KEYWORDS: ***Amorphous silica – Micro-organisms – AMS ^{14}C – Kezar Lake – Maine***

DATING KEZAR LAKE PICTOGRAMS

A. Watchman

Abstract: Pictograms painted on gneiss near the inlet of Great Brook into the north-western corner of Kezar Lake are covered and partly obscured by a thin white hydrated amorphous silica film. Detailed studies of the rock surface at one place on the cliff reveal two episodes of painting separated by an interval of time during which silica was deposited over the lower image. The basal red haematite paint layer follows the topography of the rock surface and therefore appears to have been painted directly on the rock. A layer of white amorphous silica, approximately 0.05 mm thick, was then deposited naturally from seepage water that flowed over the painting before a second haematite figure was painted. A similar white film covers and masks the details of the second figure. On-site micro-excavations were carried out to obtain powdered silica samples from which carbon, derived from fossilised micro-organisms trapped in the coating during silica precipitation, was extracted for accelerator mass spectrometry radiocarbon dating of the ages of the pictograms.

Introduction

Once upon a time, in the recent past, there was a geo-archaeometrist called Greylocks. He travelled the world dating rock paintings and engravings. He went to Portugal and dated some petroglyphs (Watchman 1995), but they were too young (Zilhão 1995) and 'far too hot' for European archaeologists. He also dated a charcoal painting in Argentina (Llosas et al. 1999), but that result was too old for the existing stylistic chronology ('too cold' for the Argentineans). He then went to Maine where he dated the Kezar Lake pictograms and the results agreed with the chronological sequence established for petroglyphs at Machias Bay (Hedden 1996); the radiocarbon determinations were 'just right'. The following is the story of the dating of the Kezar Lake pictograms, Maine.

Location

Kezar Lake is situated in western Maine, U.S.A. (Fig. 1), near the White Mountain National Forest. The shoreline rises steeply on the northern end of the lake and three coalescing streams, forming the Great Brook, drain the mountainous headwaters to the north. A precipitous cliff of gneiss forms the southern edge of the Great Brook where it enters the lake. Aboriginal paintings occur on the westerly facing surfaces. Thick growths of alder and other brush form an almost impenetrable physical and visual barrier along the swampy shoreline making access difficult from the water.

The cliff is composed of light coloured (leuco) gneiss, composed mainly of grey biotite-muscovite gneiss and schist (Osberg 1985). A narrow green, fine-grained mafic dyke (probably basaltic) has intruded along a vertical joint at an oblique angle to the cliff face. This joint and other sub-parallel joints have apparently controlled the formation, weathering and shape of the cliff. A series of relatively

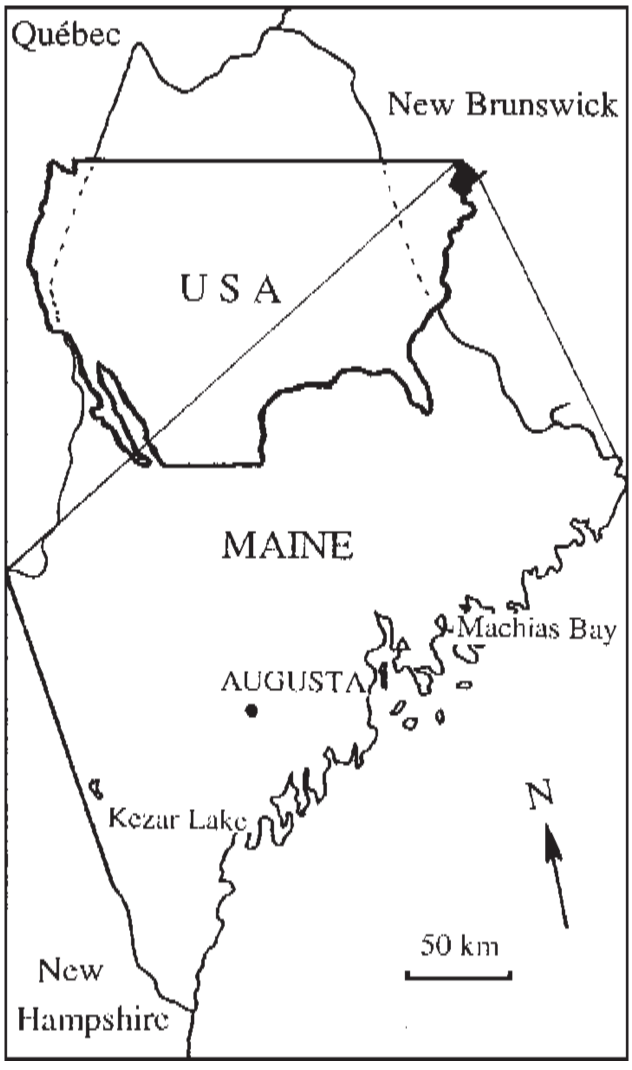

Figure 1. *Location map of Maine showing Kezar Lake in western Maine, U.S.A.*

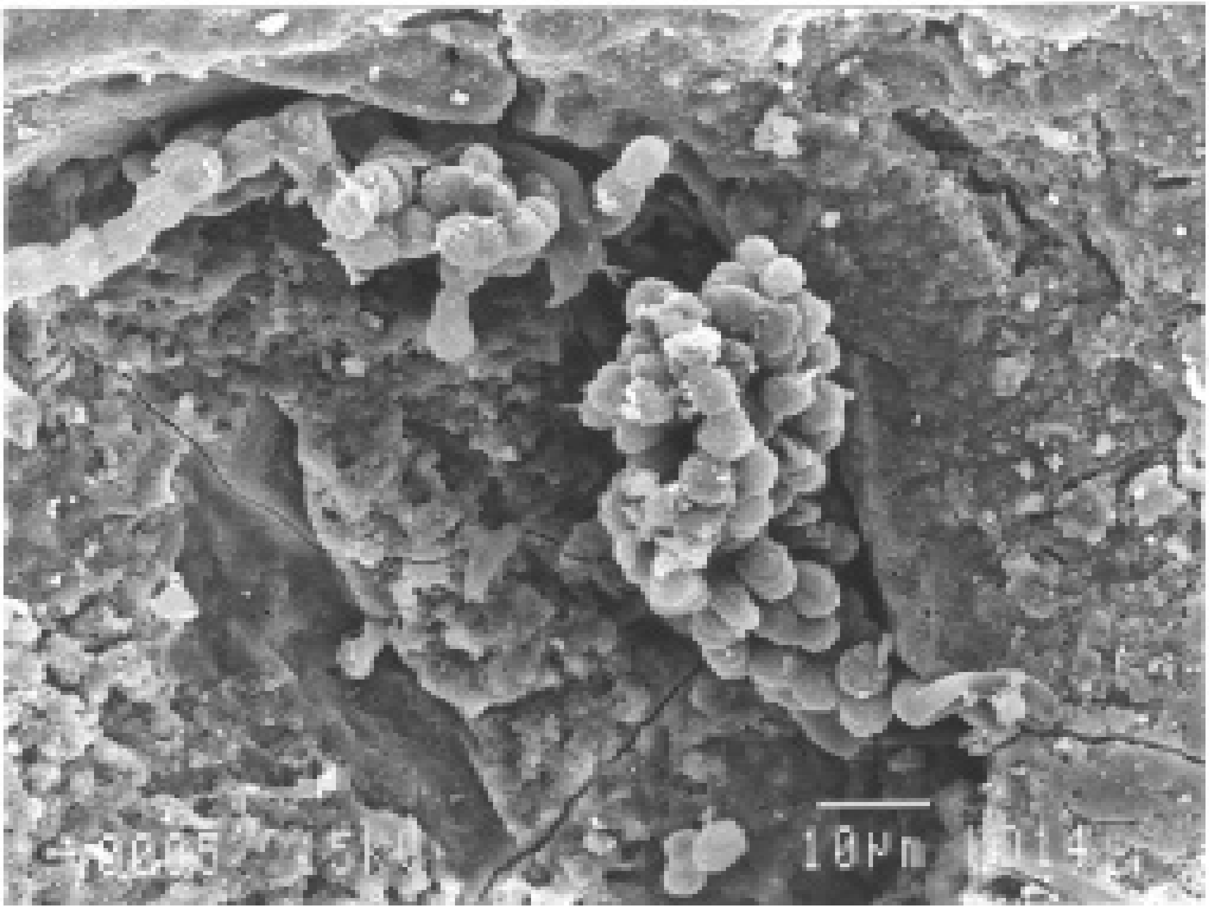

Figure 2. *Scanning electron photomicrograph of a small pit in the white amorphous silica coating created by lichen and fungi (pictured), scale bar is 10 µm.*

smooth vertical faces are offset by sub-horizontal foliation and subordinate joint planes.

Small areas of lichen are developed across the surface and these have deleteriously impacted the paintings and the rock surface (Fig. 2). Lichen acids have attacked the rock causing chemical degradation of the minerals, thereby weakening the surface. Lichen hyphae have also penetrated into micro-fissures wedging small flakes from the surface. These activities have made the rock face vulnerable to frost action resulting in detachment of rock surface flakes, including pieces containing paint. The action of frost is considered the most damaging of all the natural weathering agents at this site.

Seepage of groundwater is localised to horizontal foliation and joint planes, and white surficial deposits (accretions) have developed below these from precipitation of components from the water. These soluble components are presumably derived from chemical weathering of minerals within the gneiss. Most paintings on the surface are either completely or partly covered by these white accretions, and it is the carbon remnants in the accreted deposits associated with the paintings that make it possible to date when the paintings were likely to have been put there.

Rock paintings

One overwhelming characteristic feature of the paintings is their poor state of preservation. Through natural weathering processes of frost action, lichen wedging and chemical degradation no painting is entirely intact. Paintings are either covered by white deposits or have exfoliated with the underlying rock. These two factors make recognition of the motifs barely possible.

At least two shades of red ochre paint have been applied to some of the relatively planar vertical surfaces. Several paintings are recognisable as linear anthropomorphous or animal figures. Others are abstract, possibly remnants of original human-like or animal-like (quadruped) figures. The remnant paintings occur in two main panels located from 1.2 m to 2 m above a basal ledge surface with daubs of other paintings occurring on exfoliated surfaces in between. Fragments of paint on the two main panels cover areas measuring about 60 × 45 cm and 35 × 80 cm.

Sampling for dating

Two visits were made to the site; in October 1994 to take test samples for determining whether material suitable for dating existed and in June 1995 for on-site sampling specifically for dating. Analyses of the test samples revealed variable micro-stratigraphy of red ochre paint within the white rock surface accretion (Fig. 3). One sample of accretion covering the gneiss showed evidence of two episodes of painting; a basal red layer resting directly on the rock and another discontinuous red layer approximately in the middle of the accreted stratigraphy. Another flake showed evidence of painting as a red haematite layer located directly on the rock under a white rock surface accretion (about 0.1 mm

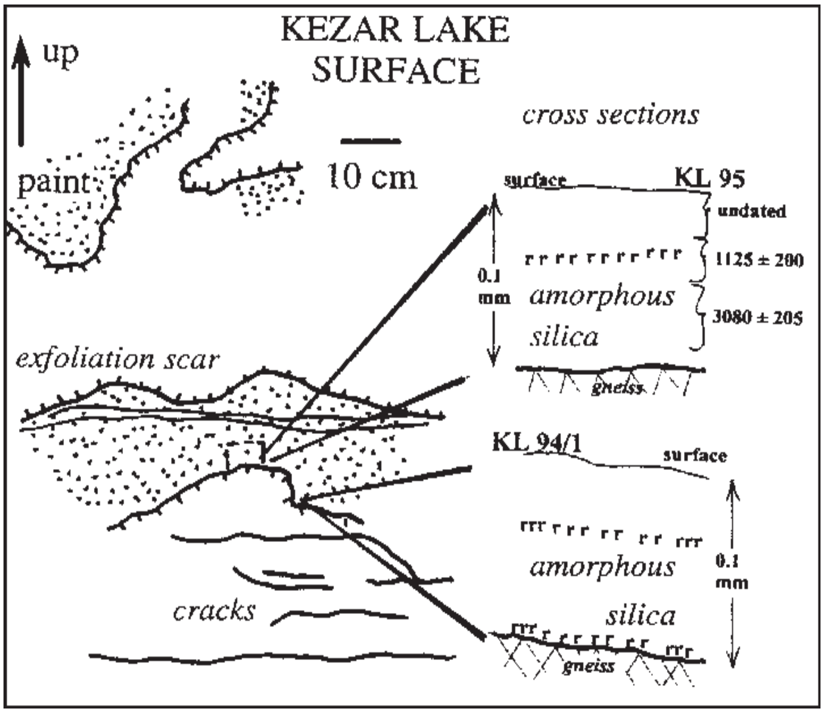

Figure 3. *Sketch plan of the Kezar Lake rock surface from where samples were taken, analysed and prepared for dating, with microstratigraphic cross-sections through amorphous silica skins to indicate the levels at which paint and dating results were recorded.*

thick). On unpainted portions of rock the accretion reaches up to 1 mm thick.

X-ray diffraction, Fourier transform infrared spectroscopy and scanning electron microscopy of the white rock surface accretion revealed a composition typical of hydrated amorphous silica (Fig. 4; Watchman 1990, 1992). Small amounts of calcium (Ca), aluminium (Al) and potassium (K) in the silica reflect the transportation of these soluble elements from minerals undergoing chemical weathering in the underlying schist.

Deposition on exposed rock surfaces of amorphous silica from groundwater seepages usually traps micro-organisms, such as bacteria, fungi and algae that were living at the time water flowed across the surface, and these carbon-bearing components can be radiocarbon dated (Watchman 1994). Determining the age of the fossilised microbes gives the age of silica deposition and this in turn can be used to estimate the age of paintings covered by silica. A layer of silica under a painting provides a maximum age for the painting whereas the age for carbon in a silica film over a painting gives the minimum age for that painting. These are the principles used to date the Kezar Lake pictograms.

A small portable dental drill, powered by a lightweight 12V battery, was used to obtain ‘layers’ of amorphous silica under and over a painting lying halfway up the white rock surface accretion. The powders, weighing 0.0184 and 0.0242 gm, were washed in hydrochloric acid (to remove carbonate), sodium hydroxide (to remove humic matter), and deionised water (to clean the products). They were dried and placed in separate silica glass tubes (Vycor) that had been sealed at one end, together with cupric oxide powder and silver wire. Each tube was evacuated to exclude modern carbon dioxide in air and sealed by melting the open end of the tube while the vacuum was maintained. Both sealed and labelled tubes were placed in a furnace at 900°C for six hours to combust the fossilised organic matter into carbon dioxide before they were cooled and shipped to the Tucson Accelerator Mass Spectrometry Facility for converting the gas into graphite targets (250 µg and 100 µg) for radiocarbon dating.

Results and discussion

The white silica and red haematite paint layer from the centre of the accreted deposit gave a determination of 1125 ± 200 radiocarbon years BP (Before Present), and the underlying amorphous silica yielded 3080 ± 205 years BP.

These two results, determinations of the radiocarbon ages for fossilised micro-organisms in the silica accretion ($\delta^{13}C$ = -20.1‰), are stratigraphically conformable as they are consistent with the depth in the accretion from where the samples were collected. The measurements are also similar in terms of age and depth to results obtained from analogous amorphous silica deposits at the Nisula site in Québec (Arsenault et al. 1995). The younger date is an estimate of the age of the red haematite paint in the centre of the accretion, calibrated to A.D. 678 – 1158 years (Stuiver and Reimer 1993). An age of more than 3080 years, calibrated to 1524 – 1015 B.C. (Stuiver and Reimer 1993), is concluded for the basal paint layer applied directly to the rock surface.

These results closely match the evidence from the archaeology and the indirect dating of petroglyphs in the Machias Bay area of Maine (Hedden 1996). Sites with archaeological deposits have been uncovered in the Fryeburg area and on the Saco River near the outlet of Kezar Lake that indicate brief occupation, presumably by the Western Abenaki people (Day 1978), from approximately 3800 BP to 400 BP (Cox 1994). Hedden (1996) has established approximate age ranges for petroglyph styles at Machias Bay using convincing geological evidence and the pictograms at Kezar Lake can be correlated with his Styles 1 and 5. Style 1, the paired rectangular to broad shouldered trapezoidal outlined anthropomorphs, is dated by Hedden to between 4000 and 3000 years BP, matching the antiquity of the basal red paint at Kezar Lake. The younger date at Kezar Lake, 1125 years BP, fits the later period of Hedden’s Style 5 at Machias Bay (Hedden 1996: 22). The dating evidence at Kezar Lake therefore seems to correlate well with existing archaeological and rock art evidence indicating that the area has been intermittently occupied from at least 3000 years ago, and that the tradition of painting and pecking anthropomorphs has also been ongoing for the same length

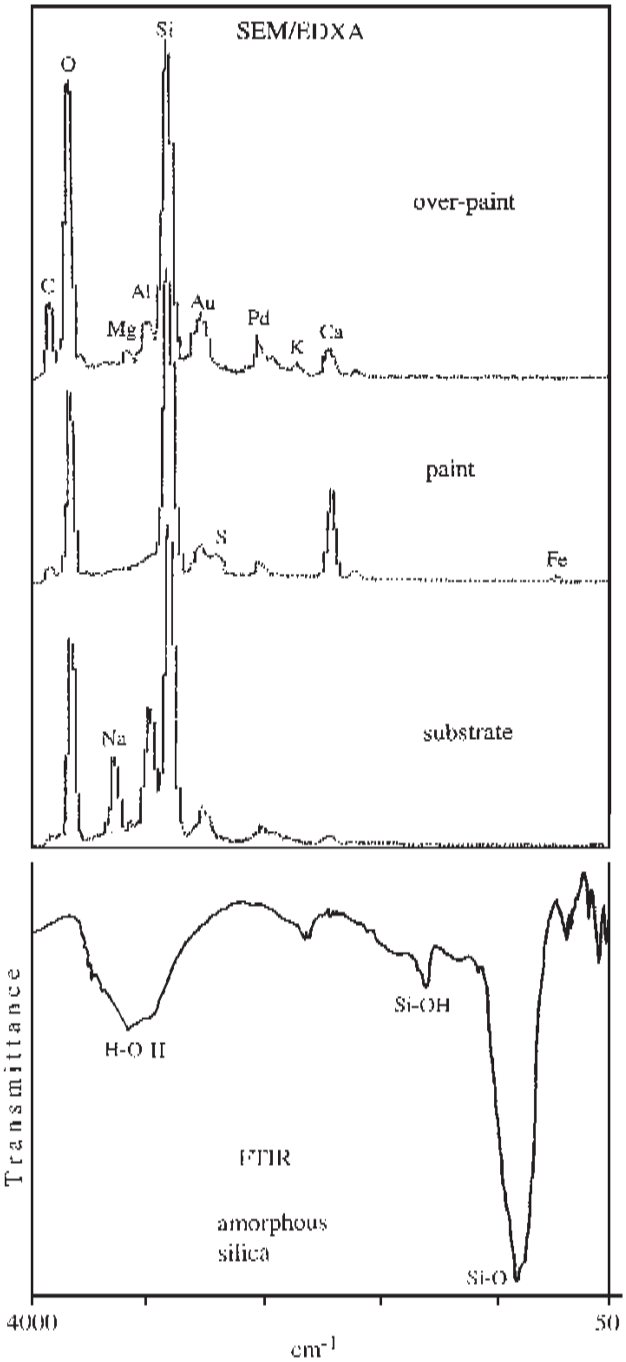

Figure 4. Scanning electron microscope energy dispersive spectra (SEM/EDXA, upper three charts), of the amorphous silica layers over and accreting the paint, and the underlying substrate gneissic rock (vertical axis is energy intensity, horizontal axis is energy frequency). The lower chart is the Fourier transform infrared spectrum of the coatings revealing the hydrated nature and presence of silicon-hydroxyl bonding that confirm optical properties indicating the presence of a silica skin.

of time. These results, while neither exactly 'hot' news items or world-shattering discoveries nor 'cold', useless pieces of unrelated numbers, are nevertheless extremely valuable in providing additional information to a growing body of consistent data that is 'just right' in terms of confirming existing archaeological knowledge in the region.

Professor Alan Watchman
Department of Archaeology & Natural History
Research School of Pacific and Asian Studies
The Australian National University
Canberra A.C.T. 0200
Australia
E-mail: *Alan.Watchman@anu.edu.au*

REFERENCES

Arsenault, D., L. Gagnon, C. A. Martijn and A. Watchman 1995. Le projet Nisula. Recherches pluridisiciplinaires autour d'un site a pictogrammes (DeEh-1) en Haute-Cote-Nord du Québec. In A. M. Balac, C. Chapdelaine, N. Clermont and F. Dugay (eds), *Recherches amérindiennes au Québec, Archéologies québecoises*, pp. 17–57. Paléo-Quebec No. 28, Montréal.

Cox, S. L. 1994. Report on 1993 archaeological investigations of sites in Fryeburg, Maine. Unpubl. file report, Maine Historic Preservation Commission, Augusta.

Day, G. M. 1978. Western Abenaki. In B. Trigger (ed.), *Handbook of North American Indians*. Vol. 15, Smithsonian Institution, Washington.

Hedden, M. 1996. 3500 years of shamanism in Maine rock art. In C. H. Faulkner (ed.), *Rock art of the Eastern Woodlands*, pp. 7–24. Occasional Paper 2, American Rock Art Research Association, San Miguel.

Llosas, M. H., A. Watchman and J. Southon 1999. Pigment analysis and absolute dating of rock paintings from Jujuy, Argentina. In M. Strecker and P. Bahn (eds), *Dating and the earliest known rock art,* pp. 67–74. Oxbow Books, Oxford.

Osberg, P. H. 1985. *Bedrock geologic map of Maine*. Maine Geological Survey, Augusta.

Stuiver, M. and P. J. Reimer 1993. Extended 14C database and revised CALIB 3.0 14C age calibration. *Radiocarbon* 35(1): 215–30.

Watchman, A. 1990. What are silica skins and how are they important in rock art conservation. *Australian Aboriginal Studies* 1990/1: 21–9.

Watchman, A. 1992. Composition, formation and age of some Australian silica skins. *Australian Aboriginal Studies* 1992/1: 61–6.

Watchman, A. 1994. Radiocarbon dating fatty acids in Holocene siliceous rock surface accretions. *Australian Journal of Earth Sciences* 41: 179–80.

Watchman, A. 1995. Recent petroglyphs, Foz Côa, Portugal. *Rock Art Research* 12: 104–8.

Zilhão, J. 1995. The age of the Côa valley (Portugal) rock art: validation of archaeological dating to the Palaeolithic and refutation of scientific dating to historic or proto-historic times. *Antiquity* 69: 883–901.

RAR 21-699