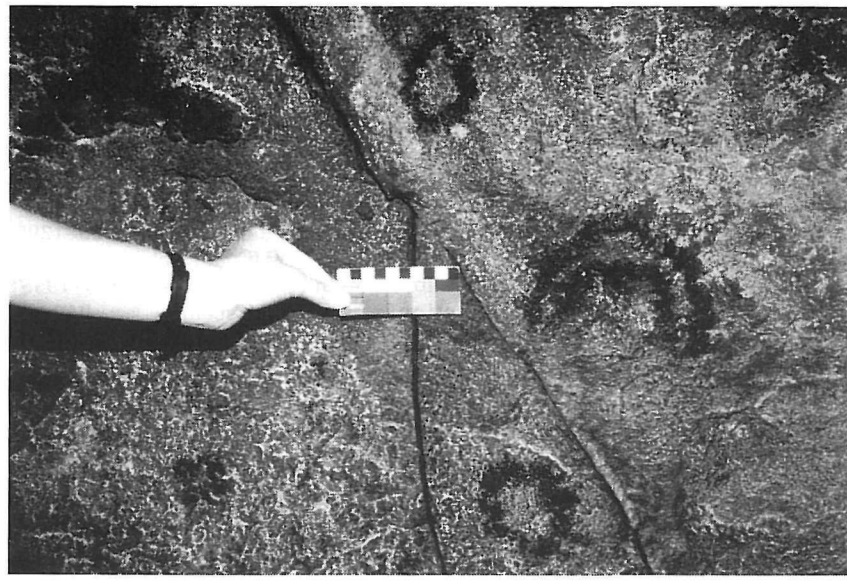

FIGURE 2. *The rock art panel showing two circles to the left of a crescent, an image that has been suggested as a recording of the* AD *1054 supernova explosion. The scale is 10 cm long.*

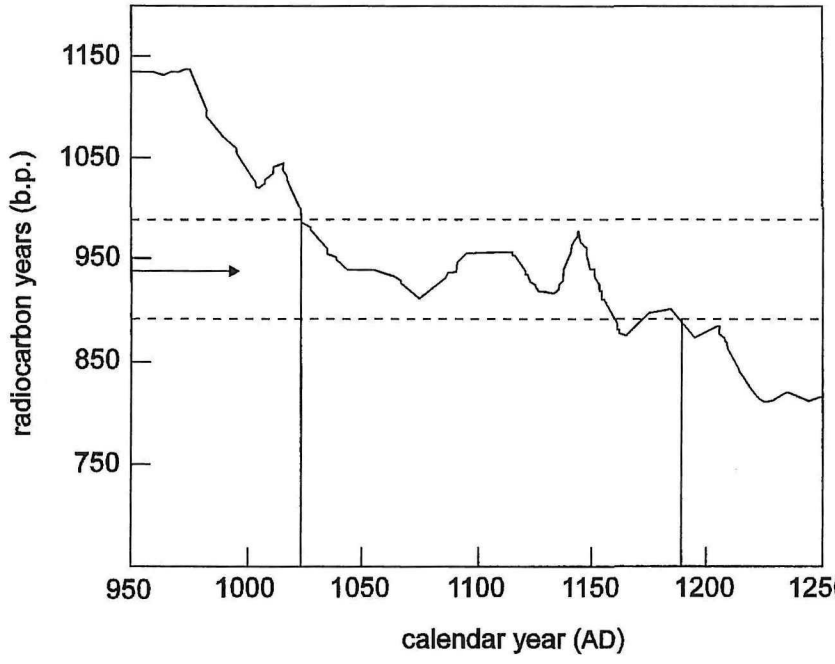

FIGURE 3. *Radiocarbon calibration curve in the vicinity of* AD *1054. The* ^{14}C *date corresponding most closely with* AD *1054 (938* ^{14}C *years b.p.) lies within the* $\pm 1\sigma$ *uncertainty band of the calibration curve for calibrated ages from* AD *1030–1160. (Stuiver & Reimer 1993).*

analysed for ^{14}C. Humic and fulvic acids are brownish-yellow in NaOH. It took 8–10 one-hour treatments with NaOH before the solutions appeared clear; we then did three additional extractions to ensure complete removal of the humic and fulvic acid components. Neutralization of the NaOH solutions with 1 M HCl produced no humic acid precipitate; thus the brownish colour was likely due to fulvic acids. The NaOH-treated charcoal samples were then rinsed with doubly distilled, de-ionised water, filtered and dried; they were then ready for plasma-chemical extraction of the organic carbon for ^{14}C analysis.

In preparation for the extraction, we use radio-frequency generated, low-temperature (<175°) oxygen plasmas to remove organic

material as CO_2 from the empty reaction chamber. Argon plasmas are used on the sample after its insertion into the chamber to remove adsorbed CO_2 from the system. Finally, oxygen plasmas are utilized on the paint sample to convert the organic carbon to CO_2, leaving the substrate rock and accretion carbonates and oxalates intact. This organic carbon is then analysed by AMS. Experimental details, reported in our previous paper (Ilger *et al.* 1996), are not repeated here. Since the introduction of our plasma-chemical technique in 1990, we have demonstrated its validity on numerous samples of known ^{14}C content: charcoal (two dated previously by Beta Analytic, Inc. and one dated previously at the University of Texas Radiocarbon Laboratory), Third International Radiocarbon Intercomparison wood and African Ostrich shell (dated at the University of Arizona). Satisfactory agreement was observed in all cases. Our analyses of ^{14}C-free samples — Albertite, IAEA wood and Axel Heiberg wood — demonstrated that our technique does not add significantly to the modern carbon background of the AMS. The following have also been studied and do not affect our ability to estimate the age of rock paintings by ^{14}C analysis: argon and oxygen sources; mass fractionation; calcium carbonate, magnesium carbonate, limestone, and calcium oxalate decompositions. The ^{14}C determinations we obtained on rock paintings from France, Montana, Texas and Utah are consistent with the age ranges expected from archaeological inference.

We used oxygen plasmas coupled with high vacuum techniques to remove organic carbon from the charcoal paint of each Fern Cave sample: the two circles and a crescent shown in FIGURE 2. The CO_2 produced was collected by freezing in a liquid-nitrogen cooled glass-finger. Radiocarbon contents of the samples were measured at the Center for Accelerator Mass Spectrometry of the Lawrence Livermore National Laboratory.

Results and discussion

Radiocarbon determinations and calibrated calendar dates are shown in TABLE 1 (Stuiver & Reimer 1993). Attempts to verify the validity of rock paintings as representations of the AD 1054 supernova are limited by the nature and uncertainty of the radiocarbon calibration curve in the critical area. The ^{14}C determination that most closely corresponds to the calendar date AD 1054 is 938 ^{14}C years before present (b.p.). FIGURE 3 illustrates that 938 years b.p. lies within the $\pm 1\sigma$ uncertainty band of the calibration curve for calibrated ages from AD 1030–1160. Even if one could measure the ^{14}C content with perfect accuracy and infinite precision, it would not be possible to limit the calendar age of a rock painting painted in AD 1054 to better than this 130-year range: there is no way to determine which is the 'true' date. Nonetheless, analysing ^{14}C from the rock paintings directly is the only way to affirm or deny that they are consistent with their assignment as representing the AD 1054 supernova. A ^{14}C content consistent with AD 1054 does not prove that a depiction *is* of the supernova; ^{14}C determinations not consistent with AD 1054 (within experimental uncertainty) effectively rule out an image as recording the supernova.

sample	weight of carbon, μg	laboratory number	uncalibrated determination, b.p. ±1σ uncertainty	calibrated AD ±2σ uncertainty
Lower circle	250	CAMS-27229	840±70	1020–1290
Upper circle	185	CAMS-27860	230±70	1490–1955*
Crescent	230	CAMS-27861	330±50	1440–1670

* 1955 denotes the influence of bomb ^{14}C.

TABLE 1. *Radiocarbon determinations and calibrated calendar dates (Stuiver & Reimer 1993) for the three Fern Caves rock art images: two circles and a crescent.*

For the Fern Cave samples, the lower circle, calibrated at AD 1020–1290 ($\pm 2\sigma$ range) is distinctly older than both the upper circle, at AD 1490–1955, and the crescent, at AD 1440–1670. Radiocarbon determinations on the upper circle and crescent are not significantly different from one another; they may have been painted contemporaneously. Both features date from several centuries after the AD 1054 supernova. There were no discernible differences in terms of colour or other visual features between the three figures studied here. The ^{14}C contents of the three figures of the painted panel demonstrate conclusively that it does not represent the AD 1054 supernova.

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