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Results from the first intensive dating program for pigment art in the Australian arid zone: insights into recent social complexity

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ABSTRACT

The Canning Stock Route Project (Rock Art and *Jukurrpa*) has yielded the first radiocarbon dates for rock paintings in the Western Desert of Australia. We report on the results of a large-scale project to directly-date both charcoal and inorganic-pigmented pictographs using plasma oxidation combined with accelerator mass spectrometry. This project has yielded the largest number of art dates from any region in the world: one site alone has produced 12 art dates (from 30 collected samples). Our work advances the testing of the dating method through the systematic use of replicates and explores the methodological implications of dating very small samples (10–40 µg carbon). Thirty-six radiocarbon age determinations range from 3000 years ago to Modern. The results contribute to an understanding of art production in the Australian arid zone during a period of extreme cultural dynamism. We have demonstrated for the first time that significant late Holocene changes in discard rates of artefacts and technological organization of the extractive technologies of implements such seed-grinders is matched by a very high level of stylistic heterogeneity in the art – which has been systematically dated within and between dialect groups.

1. Introduction

As part of a broader project to characterize rock art (petroglyphs and pictographs) and *Jukurrpa* (dreaming stories) across the Western Desert of Australia, our study has sought to contextualize rock art production in this part of the arid zone with chronological control. This is the most comprehensive dating project undertaken anywhere in the world for rock paintings from a single cultural locale. As well as recording over 500 rock art sites along the Canning Stock Route, we have collected 71 paint samples for radiocarbon dating. Our aim was to test the dating methodology as well as demonstrate and date stylistic change in art production through the late Holocene. Four of the sites where art samples were collected have also been excavated, allowing comparison of dated occupation sequences and art production results. Unfortunately, a number of these small art samples had insufficient carbon for dating. Nonetheless, we report on 36 radiocarbon dates – the first suite of reliable ages for pigment art in Australia's arid zone.

The team employed a combination of plasma oxidation and accelerator mass spectrometry, which has been used to date rock paintings worldwide (e.g., Russ et al., 1990; Steelman et al., 2005; Rowe, 2009). In contrast to traditional combustion methods, plasma oxidation occurs below the decomposition temperature of carbon-containing minerals such as carbonates and oxalates; therefore, their inclusion in the measured AMS graphite target is avoided for samples with a high mineral content (Russ et al., 1990; Steelman and Rowe, 2012). Thus, extensive acid washes used in conjunction with combustion are not necessary and can be avoided, minimizing the loss of organic material during wet chemical pre-treatment steps. McDonald et al. (1990) and McDonald (2000) observed this problem when using acid–base–acid pre-treatment with combustion, which further reduced the likelihood of achieving reliable dates.

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1.1. Study area: Canning Stock Route, Western Australia

The Canning Stock Route (CSR) is an 1800-km long historic pastoral route punctuated with 50 wells in remote Western Australia. It traverses the Great Sandy, Little Sandy and Gibson Deserts and the Native Title lands of Birriliburu, Martu and Walmajarri peoples, who are all part of the Western Desert cultural bloc. European forays into this part of Australia's arid zone were relatively late, with some of our informants only meeting settlers during the last 50 years.

The archaeology of the Australian arid zone is becoming increasingly well understood (e.g. Veth, 1993, 2000; Veth et al., 2001, 2008; Smith, 2013). Occupation of the Australian deserts is known to have occurred soon after modern humans arrived on the continent (O'Connor et al., 1998; Veth et al., 2009, 2011). Less is known about the rock art styles and techniques of this region (although see McDonald, 2005; McDonald and Veth, 2012; Veth and O'Connor, 2013), and the CSR Project's overall aim was to better understand rock art's role in the recent past, at a time where other archaeological signatures indicate extreme cultural dynamism.

Symbolic behavior is an important cultural component of Australian desert life, and well-documented arid art forms include a diverse body art repertoire (Gould, 1969; Tonkinson, 1978), decorated wooden shields and other objects (Dickens, 1996; Mountford and Tonkinson, 1969) and sand paintings (Munn, 1973). At recent European contact, desert people were occasionally observed producing extensive pigment art galleries (Gould, 1969; Phillip Playford, pers. comm. to Peter Veth in 2013), and today there is a flourishing contemporary art movement (Carty and La Fontaine, 2011). There are various phases of rock art production through time, the earliest we posit as occurring with the initial occupation of the desert (Balme et al., 2009; McDonald and Veth, 2010). This dating project has focused on the most recent pigment art phases, identifiable by superimposition analysis and by the fact that this has visibly more surviving pigment present. We collected several paint samples from older styles, but these samples yielded significantly less viable material and we were unable to successfully date this earlier underlying art.

There is no contact art, identifiable by subject matter, along the Canning Stock Route but claimants speak to certain motifs and panels in most locations, and we have documented how desert rock art is a significant way of curating mythological sagas (McDonald and Veth, 2013a). None of our informants have been involved in production of pigment art, but several remember their parents talking about being involved in, or witnessing the production of rock art, e.g. *Nangapirty*, the father of Brian and Arthur Sampson, was born in the *Jilakurru* Ranges (Tonkinson, 1978) and he told his sons that his hands were stenciled there by his father when he was a boy (AS, pers. comm. 2010). We relocated this art site in 2010. While some Aboriginal people in this part of the Western Desert only made contact with Europeans in the 1960–70s, the recent movement of people out of the desert (Peterson, 1986) would appear to indicate that we are now several generations removed from painting on rock as part of a routine practice.

This project aimed to date pigment art along the entire length of the CSR but there is generally less art at the northern end of the CSR, due to the relative scarcity of suitable geological substrates. Pigment samples were collected from sites as far north as Gravity Lakes (Well 45), but the main focus of sample collection was in four Range systems located along the southern half of the CSR (Table 1, Fig. 1). The *Tipirl* (Diebel) Hills are located south of Well 18; the *Jilakurru* Ranges are at Well 17; the Calvert Ranges (*Kaalp*i) are to the east of Well 16 and the Carnarvon Ranges (*Katjarra*) are located southwest of Well 6.

Table 1
Total Sample collections, sites and dating outcomes.

Locations	Sites	No. of paint samples	No. of backgrounds	Art dates	Background dates
Gravity Lakes	GLM1	2	2	1	
	GLM2	1	1	0	
	GLM3	1	1	0	
Wells 38-37	Nightjar Shelter	1	1	0	
Diebel Hills	Diebel 1	2	1	2	
Jilakurru Ranges/ Durba Hills	DS1	1	1	1	
	DS4	1	1	0	
	DS28	1	1	0	
	DS32	1	1	0	1
	DS55	3	1	1	
	Pinpi 5	30	2	12	
	Pirli 3	1	1	1	
	Biella	1	1	0	
Kaalpi/Calvert Ranges	Kaalpi (V12)	5	2	3	
	M23	4	1	2	1
	P13	2	2	1	
	BTD1	5	3	5	
	PV10	1	0	1	
Katjarra/Carnarvon	SG1	8	6	5	2
Ranges		71	29	35	4

1.2. Dating rock art: plasma oxidation and AMS

Reliably determining the age of rock art assemblages has always posed a major challenge for rock art studies. The development of accelerator mass spectrometry (AMS) and related techniques now makes the chronometric dating of rock art possible (Steelman and Rowe, 2012). AMS requires only very small organic samples (e.g. charcoal, plant fibers), thus largely overcoming ethical dilemmas inherently associated with destructive sample collection processes. Paint must contain organic material temporally related to the painting event – charcoal pigment, or an organic binder added during paint manufacture. Chemical identification of organic materials used in paints (using chromatography and mass spectrometry) is still in its infancy (Rowe, 2001b; Livingston et al., 2009; Mazel et al., 2010; Mori et al., 2006; Vazquez et al., 2008).

Worldwide, pictographs are more frequently made with inorganic pigments. Reds, oranges, browns, and yellows are iron oxide/hydroxide minerals in various oxidation states and degrees of hydration. Similarly, black motifs are often produced using a manganese oxide/hydroxide rather than charcoal. These inorganic minerals cannot be radiocarbon dated because they do not contain carbon related to the production of a painting. If organic material(s) were added to the pigments as part of the paint preparation process, and if enough of that organic material has survived, then measurements can be made with sufficient accuracy and reliability to determine radiocarbon ages for inorganic-pigmented paintings. The plasma oxidation method together with AMS radiocarbon measurement is a direct technique for dating both charcoal and inorganic-pigmented pictographs.

The Steelman laboratory uses a custom-built plasma oxidation apparatus to extract organic material from ancient paint samples for AMS radiocarbon dating (Russ et al., 1990; Rowe, 2001a; Rowe, 2009; Steelman and Rowe, 2012). Plasma oxidation negates the use of extensive acid pretreatments because plasma temperatures ($<150\,^{\circ}C$) are below the decomposition temperatures of carbonates and oxalate minerals (Russ et al., 1992). The main advantage is that the inorganic rock substrate (sometimes inadvertently collected with the paint sample) does not decompose during exposure to oxygen plasma. Additionally, acid washes may not completely remove oxalate minerals, which are commonly associated with rock surfaces (Armitage et al., 2001; Hedges et al., 1998). Plasma