# *Disentangling the styles, sequences and antiquity of the early rock art of western Arnhem Land*

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## Declaration

Unless otherwise acknowledged in the text all work contained therein is the original research of the author.

Tristen Jones

For Nick, who challenges me to be the best version of myself and for our darling Tommy who provides the inspiration.

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## Abstract

The rock art of western Arnhem Land represents one of the largest corpuses and most complex ancient cultural records in ancient Australia, with both the rock art and the broader archaeological landscape amongst the oldest Indigenous occupied landscapes in the country (David et al. 2013; Clarkson et al. 2015; Roberts et al. 1990, 1993, 1994). While both the archaeology and aspects of the rock art have been rigorously studied, the early rock art of Arnhem Land rock art largely remains disarticulated from the archaeological record owing to its unknown antiquity (Langley and Taçon 2010). The inability to temporally link rock art sequences to the archaeological record has thus limited the capacity of rock art researchers to inform and engage in disciplinary debates regarding the social nature and the cultural complexity of Indigenous societies in the deep past. This issue remains the greatest limitation of rock art research (Ross et al. 2016).

This thesis aims to revaluate and test the validity of the previously proposed stylistic sequences and their assumed antiquity (Brandl 1973; Chaloupka 1993; Chippindale and Taçon 1998; Lewis 1988) with particular reference to the early to middle periods of western Arnhem Land rock art (Chippindale and Taçon 1998; Wesley et al. in press). It aims to anchor the stylistic chronology and our current understanding of western Arnhem Land rock art to the broader regional archaeological record through the production of absolute chronometric age constraints for selected rock art styles. The rock art styles subject to stylistic analysis and radiocarbon dating include; the Northern Running Figure style, the Large Naturalistic style, and the early X-ray style. By producing chronometric information regarding the timings of the emergence and disappearance of key rock art styles, a revised chronology for the early to middle periods can be proposed. This revised stylistic chronology for early to middle period rock art enables a combined re-evaluation of both the archaeology and the rock art in the region, thus consolidating our understanding of the social nature, function and cultural

context of rock art production in western Arnhem Land throughout the Pleistocene – Holocene transition.

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## Chapter 1. Introduction

In 1990 the Australian Rock Art Research Association held their second congress in Cairns, Australia. The theme of the congress was 'is style dead?' Earlier in 1990 Michel Lorblanchet (1990) had coined the term 'post stylistic era' as a catchphrase to describe the profound changes occurring in the discipline of rock art research and archaeology more generally due to the scientific revolution influencing both the methods employed and the research questions asked in the study of rock art. Nearly three decades later, this thesis explores the concept of style in rock art research, assessing both the concept and the use and accuracy of stylistic chronologies in western Arnhem Land rock art assemblages. One of the aims of this thesis is to demonstrate the ongoing currency of style as an investigative method in rock art research, when adopted alongside the scientific study of rock art. AURA Congress attendees Paul Bahn, Michel Lorblanchet, John Clegg, Jean Clottes and others were indeed correct in pondering the impact of the scientific revolution on the trajectory of the discipline. Recent developments in rock art dating methods, the application of Uranium Series dating for example, have revolutionised our understanding of the age of Upper Palaeolithic rock art (Pike et al. 2012) and reconfigured our assumptions pertaining to the early modern human behavioural practices of early populations in Island Southeast Asia (Aubert 2014). Similarly in Australia investigations characterising the mineralogy and geochemistry of pigments used by artists in the production of rock art (Huntley et al. 2011, 2015; Smith et al. 1998) and rock art dating projects using both plasma oxidation and accelerator mass spectrometry (McDonald et al. 2014), have revealed pigment sourcing practices, ancient distribution networks of ochres and changes in population groupings and alliance networks through time.

There is no doubt that the data produced from the use of scientific methods has propelled the discipline of rock art research in novel and interesting directions unveiling knowledge beyond the scope of stylistic analysis alone. However, the rock art researcher still needs to extrapolate from, and *interpret* the U-Series date, or mineralogical and chemical composition of an ochre, asking what is the relevance and significance of the absolute date on that single rock art motif (and/or site), in relation to the cultural medium as a whole. This is where the stylistic study of rock art assemblages remains highly relevant in contemporary rock art research. This thesis demonstrates that the use of both scientific methods and stylistic analysis in synergy with one another provides a stable platform to undertake contemporary rock art research and the ability to relate artistic production to broader archaeological narratives.

The painted rock art of western Arnhem Land is often heralded as one of the most important assemblages in the world due to its abundance, long sequences and diversity. Additionally, the landscape constitutes one of the oldest known inhabited regions in Australia, with archaeological sites Madjedbebe (Malakunanja II) and Nauwalabila I occupied from 55,000 years ago (Clarkson et al. 2015, Bird et al. 2002; Roberts et al. 1990, 1994). Known to have been painted for over 28,000 years (David et al. 2013a), the rock art corpus is potentially of much greater antiquity owing to the presence of modified ochres in some of the earliest dated stratified archaeological deposits (Clarkson et al. 2015). As such the region provides a rarely paralleled opportunity to investigate the worldviews of the past peoples in ancient Australia as the direct 'graphic expression of past cultural systems of knowledge, composed of beliefs, thoughts, values and human perceptions of environmental and socio-cultural context' (Domingo Sanz 2012:306).

### *1.1 Research Aims of This Thesis*

The overarching research question that this thesis aims to explore is whether the current widely utilised stylistic rock art chronologies of the Early and Middle Periods of western Arnhem Land rock art, in their current form, adequately catalogue the variability of manners of depiction in the rock art record; and whether these relative chronologies sufficiently map change in rock art assemblages through space and time. In order to explore these research questions this thesis focuses on a number of discrete classes of rock art, which themselves have not been the focus of detailed research previously. The rock art styles that are explored as case studies in this thesis include: the Large Naturalistic Style (henceforth LNS); Northern Running Figures (formerly referred to as Mountford Figures, henceforth NRFs); and the Early X-ray convention.

The case studies detailed in this thesis address more specific research questions in order to evaluate the broader stylistic chronology of the Early and Middle Periods of western Arnhem Land art. Specifically, the chapters aim to investigate the following questions:

1. Can rock art be radiocarbon dated more reliably by utilising calcium oxalate mineral crusts?
2. How old is NRF art? And by proxy, Middle Period art more generally?
3. What is the nature and function of NRF art in prehistoric western Arnhem Land societies?
4. When did the Early X-ray convention emerge in western Arnhem Land artistic practice?
5. What are the manners of depiction of the LNS—the proposed earliest figurative art style for the region—and what is the antiquity of this style?

### *1.2 The Definitions and Use of Style in Archaeology*

In this thesis style is defined as a ‘formal statement of the particular ways in which different artefacts are similar to each other’ (Davis 1986:124), whereby the similarity is expressed in the invariance and repetition of form, elements and motifs in rock art assemblages (following Schapiro 1953:288). This working definition of style is not overly contentious (cf. Hegmon 1992). What is more contentious is the way that style is used as an interpretative framework (Hegmon 1992:518). Style can be understood as ‘a highly specific and characteristic manner of doing something which by its very nature is peculiar to a specific time and place’ (Sackett 1982:113–115); it can be seen as ‘a means of non-verbal communication to negotiate identity’ (Wiessner

1990:108) (following Wobst 1977) and also as a medium of social practice, a 'way of doing' (Hodder 1990:45).

In this thesis the theoretical approach that I have adopted assumes that rock art has the capacity to transmit multiple messages simultaneously, some of which may be in contradiction to others, dependent on the individual viewing the imagery. Those messages are explored in relation to specific contexts, operating and dependent at both a macro-level (landscape) and on a micro-level (site and rock surface) during specific temporal phases (Domingo Sanz 2012). Furthermore, rock art can also transmit messages pertaining to group boundaries and identities, while simultaneously reflecting active individual artistic choice, which signifies the behaviours, beliefs and feelings of an individual (cf. Gell 1998).

As Claire Smith aptly declared 'In theory, artists can depict anything they wish, but they don't' (1992:28). The methodology that I have adopted in this thesis, is to uncover the active choices, evidenced by the patterning observable in the formal variation in an assemblage of artefacts, made by the artefact producer (in this case the artist). These choices underpin the selection of materials, subject matter, form, place etc., while still acknowledging that both the artist and the motif have agency grounded within the selected context.

### *1.3 Style, Chronologies and the Question of Antiquity in Western Arnhem Land Rock Art*

Extensive recordings by numerous rock art researchers over the last six decades have resulted in the development of a number of stylistic chronologies. Major contributions have been made by Brandl (1973), Chaloupka (1985, 1993), Lewis (1988), Taçon (1989) and most recently by publications of both Christopher Chippindale and Paul Taçon (Chippindale and Taçon 1993, 1998; Taçon and Chippindale 1994). All researchers have sought to map stylistic change in rock art and have anchored relative sequences of rock art styles to different temporal periods.

Brandl (1973) undertook the first systematic recordings of rock art in the Cadell River area, near Maningrida in central Arnhem Land, and Deaf Adder Creek in western Arnhem Land. At Cadell River Brandl recorded eight different locations all within 700 metres of the Cadell River crossing, recording 500 motifs. Noting the similarities of the rock art with other areas, Brandl then undertook a comparative analysis of Cadell River art with the art of Deaf Adder Creek (particularly on Mt Gilruth), stating that 'Many minor traits and several motifs appear nearly identical in form in both areas … ' (1973:71). Brandl detailed the painting materials, pigments and techniques in the rock art, and also focused on the changing perspectives and what he termed 'symbolic representations' in the art (1973:165). Utilising overlays (superimposition) and changes in subject matter (such as the presence and then absence of extinct fauna and material culture types such as boomerangs), Brandl developed a two phase rock art sequence comprised of an earlier phase called Mimi and a later phase labelled X-ray (1973:166–178). These broad stylistic periods were broken down into phases: Early Mimi, followed by Late Mimi I and Late Mimi II. The X-ray period was broken down into four phases: Incipient X-ray, Simple X-ray, Standard X-ray and Complex X-ray (1973:168). According to Brandl, Dynamic Figures (Early Mimi art phase) dominated the earliest art, predominantly depicting humans in motion with ceremonial paraphernalia and with material cultural items, such as angled boomerangs, but without spear throwers (Brandl 1973:172–173). In contrast, humans in Late Mimi art were depicted with less animated postures, less ceremonial regalia and the introduction of Incipient and Simple X-ray features (1973:174). To the LM I phase Brandl assigns the first introduction of the spear thrower (1973:175). The presence of ceremonial attire led him to argue that the Early Period art of western Arnhem Land had a sacred mytho-totemic underpinning, while later art had a magic/sorcery function, based on ethnographic parallels derived from recent anthropological recordings in the region (1973:179–187).

| Period | Phase | | Style/Technique |
|---|---|---|---|
| PRE-ESTUARINE | 50,000 years ago<br>From this date, haematite and red and yellow ochres were used to prepare pigment | | Object imprints |
| | 20,000 years ago | *Naturalistic* | Large Naturalistic Figures Complex |
| | | | Dynamic Figures |
| | | *Stylisation* | Post Dynamic Figures |
| | | *Schematisation* | Simple Figures with Boomerangs |
| | | *Stylisation*<br>*Naturalistic*<br>*Symbolism* | Mountford Figures<br>Yam Figures |
| ESTUARINE | 8,000 years ago | *Naturalistic* | Early estuarine complex |
| | 4,000 years ago | | Beeswax designs |
| | | *Intellectual Realism and Contemporaneous Naturalism* | X-ray complex |
| FRESHWATER | 1,500 years ago | | |
| CONTACT | 300 years ago | | |
| | Ethnographic present | | Casual paintings |

Table 1. Chaloupkas stylistic chronology of western Arnhem Land rock art (modified, after Chaloupka 1993:89).

From 1973, George Chaloupka amassed an extensive collection of rock art site archives as the Curator of Rock Art at the Museum and Art Gallery of the Northern Territory. Some 30 years of recordings culminated in the publication *Journey in Time* (1993) which outlines his chronology for western Arnhem

Land rock art, although descriptions and aspects of the chronology had been published previously (Chaloupka 1977, 1979, 1983, 1984, 1985). Chaloupka's chronology, like Brandl's, used the method of superimposition, and the changing depictions of material culture types to build a sequence. However unlike his predecessors Chaloupka extended his methodological approach to incorporate other forms of evidence derived from climatic and environmental data. Chaloupka

> … identified a number of styles with paintings of specific forms, constant elements and overall aesthetic quality of expression … styles were then structured with other forms of rock art, by their order of superimposition, into a chronological sequence … This work was followed by a detailed analysis of each style's content, during which it was noted that certain subjects were present in two or more styles, but absent in others … the climatological, geomorphological, archaeological and historical data, along with the zoological and botanical evidence, were sought and considered. The styles were then divided into art periods and phases, and positioned between time indices indicated by the study' (1993:88).

From his data, Chaloupka presented a four-stage chronology: Pre-estuarine (50,000 to 8,000 years ago), Estuarine (8,000 to 4,000 years ago), Freshwater (1,500 to 150 years ago) and Contact Periods (150 years ago to ethnographic present) (Table 1).

This thesis focuses on the rock art styles that occurred within Chaloupka's Pre-estuarine Period. This period encompasses a range of divergent art styles argued to occur in a sequence (i.e. not contemporaneous with each other) and includes: Large Naturalistic Figures Complex, Dynamic Figures, Post Dynamic Figures, Simple Figures with Boomerangs, Mountford Figures and Yam Figures (1993:89). Chaloupka's definition of LNS is discussed at length in Chapter Six, while NRFs are detailed in Chapters Three and Four. Dynamic Figures are not discussed at any length in this thesis as they are currently the subject of doctoral research by my Australian National University colleague Iain Johnston. Additionally, as an art style the Dynamic Figures have been studied to a greater degree than any other form of early western Arnhem Land rock art (Chaloupka 1984; Chippindale et al. 2000;

Johnston in press; Johnston et al. in press; May et al. in press; Taçon and Chippindale 1994, 2001). This recent research (Johnston in press; Johnston et al. in press; May et al. in press) proposes that Dynamic Figures illustrate ritual behaviours and beliefs, that the art style is depicted in selected places and that, contra Chaloupka, there are no defined stylistic subgroups evident in the Dynamic Figure style. Chaloupka argued that the earlier art styles, such as the Dynamic Figures, had a wide ranging distribution across the Arnhem Land plateau, were painted over a very long period with evidence of stylistic transformations through time. Furthermore, he also proposed that the only other painting styles that had a comparable spatial and perhaps temporal distribution were the descriptive (recent) X-ray style (1993:106).

Chaloupka refers to Pre-estuarine Period art as being representative of the Arnhem Land cultural plateau block (1993:91). He characterised the art of the Pre-estuarine Period as oscillating between naturalistic through to stylised and schematised forms (Table 1). Regarding methodology, Chaloupka defined the use of style in his study as ‘the repetition of paintings with specific forms with constant elements and overall aesthetic equality of expression’ (1993:88). Following his stylistic classifications, he then used the presence of superimpositions and supplementary data from environmental studies (detailed above) in order to place or to anchor the art into chronological sequences (Chaloupka 1993:88). However, this methodological approach has been criticised and alternative chronologies proposed, such as those proposed by Lewis (1988) who rejected the use of superimpositions. After noting the technological changes evident in material culture types represented in the western Arnhem Land rock art assemblage, as originally identified by Brandl (1973), Lewis selected changing material culture representations as a method to develop a sequence. He argued that the depictions of material culture were constant phenomena present throughout the entire sequence of western Arnhem Land art, and therefore that changes in material culture types can be used as temporal markers because they appear and disappear from rock art. These material culture items are then used to anchor associated human figures, animals and other motif types in a relative sequence. Subsequently, Lewis identified four periods from this data, thereby developing a chronology: Boomerang Period, Hooked Stick Period, Broad Spear Thrower Period, and Long Spear Thrower Period (Table 2). Lewis' chronology and findings have been criticised as some reviewers maintain that his schema does not allow many motif types to be classified or incorporated into his typology, and that classification according to association is inherently problematic (Franklin 1994; Sales 1990). Recent rock art recordings and analysis by Hayward (2016; in press) convincingly showed that some periods in Lewis' schema, for example the Broad Spear Thrower Period, have been completely misassigned to a temporal period. Hayward's research suggests that Lewis' chronology requires radical re-evaluation.

However, Lewis' schema offers two advantages over Chaloupka's chronological framework. The first is that Lewis' schema allows for more than one art style to be produced at any one point in time, whereas Chaloupka's does not (Lewis 1988:8). Secondly, Lewis noted that there is an increasing number of rock art styles occurring from the Hooked Stick Period, with increased diversity and regionalism evident, arguing that these changes 'reflect adaptive response to change in ecological conditions ultimately created by the change in global climate' (1988:95).

Figure 1. Examples of Lewis' (1988) Hooked Stick period figures from Mt Brockman (after Lewis 1988:230). Note that NRFs are assigned to this temporal period. Tracing by Meg Walker.

| Period | Identifying Characteristics | Years BP (approx.) |
| --- | --- | --- |
| **Boomerang** | Figures in monochrome red with ornate headdress, carrying boomerangs and/or spears only. Naturalistic perspective usually with allusion to movement. Stencils of hands and material culture items are common. Distribution: pan-plateau | Maximum: ? (no megafauna)<br>Minimum: 9,000 |
| **Hooked Stick** | Figures with 'hooked sticks' as well as boomerangs and spears, usually with simplified headdress. Regional variation in perspective and style. Rainbow snake complex appears throughout the plateau late in period and continues, with changes, until the present time. | Maximum: 9,000<br>Minimum: 6,000 |
| **Broad Spearthrower** | Figures with short, broad spearthrowers, and cylindrical spearthrowers, and a great variety of spear types. Varies perspective, style and colour. In northwest of plateau, long-necked spearthrowers appear to be transitional between broad and long spearthrowers. | Maximum: 6,000<br>Minimum: 1,000-2,000 |
| **Long Spearthrower** | Figures with long, narrow spearthrower varied perspectives, painting techniques, and styles. Includes fully developed X-ray art. Limited variety of spear types. | Maximum: 2,000 (probably less than 1,000). Minimum: Ethnographic Present |

Table 2. Lewis' chronology of western Arnhem Land rock art (after Lewis 1988:105)

| Phase | Episode | Type (Forms + Manners) | | Approx. Age |
|---|---|---|---|---|
| OLD | 1 | Some pigment | | 30,000-35,000 years |
| | | Panaramitee-like engravings | | Unknown |
| | 2 | Large Naturalistic fauna | | Unknown |
| | 3a | Dynamic Figures (in situ development) | | About 10,000 years (?) |
| INTERMEDIATE | | | Post Dynamic Figures | Unknown |
| | | Northern Running Figures | Simple Figures with Boomerangs + some large fauna | Unknown |
| | 3b | Simple Figures + Yam Figures + large human figures + some large fauna + Early X-ray | | 6,000 years |
| NEW | 3c | Complete Figure Complex, some engravings | | 4,000-3,000 years to 1960s |
| | | Rare rock paintings, bark paintings, various other media | | Present |

Table 3. Taçon and Chippindale's (1994) revised western Arnhem Land rock art chronology (after Taçon and Chippindale 1994:215). This chronology is amended in 1998 (refer to Chapter Three, Table 1).

Chaloupka's chronology was again evaluated in 1993 with the publication of 'Two old painted panels from Kakadu: variation and sequence in Arnhem Land rock art' (Chippindale and Taçon 1993). One of the primary aims of the study was to test whether the motifs for two sites, Kungurrul and Brockman, could be unambiguously assigned to Chaloupka's defined styles or manners of depiction, according to his chronological sequence. The results revealed that only 43% (Kungurrul) and 69% (Brockman) of motifs could be attributed to one of the defined manners. This led Taçon and Chippindale (1994) to propose a revised chronology (Table 3). In this chronology they identified a number of points of departure from Chaloupka's chronology. They disputed that humans are depicted as part of the Large Naturalistic Figure style (1994:214). They also argued that there is no evidence that handprints occur in isolation prior to Large Naturalistic Figures (1994:216). Taçon and Chippindale use the terminology 'Old', 'Intermediate' and 'New' to describe a three-phased chronology (Table 3). Furthermore, in their 1994 chronology, they separate Simple Figures with Boomerangs from Simple Figures, but there is no explanation in the text for this separation. Their chronology was again revised in their 1998 paper (Chippindale and Taçon 1998:95–111) where they clarified that, according to the 'principle of continuity', the presence of the boomerang in the Dynamic Figure, Post-Dynamic Figure, Simple Figure and NRF styles probably indicates that these manners of depiction were produced in the same temporal period (1998:102). They also noted that depictions of Large Naturalistic Animals continue throughout the Old to Intermediate phases of the art sequence (discussed in Chapter Six). Additionally in this revision they elucidated their objection to Chaloupka's sequence for Simple Figures and Yam Figures (Chippindale and Taçon 1998:105). They presented a case study which demonstrated that Simple Figures are painted over Yam Figures and vice versa, leading them to conclude that both styles are contemporaneous. They argued that these observations are consistent and verified by the supplementary material culture art record with similar spears and spear throwers occurring in both styles. Thus they concluded that 'Simple Figures depict activities that appear to belong to the human domain (e.g. scenes of humans fighting) while Yam

Figures depict activities in the spiritual domain (e.g. images of rainbow serpents)' (Chippindale and Taçon 1998:106).

Elements of the Chaloupka chronology (1993) have been criticised by some researchers, as summarised above, with proponents such as Lewis (1998) and Haskovec (1992a) suggesting major changes are required. However in general terms, Chaloupka's chronology and its revised and amended forms developed by Chippindale and Taçon (1998; Taçon and Chippindale 1994) remain widely influential both in academic research and popularised literature.

### *1.4 Background to the Study Area*

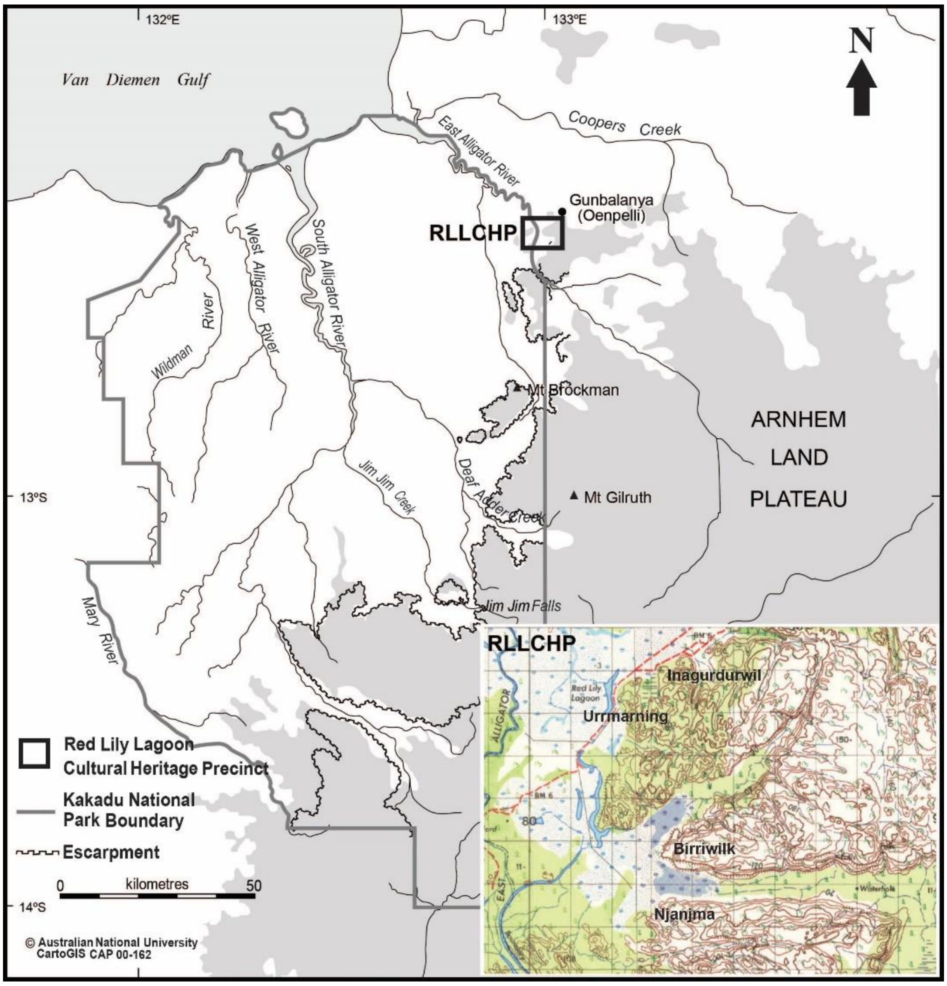


Figure 2. Map of the Red Lily Lagoon Cultural Heritage Precinct with major place names and the surrounding region. Map by ANU CartoGis and Tim Maloney.

### *1.4.1 Red Lily Lagoon Cultural Heritage Precinct*

The Manilakarr (and old Mirarr Erre) clan estates are situated on the main road to Gunbalanya east of Cahill's Crossing and the East Alligator River, in western Arnhem Land (Figure 2). The northern-most part of the estate, formerly known as Inagurdurwil Hill (Chaloupka 1993; Mountford 1956), is bordered by Wulk (Red Lily Lagoon). In this thesis this area, and the dense distribution of rock art sites contained within, are referred to as the Red Lily Lagoon Cultural Heritage Precinct (RLLCHP). The RLLCHP lies approximately 10 km southwest from Gunbalanya and 35 km northwest of the Jabiru township situated in Kakadu National Park (KNP). The most southern section of the Manilakarr clan estate is Minkinj Valley and is the region where the East Alligator River emerges from the Arnhem Land plateau. The valley is surrounded on the north, east and southern sides by the escarpment of the plateau that is formed of Proterozoic Kombolgie Formation sandstone. The topography of the plateau is characterized by heavily dissected chasms and gorges. The East Alligator River runs from its headwaters in the plateau, south to north across low lying plains into the Van Diemen Gulf. During the wet season the water levels of the river rise, flooding the plains and creating a myriad of freshwater billabongs that support a rich and diverse floral and faunal ecology. These wetlands are bordered by eucalypt-dominated open forest and woodlands.

The climate in the region is tropical, with consistently high temperatures and two major seasons, the wet (November to March) and the dry (May to October). The wet season is brought by northerly to northwesterly monsoonal winds and is marked by cyclonic activity. It is characterised by warm temperatures and rain, with the average maximum temperature for January being 33°C, and with much of the average annual rainfall (800 mm to 1,600 mm) falling in this season. In comparison the months from May to October are typified by southeasterly trade winds, low humidity, and very dry conditions often resulting in the characteristic hazy conditions due to bushfire smoke and dust. The environmental and climatic conditions of this landscape have been identified as dominating factors negatively impacting upon the conservation outcomes for rock art in the region (Chaloupka 1977:77).

The RLLCHP and Minkinj Valley areas have been frequently visited by researchers in the past, with intermittent archaeological excavations, recordings of rock art and Indigenous material culture undertaken by European academics from the early twentieth century to the present day.

### *1.4.2 Archaeological Excavations*

<u>Malangangerr</u>

Malangangerr is a rock shelter located approximately one kilometre from the East Alligator River and situated in KNP within the bounds of the Manilakarr clan estate. The Traditional Owners have a personal connection to this place because it was a camping ground for the old man Nakodkoj Nayinggul[1] during times of living memory. The site was excavated by Carmel Schrire (formerly White) as part of her PhD research during 1964 and 1965. Schrire Identified three stratigraphic units with the lowest stratigraphic unit 3 dated to 22,900±1000 (1982:84). Finds from the excavation included dense deposits of shell and faunal remains, and bone and shell implements in the upper level, unit 1, dating from 5980±140 (Schrire 1982:85). These results mirror findings from other excavations (e.g. Allen and Barton 1989; Clarkson et al. 2015; Kamminga and Allen 1973; Jones 1985). They also reflect the broader regional taphonomic issues in Arnhem Land where, due to the highly acidic nature of the soils, organics do not preserve at depth (cf. Gregory 1998; Jones 1985; Schrire 1982). Human burials were also present in the unit 1 of Malangangerr with at least ten individuals identified (Schrire 1982:85–95). Stone artefacts were reported throughout the entire excavated sequence, as is ochre (to the base of unit 3). The reported finds from Malangangerr, in conjunction with the results from Schrire's excavations of other plains sites, Nawamoyn and Paribari, and plateau sites, Jimiri I and II, were interpreted and developed as representing a two part cultural sequence (Schrire

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[1] Due to family wishes we refer to the Nakodkoj Nayinggul (deceased), former Senior Traditional Owner of the Manilakarr clan estate, by his skin name.

1982:227–257). The relevance of Schrire's conclusions will be discussed in more detail in Chapter 8.

Birriwilk, Bindjarran and Ingaanjalwurr

Throughout the dry season of 2011 three excavations were undertaken across the Manilakarr clan estate led by Denis Shine (2013, 2015, 2016). One of the excavations was undertaken at the Birriwilk rock shelter. The rock art at the site and the Dreaming mythology that is attached to this place have been recorded previously (Berndt and Berndt 1989; Gunn 1992). As outlined in Chapter Two, this cultural heritage site has immense contemporary significance to the Traditional Owners, being a Dreaming site (*djang*). The rock art present in the shelter is understood as being directly descended from the Dreaming, with the spirit-being still residing at the place (Alfred Nayinggul pers. comm. October 2014; McKenzie 1980). Results from the excavations reported initial occupation of the Birriwilk shelter from 4,524±29 BP, with a main occupation phase evident from artefact, fauna and fish remains from 750–50 BP (Shine et al. 2013:72, 76).

Ingaanjalwurr is another occupation shelter on the Manilakarr estate with a high incidence of beeswax rock art. The rock art of Ingaanjalwurr has been described by May et al. (in press) who recorded 76 painted images and another 45 beeswax motifs. Radiocarbon dating of two of the beeswax rock art motifs yield broadly contemporaneous ages, producing ages of 8–275 cal. BP (May et al. in press). Radiocarbon ages produced from in situ and sieved charcoal from the deposit indicate two periods of intense site usage: the first dating to ca 1,900–1,300 cal. BP and the second dating from ca 460–300 cal. BP (Shine et al. 2016). The deposits spanning the second period of intense occupation also evidence an increase in the deposition of worked ochre. It is highly likely then that the second phase of intense occupation at Ingaanjalwurr coincides with the major phase of rock art production.

Excavations on the Manilakarr clan estate in KNP at Bindjarran rock shelter have produced occupation deposits dated from 13,140–12,771 cal. BP, with an increase in site use (seen in increases in lithics and burning activity) reported to occur from 8,014–7,858 cal. BP (Shine et al. 2015:108). The site is more densely occupied throughout the mid to late Holocene with increases in stone artefact discard and macro charcoal dated between 5,265–4,865 cal. BP, and 2,918–2,762 cal. BP, and a peak in activity between 1,270 and 1,075 cal. BP (Shine et al. 2015:109). The rock art in the shelter has been recorded by Melissa Marshall as part of her doctoral research which focuses on rock art conservation. The rock art present at the Bindjarran rock shelter is briefly reported, focusing on the contact assemblage present, with the other rock art types reported according to Chaloupka's schema (Shine et al. 2015:105, 110).

## *1.5 Rock art recordings and ethno-historical accounts of Manilakarr country*

### 1.5.1 American–Australian Scientific Expedition to Arnhem Land (AASEAL)

While some recordings and commentary on the presence of rock art in the regions surrounding Gunbalanya (formally Oenpelli) are published in the early historical and ethnographic literature (see Chapter Two for a more detailed discussion), the first detailed recordings of rock art in the Red Lily Lagoon area were undertaken by Charles Mountford as part of the American–Australian Scientific Expedition to Arnhem Land (AASEAL).

The expedition, funded by The National Geographic Society, the Australian Government and the Smithsonian Institution, travelled across Arnhem Land from east to west, camping at Umbakumba, Groote Eylandt and Yirrkala, in eastern Arnhem Land, with Oenpelli (Gunbalanya) in western Arnhem Land the last camp (cf. Thomas and Neale 2011). The expedition was made up of participants from a broad range of disciplines, including archaeology, anthropology and the environmental sciences and included Frank M. Setzler, Deputy Leader and archaeologist, Head Curator, Department of Anthropology, Smithsonian Institution, Washington; Frederick D. McCarthy, anthropologist from the Department of Anthropology, Australian Museum, Sydney; and Harrison Howell Walker, a photographer and staff writer from the National Geographic Society, Washington, as well as cinematographer, Peter Bassett-Smith. A detailed history of the significance of the expedition is provided in Thomas and Neales' monograph titled *Exploring the Legacy of the 1948 Arnhem Land Expedition* (2011) and is beyond the scope of this introduction. However the *Records of the American–Australian Scientific Expedition to Arnhem Land* (Mountford and Specht 1956–64) contain some of the most important information detailing rock art and archaeology surrounding Gunbalanya. Charles Mountford recorded the rock art at locations around the camp, including at Injalak Hill and Inagurdurwil. Inagurdurwil is the earliest recorded name for the RLLCHP, and his records are the first for the extensive rock art assemblages present in the study area. For Mountford, it was the diversity of the rock art within the Inagurdurwil sites that attracted his interest and, as such, the sites formed a large part of the reporting from the expedition. From eight rock art localities around Inagurdurwil Hill, Mountford documented this high diversity of rock art styles and motifs, mainly anthropomorphic figures depicted in a variety of poses with a multitude of material culture (see Mountford 1956 and Chapter Four for a more detailed discussion of his recording of NRFs). Importantly, Mountford's study of the Red Lily Lagoon area highlighted that it formed only a small part of a larger Indigenous site complex consisting of sacred features, historical relics, potentially ancient cultural deposits and a long record of rock art from the terminal Pleistocene through to the recent past, potentially with motifs numbering into the thousands. His published research along with the anthropological recordings of other notable researchers, such as Ronald and Catherine Berndt (see Chapter Two), motivated a large number of academics to focus on the rock art, archaeology and cultural landscape of western Arnhem Land, including the rock art of Inagurdurwil (Red Lily Lagoon) and the Minkinj Valley areas over the next half century.

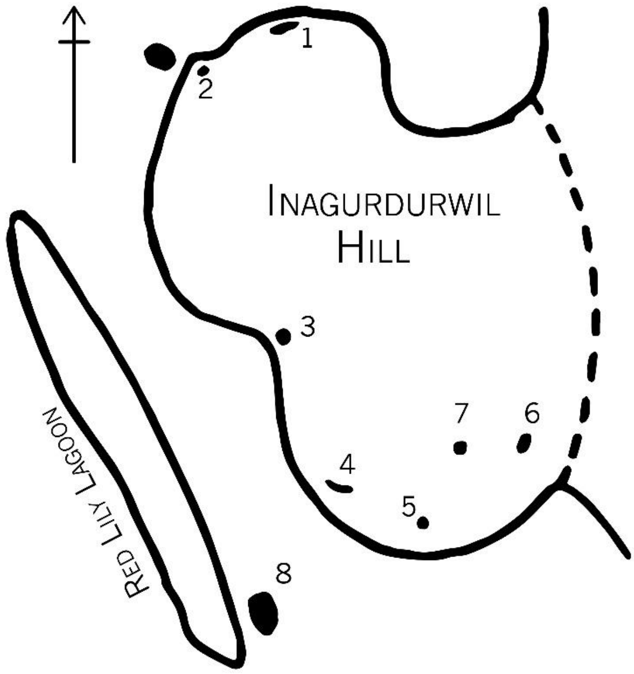


Figure 3. Mountford’s map of Inagurdurwil Hill (1956) marking the locations of the sites he recorded as part of the AASEAL expedition (after Mountford 1956:144).

### 1.5.2 Systematic Rock Art Surveys and Recordings

As detailed above, the first systematic recordings of Arnhem Land rock art were made by Brandl in the Cadell River area near Maningrida and Deaf Adder Creek. Brandl developed a two-phase rock art sequence comprised of an earlier phase, called Mimi, and a later phase, labelled X-ray. These two phases were broken down into subgroups mapping stylistic change through time, creating the first temporal sequence for Arnhem Land art (Brandl 1973).

Detailed surveys of archaeological sites including rock art were undertaken across the East Alligator River, Cooper Creek and the South Alligator River catchments in 1972 by Robert Edwards and colleagues as part of the Alligator Rivers Region Environmental Fact Finding Study to collect data in order to prepare detailed plans for the establishment of a national park (Edwards 1979). Edwards again recorded the two main rock art provinces surrounding Gunbalanya (Injalak and Inagurdurwil), but also recorded for the first time in detail the diversity and abundance of rock art sites situated in and surrounding areas of Jim Jim Creek, Deaf Adder Gorge, Mt Gilruth, Mt Brockman, Nourlangie Rock, Ubirr, Cannon Hill and Mt Borradaile (Edwards 1979). While the presence, absence and locations of sites across western Arnhem Land were recorded by Edwards, systematic recordings of motifs and motif types were not and so Edwards' record does not significantly improve our understanding of the type of rock art present in the Manilakarr clan estate.

From 1973, when he was appointed as curator of rock art at the Museum and Art Gallery of the Northern Territory, George Chaloupka recorded in excess of 1,500 rock art sites in western Arnhem Land. The significance and legacy of Chaloupka's work, particularly his proposed relative stylistic chronology, is detailed above. Of interest here is that throughout his hallmark publication, *Journey in Time* (1993) Chaloupka provided photographs from the Red Lily (Inagurdurwil) and Mikinj Valley sites as motif examples to support the styles and sequences proposed in his chronology. For example, two sites from Red Lily featuring Large Naturalistic macropods were published in *Journey in Time* (1993:95) as examples of the LNS. One such panel, argued by Chaloupka to be reminiscent of the LNS, is site RLL32D, which features typecast examples of Lined Infill manner macropods (Chapter Six, Figure X). The Red Lily Site 32, dominated by NRF scenes (discussed in Chapters Three and Four) were also published by Chaloupka in the monograph (1993:134–135). More recent rock art from Red Lily, depicted utilising fully developed X-ray conventions, was also published in the monograph (1993:1,148, 184, 210, 226). There is a very high frequency of mid to late Holocene rock art present in the study area. Although mid to late Holocene rock art production and styles are not the focus of this thesis, they are detailed in Appendix A.

From the mid to late 1980s, Paul Taçon undertook fieldwork across areas of western Arnhem Land to collect data for his doctoral research, in order to explore the recent rock art and painting traditions in the region. One of his study areas—referred to as area O in his thesis—encompasses the northern sections of the Manilakarr clan estate (Taçon 1989). Taçon recorded a number of rock art sites at Ubirr, Malangangerr and Red Lily, primarily rock art motifs painted in the X-ray convention and other mid to late Holocene rock art styles.

In 1991 Ben Gunn received funding from the Australian Institute of Aboriginal and Torres Strait Islander Studies (AIATSIS), Canberra, to undertake rock art recordings in Mikinj Valley, focusing on sites of significance to Nakodkoj Nayinggul. He subsequently (1992) recorded the Birriwilk and Njanjma sites (see Chapter 2), Urrmarning (a Red Lily Dreaming site, destroyed after Cyclone Monica discussed below), Minjnyimirnjdawabu sites (formerly Inagurdurwil Hill), and other cultural heritage places and mythological beings associated with the cultural landscape on the Manilakarr clan estate and surrounding areas. Other aims of the project were to assess the archaeological significance of the sites and the study area in general. In the report Gunn (1992) concluded that the sites in the RLLCHP and Minkinj Valley areas have very high levels of Indigenous cultural heritage and archaeological significance, with many sites still undocumented. In particular, Gunn (1992:118) asserted that the sites in the RLLCHP, originally recorded by Mountford in 1948, should be the subject of a revised program of documentation and study.

The rock art site known as Urrmarning (place name) was recorded by Gunn in 1991. However, the Dreaming site had previously been recorded by Berndt and Berndt (1989:57–64). The site featured rock art paintings of red lilies. Mountford had previously recorded this place as a focus of ‘intense ritual’ (Mountford 1956:214, footnote 11). Gunn confirmed in his recordings of the associated mythology for the site that according to Senior Traditional Owner Nakodkoj Nayinggul, the responsibility of the site custodian of this site was to perform an increase ceremony if there was a shortage of lilies in the lagoon or the broader region. This site was destroyed following Cyclone Monica in 2006. Tree debris from the cyclone was pushed from the Gunbalanya Road, which tracks close to the site, up against the rock art panels. The rock art panels exploded from heat stress following seasonal fires (Earth Sea Heritage Surveys 2009). Subsequently Nakodkoj Nayinggul sought government assistance to undertake a cultural heritage site assessment of other Red Lily rock art sites situated near Urrmarning. The site assessment was undertaken by Daryl Wesley (formerly Guse), who also produced a cultural heritage management plan for the Red Lily cultural sites.

### *1.6 Participatory Consultation and Indigenous Engagement*

Due to the abundant and diverse rock art assemblages and the study area's potential to inform the research aims of this thesis, the RLLCHP was identified as an ideal study area in which to undertake this research project.

Through his consulting work, ANU colleague Daryl Wesley had existing relationships with Manilakarr clan estate Senior Traditional Owner Nakodkoj Nayinggul and family. Consultations with Senior Traditional Owner Nakodkoj Nayinggul and son Alfred Nayinggul, and with other clan group members, were undertaken in July 2011, when the ANU Department of Archaeology and Natural History-led Masters of Archaeological Science field-school was co-led and attended by the author. The field-school was run as part of the George Chaloupka Fellowship awarded to Wesley. Following approval from the Traditional Owners, agreement was made between the clan group and the author to continue an ongoing rock art research project of which this thesis is the result.

### *1.7 Thesis Structure and Case Studies*

This thesis is a 'Thesis by Compilation' whereby the chapters contained within are written, styled and formatted as independent research papers that have been submitted to peer-reviewed academic publications. The ANU guidelines for 'Thesis by Compilation' are detailed in Appendix D. Accordingly thesis chapters have either been published (Chapters Two and Three), are currently 'in press' (Chapters Four and Five) or are 'in review' (Chapter Six and Seven), having been submitted to the identified journals. As far as practicable, care has been taken to minimise the degree of repetition presented in the chapters, particularly in sections detailing site descriptions, literature reviews and background to the studies. However, as the research articles are underpinned by an overarching research agenda and address similar subject matter in recurrent locations, some repetition could not be avoided.

Due to the structure of this thesis there is no separate presentation of methodology in the opening sections of this thesis. As the chapters function as discreet research papers, the methods employed in addressing the research questions are addressed in each chapter. However, Chapter Two offers a critical review of current rock art recording practices as utilised in this research project and examines the theoretical development and methodological practice of the discipline of rock art research within the broader framework of Australian archaeology. Examples of recording forms detailing rock art site data capture methods are also presented in this chapter (Chapter 2, Figure 6).

The pedestrian survey strategy and rock art site recording methods used in this project are described in Appendix A (Wesley et al. in press). Additionally, this paper details the results of the cultural heritage site surveys undertaken in the first field season: the site locations, geomorphological setting and cultural features in the study area. Additionally, this paper details descriptive statistics describing the presence and absence of rock art styles and subject matter, and the abundance, diversity and density of the rock art assemblage present in the RLLCHP.

The methods used in the pre-treatment and processing of radiocarbon dating samples are detailed in Chapter 3. The novel compound specific separation technique used was developed by co-authors Vladimir A. Levchenko and Alan A. Williams from the Australian Nuclear Science and Technology Organisation (ANSTO). Methods used in the mineralogical characterisation of samples before samples were radiocarbon dated are presented in Appendix B (King et al. 2017). Methods used include X-ray diffraction (XRD), scanning electron microscopy-energy dispersive spectrometry (SEM-EDS) and Fourier Transform Infrared (FTIR) Spectroscopy.

This introduction (Chapter One) has provided an historical overview of the research describing the extensive corpus of rock art in both the study area and western Arnhem Land. In particular, this thesis has sought to highlight the development of, and trajectory of, both the methods employed and the content of proposed stylistic sequences and assumed antiquity of the rock art. Following this detailed literature review, the significance of the subject matter, chronologies and methods detailed in western Arnhem Land rock art research has been contextualised within the regional archaeological landscape and the broader theoretical developments and debates in both the disciplines of rock art research and Australian archaeology.

Chapters Three to Seven address discrete research questions outlined in the research aims of this thesis. Chapter Three presents the results of the radiocarbon dating program attempting to produce absolute chronometric data for Middle Period art styles by targeting the NRF rock art style. Nine radiocarbon age determinations produced minimum and bracket age ranges, providing age constraints for both Pleistocene and early Holocene rock art in western Arnhem Land. The radiocarbon age determinations are produced by extracting calcium oxalate contained within mineral crusts associated with the rock art. This chapter details a novel compound-specific separation technique that improves the reliability of dating mineral crusts.

Chapter Four explores the nature, content and social function of NRF art through an analysis of the distribution, abundance and diversity of NRF assemblages and their archaeological contexts from two study areas, Jabiluka and Red Lily Lagoon. Motif design elements in the NRF style such as the inclusion of sex and material culture are indices used to explore social function in NRF art. The relationship between NRF archaeological contexts (i.e. distribution, abundance, diversity and overall rock art site contexts) and the variables of sex and material culture are explored via statistical analysis.

In Chapter Five a 'cabled' methodology (see Chippindale and Taçon 1998:93), where multiple lines of evidence are developed in tandem, by combining absolute and relative dating techniques, is adopted to investigate the emergence of the X-ray convention in western Arnhem Land rock art practice. Absolute radiocarbon dates are made on two different substances (mud-wasp nest and calcium oxalate mineral crust). They have been linked with relative dates derived from a single rock art panel by assessing motif superimpositions, stylistic analysis of motifs and degree of preservation. Combined, the absolute and relative methods provide reliable dates for the painted motifs.

Chapter Six investigates one of the earliest figurative art styles, the LNS, as originally proposed by Chaloupka in the 1970s (1977, 1979, 1985, 1993). The chapter reports on the distribution, frequency and nature of Early Naturalistic macropod paintings from four study areas across western Arnhem Land. It maps the stylistic design elements used by artists in the depictions of Early Naturalistic animal forms that occur throughout the Early and Middle Periods. The results enable an opportunity to re-evaluate the existence and coherence of the LNS as a class of rock art.

Chapter Seven reports the first reliable radiocarbon age determinations for early LNS macropod motifs. These dates confirm that this class of rock art is potentially of great antiquity, as previously proposed by other researchers. The radiocarbon age determinations reported in this chapter further support the proposed minimum ages for the X-ray convention detailed in Chapter Five.

In the final chapter, the major findings of the thesis are discussed and evaluated in relation to the overarching research questions posed in this introduction. By producing absolute chronometric data regarding the timings of the emergence and disappearance of the key rock art styles explored in the case studies, a revised chronology for the Early to Middle Periods is proposed. Furthermore, in the conclusion, this revised stylistic chronology is anchored to the broader regional western Arnhem Land archaeological record. This revised stylistic chronology for Early to Middle Period rock art enables a re-evaluation of interpretations for both regional archaeology and the rock art, thus consolidating our understanding of the social nature, function and cultural context of rock art production in western Arnhem Land throughout the Pleistocene–Holocene transition.

In accordance with formatting requirements of ‘Thesis by Compilation’ at the ANU, references cited within both the Introduction (Chapter One) and the Conclusion (Chapter Eight) are consolidated into a single reference list at the end of the thesis. All references cited in the chapters and appendices are also listed at the end of each individual chapter/article. In addition, signed authorship declarations detailing the contribution of each author are included at the beginning of each chapter.

# Chapter 2

**Towards multiple ontologies: Creating rock art narratives in Arnhem Land**

Authors: Tristen Jones and Daryl Wesley.

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Tristen Jones: Developed the research question. Undertook field work and recorded the data. Formulated the arguments in the manuscript. Drafted the majority of the manuscript, including introduction, site description, discussion and conclusion.

Signed: 27/3/17

**Tristen Jones**

Daryl Wesley: Assisted in field work and data recording. Drafted sections of the manuscript, including background and case study copy. Edited and reviewed the manuscript.

Signed:

27/03/2017

**Daryl Wesley**

# Towards multiple ontologies

## Creating rock art narratives in Arnhem Land

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**Abstract:** A rock art and museum collection project undertaken in Arnhem Land, Northern Territory, Australia found that there were significant collection legacy issues surrounding different archaeological documentation of rock art sites. This prompted an examination of current rock art recording practice using a Western Arnhem Land case study. This required an examination of the theoretical development and methodological practice of rock art research. Surveying of current museum theory uncovered the theoretical concept of multiple ontologies which may have specific applications for rock art studies in northern Australia.

**Keywords:** rock art, method, multiple ontologies, disciplinary theoretical legacies

> The past is conceived and written by people who are fighting for a place in society and within their own discipline. The language of 'scientific' detachment is in fact the language of a covert position. Writers' values mould the past as they reconstruct it. (Lewis-Williams 1990:134)

### Introduction

In 2014 a rock art and collections research project was undertaken by both authors as part of the Museum and Art Gallery of the Northern Territory's (MAGNT) George Chaloupka Fellowship in collaboration with the Traditional Owners of the Manilakarr and Mirarr Erre Clan Estates. The project revisited the George Chaloupka Rock Art Collection at MAGNT and located all records within the Manilakarr and Mirarr Erre Clan Estates. It sought to develop the museum's existing collection through revisitation of sites and updating of cultural heritage site data; through re-recording to contemporary standards the rock art and archaeological features, and by including site oral histories, and updated traditional ownership and cultural restrictions on the cultural heritage site information.

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During the recording of cultural heritage sites our inability to adequately reconstruct the cultural landscape of a place from current data capture practices and through data integration from legacy data sets, motivated us to evaluate critically recording methodologies. This spawned a critical reflective evaluation of the methods currently employed in rock art research, and in turn generated an analytical assessment of both the historical trajectory and varying epistemological legacies underpinning the discipline, and Australian archaeology more generally. The theoretical foundations of both archaeology and rock art studies are built upon more than one hundred years of multidisciplinary knowledge borrowing, from the biological, geological and ecological sciences to art theory and anthropology. In this paper we reflect on how the theoretical legacies of these disciplines, combined with wider social and historical movements of colonialism and post-colonialism have created an antithetical theoretical and practical context for researching rock art, particularly Indigenous Australian rock art research in collaboration with Traditional Owners.

Archaeological and museum practice operate within a similar postcolonial environment, with both disciplines sharing comparable theoretical and historical legacies. How contemporary museum practice has sought to navigate and rectify these shared theoretical and methodological concerns has generated diverse post-modernist understandings of culture, resulting in an epistemology of multiple ontologies. This c oncept p ractically a ctioned utilising digital technologies allows for the integration of many diverse knowledges into the museum catalogue. Here we consider the concept of multiple ontologies and suggest that actioning this theory in rock art research may provide an opportunity for rock art researchers to decolonise our practice and generate legacy data sets that value indigenous world views, ultimately building integrated archaeological narratives.

## From colonial encounters to rock art science in Arnhem Land

Early descriptions and commentary of Indigenous rock art and contemporary art production in the historical literature tell us much about the attitudes of the explorers, early settlers and antiquarians who were the first to record it. Aboriginal art was classified within a primitive artistic tradition and commentary generally focused on decorative and formal elements (Jorgensen 2008:416–417; Neale 1998:212). The art of Aboriginal Australians was collected as ethnographic curiosities rather than as art *per se* (Morphy 1998:25). The classification of 'primitive' functioned within a broader social evolutionary

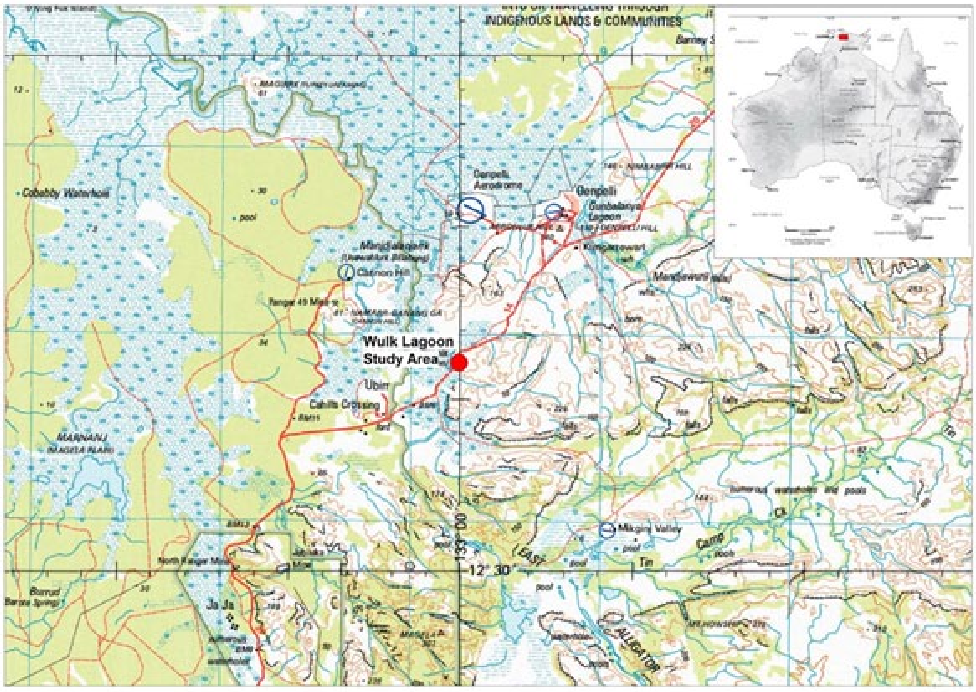



Figure 1 Regional map highlighting the study area of Wulk (Red Lily Lagoon) part of the Manilakarr Clan Estate.

epistemology typified by social Darwinism, that ascertained that hunter-gatherers were the earliest form of society which had not developed technically, economically, socially and culturally along the linear evolutionarily trajectory of which European civilisations represented the pinnacle (Morphy 1998:22). This epistemology continued to be supported by the ongoing colonial narrative of *terra nullius*, a land not peopled, which can be often overlooked when reflecting on Australian anthropological and archaeological research. This concept was the basis for effectively excluding Indigenous people by mostly forcing them to live on reserves or missions on the margins of Australian society (cf Attwood and Markus 1999; Attwood 2005a, 2014; Buchan 2001). Therefore the impact of the belief in *terra nullius* should not be underestimated on early scientific research on Australian Indigenous culture.

Notably sustained culture contact with Indigenous people in Arnhem Land was relatively late compared with other regions of Australia. British settlements repeatedly failed in the Northern Territory from 1824 to 1848 until the establishment of Palmerston (Darwin) in 1870 (cf Powell 1996). It is significant to note this time difference towards the latter period, when colonial notions regarding Indigenous peoples of Australia which were firmly grounded after almost 100 years of experience elsewhere in Australia (cf Attwood 1996; Buchan and Heath 2006; Stanner 1979). Therefore the first recordings of Indigenous rock art and contemporary art practices in Arnhem Land noted by explorers, early settlers and antiquarians were made with specific preconceived notions of Indigenous Australia. References to the abundance of Indigenous rock art in Western Arnhem Land began after people started to visit the Aboriginal Government Station of Oenpelli (Gunbalanya), established by Paddy Cahill in 1909, in the East Alligator River region (NAA A1 1927 to 1930).

Elsie Masson, one of these visitors to Paddy Cahill's settlement at Gunbalanya in 1912, encountered rock art paintings in a rock shelter along the East Alligator describing them as 'crude images in red, yellow and white clay […] the paintings seemed to be of birds and fishes, but here and there was an unmistakable alligator or human form' (Masson 1915:102–113). The tone and language used to classify the art of Indigenous Australians as unsophisticated and archaic in comparison to western art is echoed in these early descriptions, and was commonplace until later in the twentieth century. Baldwin Spencer (1914) was amongst the first visitors to western Arnhem Land to recognise the rich Indigenous culture and was the first to provide detail on the rich and diverse nature of the rock art in the region. During his stay, he collected in excess of 200 bark paintings which were bequeathed to the Museum of Victoria in 1917. While Spencer stated that 'taking them altogether, the bark and rock drawings of the Kakadu […] tribes represent, I think, the highest artistic level amongst Australian Aboriginals' (Spencer 1914:435). He on the other hand also revealed his European prejudices when he categorised the art as being 'quaint but often very realistic drawings of the animals on which they feed, all crudely drawn in red and yellow ochre, white pipe-clay and charcoal mixed with grease' (Spencer 1914:31).

The epistemological lens by which Aboriginal artistic practice, both contemporary and prehistoric, was viewed began to change following the Second World War. The 1948 American Australian scientific expedition into Arnhem Land (AASEAL) heralded the true beginning of anthropological and archaeological interest in Western Arnhem Land. Anthropologists Ronald and Catherine Berndt, Charles Mountford and Fred McCarthy were the first to widely report and publicise the wealth and complexity of Arnhem Land rock art and contemporary artistic traditions to the Australian public (Berndt and Berndt 1954; Mountford 1939, 1950, 1956, 1964, 1965, 1975; McCarthy 1965). Mountford (1964:12) went to great lengths to describe rock art from Western Arnhem

Land as the most colourful in Australia and containing the only known examples of x-ray rock art in the world. Clarke and Frederick (2011:136) state that the 1948 AASEAL expedition brought about the scientific understanding of rock art in Arnhem Land and the resultant publications were a reflection of an emergent Australian discipline. Indeed the 1960s represented a coming of age for the disciplines of Australian history and archaeology with the rejecting of nationalist narratives, changing the way in which Aboriginal culture was viewed within the suite of world history (Attwood 2005a, 2005b; Barnard 2000; Mulvaney 1969; 1996; Mulvaney & Ambrose 1972). The motivations behind the recordings and publications of Aboriginal art and culture were complex which included Indigenous self-determination, land rights and academic inquiry (Hinkson 2008; Layton 1992; Morphy 1998; Trigger 1997).

Brandl's (1968, 1970, 1973) detailed research recognised that there may be significant antiquity in Arnhem Land rock art. He also demonstrated the many different artistic art traditions within Aboriginal art. Another early rock art researcher George Chaloupka attempted to link the development of rock art to the archaeology of the region utilising multidisciplinary lines of evidence. He was the first to develop a theory of changing depictions considering 'the climatological, geomorphological, archaeological and historical data, along with the zoological and botanical evidence […] styles were then divided into art periods and phases, and positioned between time indices indicated by the study' (Chaloupka 1993:88). Lewis (1988) through his long association with Eric Brandl and background in geology also drew on a similar multidisciplinary approach with anthropology, geosciences and archaeology. The inclusion of rock art into the Australian National University's archaeological research programme in conjunction with the then Australian National Parks and Wildlife Service (ANPWS) is one of the earlier examples in Australia where rock art was considered as part of the wider archaeological data set and integral to the archaeological interpretations of past Indigenous occupation of Arnhem Land (Jones 1985). The adoption of external scientific data sets, signalled a paradigm shift in the methods employed to investigate rock art alongside the cultural and symbolic values relating to Indigenous art as discussed by Berndt and Berndt (1996).

Rock art research as a discipline in Australia increasingly focused on chronology (cf Berndt & Berndt 1996:413–420). Therefore the development of stylistic art sequences, some of which were modelled on Harris matrices and heavily relying on regional environmental, climate and technological change, was significant towards achieving relative chronological sequences (Chippindale & Taçon 1998; Chippindale et al 2000; Chaloupka 1985, 1993; Lewis 1988). The inclusion of environmental, climate, and interpretations of technological change, inadvertently shifted the analysis of rock art into a soft form of environmental and technological determinism. Choices of the artists' subject matter in the rock art were inferred to be determined by the environmental conditions of the time (Chaloupka 1993). The depiction of human interactions, weaponry and technologies in relation to social and cultural pressures are also assumed to be responses to environmental and climate change (Chaloupka 1993; Taçon & Chippindale 1994; Lewis 1988). These ecologically focused paradigms were deemed highly appropriate for the study of past Indigenous hunter-gatherer societies in Australia owing to the perceived unqualified dependence on environmental and climatic factors. This interpretative framework is embedded in cultural ecology theory. The theory of cultural ecology has had a significant impact on advancing all forms of Australian archaeological research more generally, not just rock art. The theme of socio-cultural and technological change as dependent and driven by environmental and climatic risk has become a major Australian archaeological model for analysing technological change in stone artefact assemblages (Attenbrow et al 2009; Hiscock 1994, 1996, 2002, 2006; Veth et al 2005, 2011; Williams et al 2010). This environmental and climatic risk response framework has also been criticised for its lack of inclusion of socio-cultural explanations for change (Kuhn 2011; McNiven 2011; White 2011).

Indeed the widespread adoption of cultural ecology, and more broadly environmental data sets from the 'hard sciences', into archaeological interpretations arose from the establishment of the 'new archaeology', more commonly known as Processualism. Since the Processualist movement of the 1960s, systematic approaches to data collection has become the most used methodology when investigating a research area in archaeology (Redman 1974, 1987; Plog et al 1978; Foley 1981; Thomas 1973, 1989; Schiffer et al 1978). Rock art researchers took note of these theoretical discussions about archaeological data acquisition and hypothesis testing within this scientific philosophical framework reconsidering how rock art studies was to be progressed (Morwood & Smith 1994), with some archaeologists even questioning the appropriateness of rock art as an archaeological data set (Hampson 2015; Schaafsma 1985). An unforeseen circumstance from the introduction of the scientific method into archaeological theory was that it placed the use of ethnography in an uncomfortable space within archaeology practice (Gorecki 1985; Jones 1978; Meehan 1982; Meehan & Jones 1988; Wylie 1985). The result of these theoretical debates has created a fundamental epistemological dichotomy between the use of ethnographic research and scientific inquiry in rock art studies, a fact that is acknowledged by contemporary rock art practitioners (McDonald 2013; Porr & Bell 2012; Porr 2015).

Yet, despite the disciplinary cautions in adopting ethno-archaeological approaches, the inclusion of Indigenous collaborators working with rock art researchers has continued to provide invaluable insight in understanding the meaning of rock art and the role of contemporary art in Aboriginal culture in western Arnhem Land (cf Brandl 1973; Chaloupka 1993; Taçon 1989). Chaloupka (1993), Brandl (1973) and Taçon (1989) worked with Indigenous collaborators who provided significant information about a range of issues including social systems and meanings encoded in rock art, animal species and material culture. The definition of the Yam Figure Style arose specifically from interpretations by Indigenous informants from the 1970s (Chaloupka 1993:138–139). The Yam Figure Style, including Rainbow Serpent imagery, is estimated to be up to 8000 years old (Chaloupka 1993:139; Taçon et al 1996). For many years the x-ray style of rock art had been interpreted by Europeans as simply a depiction of internal features of economic important animal species. In his study underpinned by anthropological inquiry, Taçon (1989) explained that the complex relationship between people and x-ray paintings of fish in the region was not simply a reflection of 'fishing', but also revealed a complex relationship of totemic and spiritual symbolism communicated through stylistic patterns. Recently, the use of ethnography has seen a resurgence with greater incorporation into rock art studies (cf Brady & Bradley 2014; Cole 2011; David 2002; Flood & David 1994; Mulvaney 2009). While scientific principles of inquiry and data production have flourished in rock art research, ethnography as an investigative tool in rock art research has persisted, and has commonly been mobilised as lines of evidence in post-processualist archaeological research (cf David et al 2006; Lourandos 1997).

However, it should be noted that any contemporary study that would attempt to use ethnographic analogy for the interpretation of rock art beyond 1500 years would do so within an environment of heightened criticism from the wider discipline of Australian archaeology given certain views on the construction of Indigenous belief systems (Hiscock & Faulkner 2006; Hiscock 2008; Swain 1993). Indeed, it can be argued that Australian rock art research remains firmly grounded within a processualist epistemology. This is evidenced in two ways. Firstly, emerging technologies have allowed for the proliferation of rock art science to answer specific research questions regarding rock art assemblages (Huntley 2012; Huntley et al 2011, 2014; Roberts et al 2015; Scadding et al 2015; Wesley et al 2014). Secondly and most importantly, the method by which rock art research is undertaken and the method employed by researchers to capture rock art data continues to be constructed along scientific principles of enquiry. These methods tend to privilege scientific data sets over others ie ethnographic and anthropological data sets (Hampson 2015). The following case study illuminates these issues and in some cases the inadequacies, by focussing on current methodological practice determining data production in contemporary rock art research.

### *The Njanjma narrative*

Jacob Na-kodjok Nayingull 1982 (McKenzie 1980)

> Behind that dark figure in the middle almost is a catfish and you can find these catfish in this little pool over here…
>
> These long things were sticks or rails that one of our story say that this man was alive a long time ago, he was a human being, and he got all these sticks together and then across he tied those rails together with stringybark…
>
> But the water was almost up to the rock and past the tree, that's how the water was before he got down, and he used this raft but going round and round in the water and his wife was also with him…
>
> So right in the middle of the water, right in the middle of it, there's a rock sitting underneath…
>
> A long time ago and the lady that was with this man she's, her painting was put on one of the wall there, a camping spot, it's not a dreaming it's just a story of a woman…
>
> And this picture here represents there's a lot of catfish that you can find there, it's not dangerous, it's djang, we would say in Kunwinjku they say djang and it's a Dreamtime story…
>
> It's just a hunting area that my father told me about, and I told that to my kid, and every time they like it over and over and so I just repeat it again, and as I said it's not dangerous, it's just been painted there just to tell me or all others who are before me and I'm passing this story to my children.

Alfred Nayingull 2014

> Birriwilk was getting sick, she couldn't move and she wanted something to eat, and so Njanjma had a plan, he made a guluyambi, he made a little raft. And both of them came to this billabong, here looking for lilies, whatever they could find to eat but I don't know what happened to them there but they got drowned, both of them and they became djang…
>
> So now they're at the other side and that where they are now but the raft itself the guluyambi it's in the billabong, you can always see it like when it's dry up, see the guluyambi there…
>
> That's Birriwilk, Birriwilk roughly she came over that way western side, she came travelling and she got to Ubir, and past Ubir, and she sat down at the East Alligator River feeling herself no good, like she was sick maybe, and suddenly she came all the

> way travelling slowly until she meets Njanjma, she met Njanjma here and that's her husband Njanjma. And Birriwilk were getting sicker and sicker here and Njanjma had to do something to feed her, so Njanjma had to make a little raft…
>
> And so they made a raft and they wanted to come and collect lilies and maybe fish, something to eat. While they were collecting lilies and fish and all that something stopped them there, and suddenly right in the middle of this billabong there's a rock that's where they got sunk. And they went back this way to Birriwilk, came as a djang. So their spirit went this way and that where Birriwilk now…
>
> I don't normally show them to visitors but my Dad told me that we want to look after her, we always go and visit her talk to her sometimes when we got vehicles, but people use to camp there as well, now they are back where that cave is Birriwilk and Njanjma.

Wulk (Red Lily Lagoon) and the nearby Mikinj Valley areas have been frequently visited by researchers with intermittent recordings of rock art and Indigenous material culture undertaken by European academics from the nineteenth century to present day (see above discussion) (Figure 2). Most relevant to this research project was that the Manilakarr Traditional Owners recalled that Chaloupka had spent time on their country, however the places that he had visited had been lost in the historical memory of the group. Throughout his career, Chaloupka recorded approximately 1400 archaeological sites throughout Western Arnhem Land, including sites from Wulk and the Mikinj Valley. These sites were known generally through photographic reference to Inagurdurwil (RLL032 and MN012) and Mikinj locations in his landmark publication *Journey in time* (1993) (Figure 2).

MAGNT sites record revealed that there are 15 cultural heritage sites previously documented within the Manilakarr and Mirarr Erre Clan Estates. The detail of data captured in the MAGNT site records was highly variable, some only with a site reference and note book description. Other sites had a complete cultural heritage site card. Recorded data in the site cards included the following: site name / number; geographic location; land ownership and land status; and site description. Rock art specific data included: range of technique; style; motifs and distribution and comments for preservation. The card also included sections for descriptions of other archaeological material, such as surface artefact concentrations and other general information.

Njanjma was assigned a site catalogue number of 55730049. The MAGNT site record for the Njanjma site did not include a site card but rather was a description in a notebook stating the following: 'bright red hatched on a white wall, abstract design superimposed over red catfish' with a single photograph attached (Figure 3).

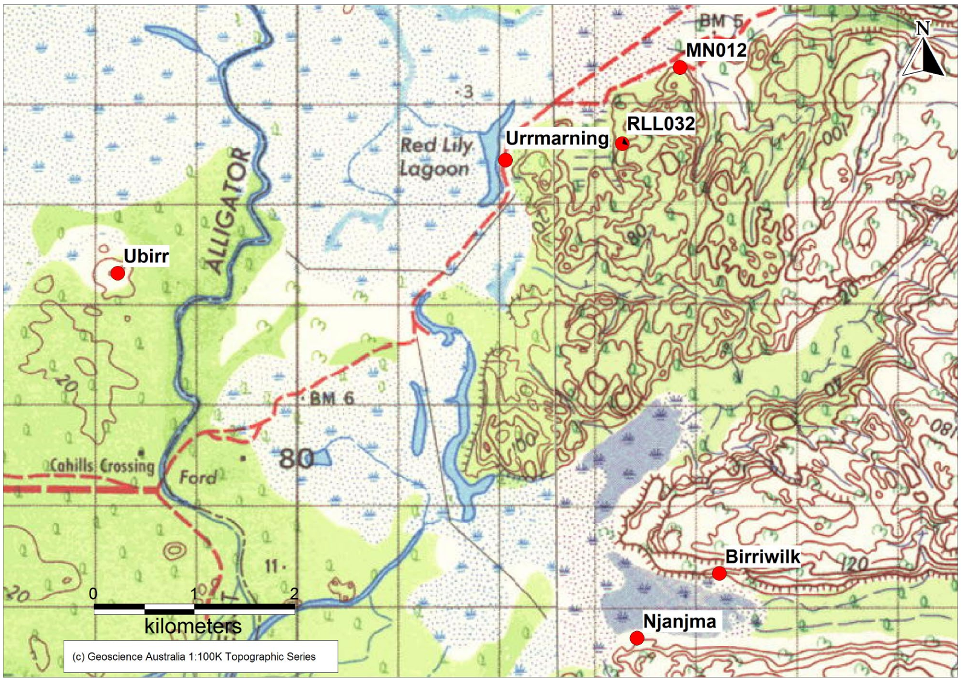



Figure 2  Map of a portion of the Manilakarr-Erre Estate showing interrelated major cultural, archaeological and rock art site locations

Figure 3  Original photographic slide taken in February 1975 by George Chaloupka (Courtesy of MAGNT)

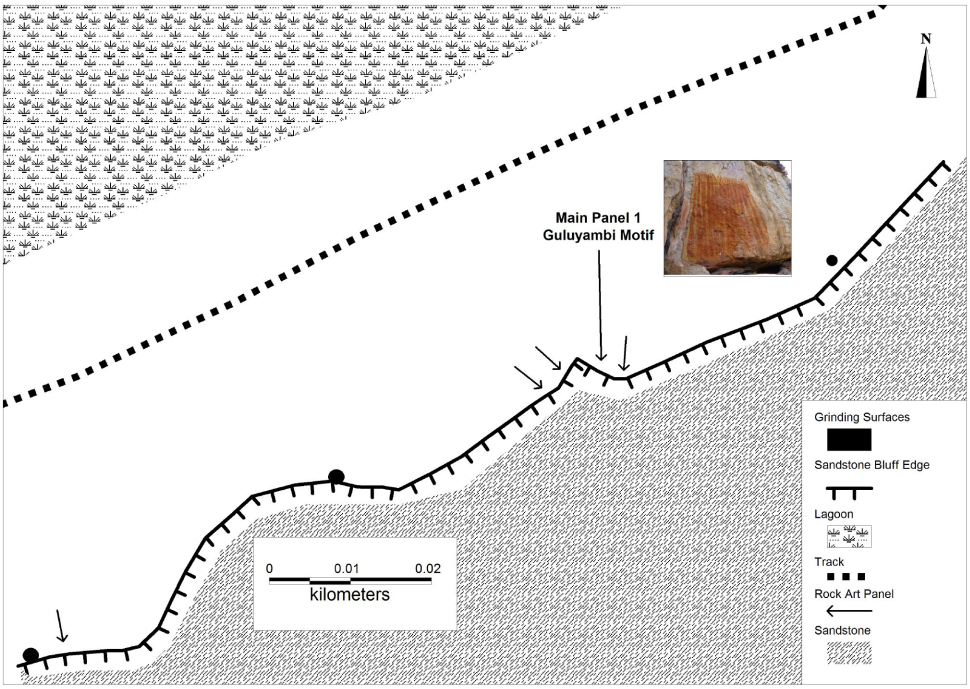



Figure 4 Map illustrating the context of the Njanjma rock art site

Figure 5 Rock art images of a catfish (underneath) and the Guluyambi raft at the Njanjma site 2014

At the time that the Njanjma site was recorded by Chaloupka in 1975, rock art research theory, methods and techniques were still being developed as a modern archaeological discipline within Australia. Due to the limited number of rock art motifs present at the site, the short description and photograph met the standard for recording requirements of a preliminary rock art survey. Yet there was no inclusion of the Indigenous interpretations of the site, no information detailing the *djang* (as evidenced from the transcripts above), or indeed the Indigenous site use or occupation. The lack of ethnographic information in the site data does not mean that the Indigenous narratives about this place were not known by the recorder and author in 1975 when the Njanjma site was recorded. Indeed George Chaloupka was known for his detailed ethnographic accounts and the integrations of Indigenous interpretations of rock art (Chaloupka 1993). However what is important to note here is that the data generated for this place, the legacy of the recording, contains no information of the interpretation of the rock art content, no recording of the Traditional Owners' interpretation or description of the rock art and information about place. Furthermore, no interpretation to the meaning of the rock art was attempted at the time by the recorder. Subsequently the sacred and cultural landscape of which the Njanjma site is integral remained completely unaccounted in the MAGNT records.

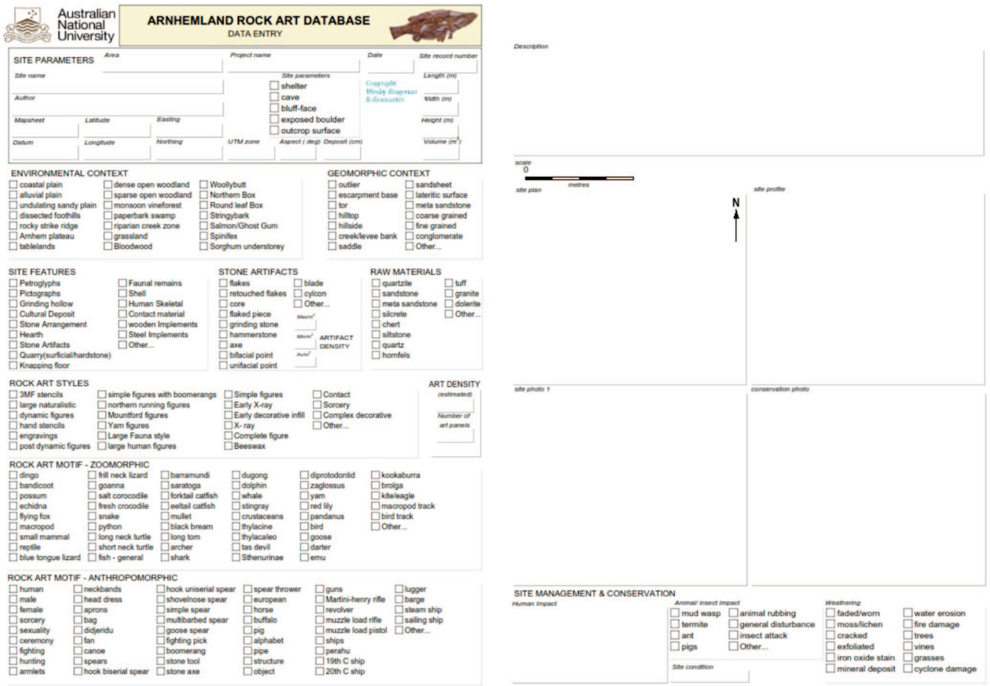
Research into external collections and literature undertaken by the authors uncovered the *djang* of which Njanjma is a part and the rock art site's relationship within a sacred and cultural landscape. This cultural landscape had been recorded by anthropologists Ronald and Catherine Berndt in 1950. The Berndt's recorded two stories for this country on the rock paintings of Birriwilk which concur with the later narratives given by Manilakarr Traditional Owners (Berndt & Berndt 1989:57–64). Birriwilk and Njanjma were later recorded amongst a number of places during an Australian Institute of Aboriginal and Torres Strait Islander Studies (AIATSIS) funded rock art and sites of cultural significance survey conducted by Gunn (1992:24–27) with senior Manilakarr elder, Jacob Na-kodjok Nayingull. Gunn also conducted typical anthropo-logical ethnographic research to document the cultural traditions associated with the places including the Njanjma and Birriwilk sites. His assessment of archaeological significance and recording of interpretations did draw on the traditional narratives described in association with the rock art. Gunn infers that the Njanjma raft and story (1992:26) may be connected with the creation of the freshwater swamp phase some 1500 years ago in the Alligator Rivers region (Hope et al 1985). Based on this scientific environmental data, Gunn (1992:26) concludes that the 'raft image and hence possibly also the Birriwilk -Njanjma myth is at most in the order of 1000 years old'.

Recently, investigations at the Birriwilk site were undertaken as part of a larger archaeological project by Shine et al (2013). The report includes detailed ethnographic narratives from Manilakarr Traditional Owners and reviews the previous documentation of the Birriwilk-Njanjma story. Shine et al (2013:76) concluded that the Birriwilk site was intensively occupied after 750 BP with the faunal assemblage demonstrating a focus by the Indigenous inhabitants on the nearby freshwater environment. Importantly, Shine et al (2013:76) surmise that this archaeological connection to the freshwater environment corresponds with the Birriwilk *djang* and associated cultural narratives and suggests that much of the rock art production at the site is dated to between 750 BP to 200 BP.

Njanjma was visited again in 2014 by the authors with Manilakarr Traditional Owners to conduct a formal recording of the rock art site. The entire site consists of six panels of rock art found along 70 metres of the vertical sandstone outcrop (Figure 4). The main panel (240 cm x 240 cm) consists of the Guluyambi raft painting connected to the Njanjma dreaming (Figure 5). This large painting consists of red outline with yellow solid infill and red solid infill to depict the raft logs. Under the main Guluyambi raft painting are approximately eight other motifs. These motifs consist of catfish, barramundi and an anthropomorphic figure with a possible spear or object. The site has a number of vertical panels with limited overhang protecting the motifs.

The site recording in 2014 utilised contemporary archaeological research recording forms capturing data relating to the location, count, content and techniques used in the rock art imagery. This methodology sought to document data on the material culture (in this case rock art) by which variables can be tested for abundance, diversity and distribution (Figure 6). While scientific principles of investigation assert that theory and method are discrete and independent variables, scientific epistemology has significantly determined the scale and type of features of rock art that is recorded and the data that is generated via this research method. The unintended consequence of utilising the site record is that it creates an environment of privileging certain data sets and knowledge over others, in this case Indigenous worldviews. The recording of ethnographic information is classed as an additional investigative technique. Therefore, Indigenous interpretations of rock art are not always integrated into the core of the site record and data set which will impact on all future archaeological inferences (Figure 7). The Indigenous point of view can be marginalised via this process even though they are generally participating in contemporary rock art surveys.

The tradition of rock painting in Arnhem Land is part of a wider Indigenous belief system of Dreamtime narratives and ancestral connections to country.



Australian National University

ARNHEMLAND ROCK ART DATABASE
DATA ENTRY

SITE PARAMETERS
Area | Project name | Date | Site record number
Site name
Site parameters: ☐ shelter ☐ cave ☐ bluff-face ☐ exposed boulder ☐ outcrop surface
Copyright Wesley Brugman & Associates
Length (m) | Width (m) | Height (m) | Volume (m³)
Author
Mapsheet | Latitude | Easting
Datum | Longitude | Northing | UTM zone | Aspect ( deg) | Deposit (cm)

Description

scale 0 metres
site plan N
site profile

ENVIRONMENTAL CONTEXT
☐ coastal plain ☐ alluvial plain ☐ undulating sandy plain ☐ dissected foothills ☐ rocky strike ridge ☐ Arnhem plateau ☐ tablelands
☐ dense open woodland ☐ sparse open woodland ☐ monsoon vineforest ☐ paperbark swamp ☐ riparian creek zone ☐ grassland ☐ Bloodwood
☐ Woollybutt ☐ Northern Box ☐ Round leaf Box ☐ Stringybark ☐ Salmon/Ghost Gum ☐ Spinifex ☐ Sorghum understorey

GEOMORPHIC CONTEXT
☐ outlier ☐ escarpment base ☐ tor ☐ hilltop ☐ hillside ☐ creek/levee bank ☐ saddle
☐ sandsheet ☐ lateritic surface ☐ meta sandstone ☐ coarse grained ☐ fine grained ☐ conglomerate ☐ Other...

SITE FEATURES
☐ Petroglyphs ☐ Pictographs ☐ Grinding hollow ☐ Cultural Deposit ☐ Stone Arrangement ☐ Hearth ☐ Stone Artifacts ☐ Quarry(surficial/hardstone) ☐ Knapping floor
☐ Faunal remains ☐ Shell ☐ Human Skeletal ☐ Contact material ☐ wooden Implements ☐ Steel Implements ☐ Other...

STONE ARTIFACTS
☐ flakes ☐ retouched flakes ☐ core ☐ flaked piece ☐ grinding stone ☐ hammerstone ☐ axe ☐ bifacial point ☐ unifacial point
☐ blade ☐ cylcon ☐ Other...
ARTIFACT DENSITY: Max/m² | Min/m² | Av/m²

RAW MATERIALS
☐ quartzite ☐ sandstone ☐ meta sandstone ☐ silcrete ☐ chert ☐ siltstone ☐ quartz ☐ hornfels
☐ tuff ☐ granite ☐ dolerite ☐ Other...

ROCK ART STYLES
☐ 3MF stencils ☐ large naturalistic ☐ dynamic figures ☐ hand stencils ☐ engravings ☐ post dynamic figures
☐ simple figures with boomerangs ☐ northern running figures ☐ Mountford figures ☐ Yam figures ☐ Large Fauna style ☐ large human figures
☐ Simple figures ☐ Early X-ray ☐ Early decorative infill ☐ X- ray ☐ Complete figure ☐ Beeswax
☐ Contact ☐ Sorcery ☐ Complex decorative ☐ Other...

ART DENSITY (estimated)
Number of art panels

site photo 1
conservation photo

ROCK ART MOTIF - ZOOMORPHIC
☐ dingo ☐ bandicoot ☐ possum ☐ echidna ☐ flying fox ☐ macropod ☐ small mammal ☐ reptile ☐ blue tongue lizard
☐ frill neck lizard ☐ goanna ☐ salt corocodile ☐ fresh crocodile ☐ snake ☐ python ☐ long neck turtle ☐ short neck turtle ☐ fish - general
☐ barramundi ☐ saratoga ☐ forktail catfish ☐ eeltail catfish ☐ mullet ☐ black bream ☐ long tom ☐ archer ☐ shark
☐ dugong ☐ dolphin ☐ whale ☐ stingray ☐ crustaceans ☐ thylacine ☐ thylacaleo ☐ tas devil ☐ Sthenurinae
☐ diprotodontid ☐ zaglossus ☐ yam ☐ red lily ☐ pandanus ☐ bird ☐ goose ☐ darter ☐ emu
☐ kookaburra ☐ brolga ☐ kite/eagle ☐ macropod track ☐ bird track ☐ Other...

ROCK ART MOTIF - ANTHROPOMORPHIC
☐ human ☐ male ☐ female ☐ sorcery ☐ sexuality ☐ ceremony ☐ fighting ☐ hunting ☐ armlets
☐ neckbands ☐ head dress ☐ aprons ☐ bag ☐ didjeridu ☐ fan ☐ canoe ☐ spears ☐ hook biserial spear
☐ hook uniserial spear ☐ shovelnose spear ☐ simple spear ☐ multibarbed spear ☐ goose spear ☐ fighting pick ☐ boomerang ☐ stone tool ☐ stone axe
☐ spear thrower ☐ european ☐ horse ☐ buffalo ☐ pig ☐ alphabet ☐ pipe ☐ structure ☐ object
☐ guns ☐ Martini-henry rifle ☐ revolver ☐ muzzle load rifle ☐ muzzle load pistol ☐ ships ☐ perahu ☐ 19th C ship ☐ 20th C ship
☐ lugger ☐ barge ☐ steam ship ☐ sailing ship ☐ Other...

SITE MANAGEMENT & CONSERVATION
Human Impact
Animal/ insect Impact: ☐ mud wasp ☐ termite ☐ ant ☐ pigs ☐ animal rubbing ☐ general disturbance ☐ insect attack ☐ Other...
Site condition
Weathering: ☐ faded/worn ☐ moss/lichen ☐ cracked ☐ exfoliated ☐ iron oxide stain ☐ mineral deposit ☐ water erosion ☐ fire damage ☐ trees ☐ vines ☐ grasses ☐ cyclone damage

Figure 6  Rock art site recording form used for 2011–2014 George Chaloupka Fellowship projects

Figure 7  Recording the significance according to Aboriginal tradition of the Njanjma site

Art is not painted in a social vacuum. It was painted as part of a wider Indigenous narrative. This narrative is sometimes interpreted as part historical chronical, part mythological, but nonetheless any production of art has always been conducted within a particular set of customs, ceremonies and traditions of past local Aboriginal descent groups. The ethnographic documentation of Njanjma revealed that there was continuity in Aboriginal customary practice, it was a place of significance according to Aboriginal tradition, and that it had specific connections with other landmarks in the nearby East Alligator River area. The Njanjma narrative for instance is clearly related to the existing landscape features and networks of billabongs and swamps. Shine et al*'s* (2013) excavation of Birriwilk could be used as a proxy for the formation of the nearby swamps with intensified use after 750 BP. However fauna from the excavation revealed freshwater species diversity of fish and turtle occurs from 4298–4087 cal BP indicating that significant change in the freshwater environment was occurring from the mid Holocene (Shine et al 2013:72–76). These sites and their interconnectedness, the rock art imagery, and land use and occupancy of the East Alligator River landscape is clearly evidenced in both Jacob and Alfred Nayingull's accounts that span a 40-year time difference.

All of the records that detail the Njanjma – Birriwilk *djang* are not formally attached to the MAGNT record of Site 55730049 in the MAGNT collection. The multiple layers of information recorded about Njanjma can be tracked down to at least five different government and non-government organisations with varying legislative and practical responsibilities none of them referencing or linking to the other. This is a particularly significant issue for researchers and Traditional Owners alike, where the information that is recorded about a place is stored, archived and managed in a non-disclosed place, not easily navigable particularly for Indigenous communities. Furthermore in all of the site recordings (with the exception of Gunn), the 'stories' of place, land use, occupation, customary practice, including the Njanjma – Birriwilk *djang* are not integrated with the core archaeological data.

### *Adopting the concept of multiple ontologies from museum theory: towards building rock art narratives*

Recent developments in museum theory potentially offer a theoretical and practical solution to build inclusive narratives incorporating knowledges from both the archaeologist (scientific expert) and the Indigenous knowledge holder. Like the discipline of archaeology, museums have functioned within an increased social context of heightened criticism in a postcolonial world.

The concept of museums displaying archetypal representations of culture in 'cabinets of curiosities' has been largely abandoned and replaced by the notion of the museum as public educator and as a safe house for the preservation of culture for all humankind (Barker 2010; Cuno 2009). However like archaeology, many would argue that the colonial legacy is inescapable within the museum context. Museums continue to curate, display cultures, and assert an authoritative voice through the process of embedding 'expert knowledge' through the curation, display and cataloguing of objects. In the case of first nation peoples whose culture remains a continuing living entity, the core nature of the museum is seemingly eternally bounded to its colonial past.

So how has the museum sought to unshackle itself from its historical legacy and what is the method currently employed? In the museum context practitioners see themselves as providing a social 'contact zone' (cf Clifford 1997). The museum therefore becomes 'a social space where cultures meet, clash, and grapple with each other, often in contexts of highly asymmetrical relations of power, such as colonialism, slavery, or their aftermaths as they are lived out in many parts of the world today' (Pratt 1991:34). It can more simply be defined as, 'a permeable space to transcultural encounter' (Mason 2006:25). To achieve this 'contact zone' museum practitioners have explored the materiality and the agency of objects, and have sought to build the biographies of 'things' (Dudley 2010; Herle 1997; Hoskins 2006; Scott 2012). These biographies explore the relationship of entanglement between object and people, and the subjective experience of people upon things and vice versa. Therefore, the biography of an object can contain multiple facets of information, even conflicting interpretations of what an object means. Therefore objects embody multiple ontologies. Objects exist in different contexts determined by the epistemological lens of the viewer which is mutable. These interpretations are valued as more than just 'stories' in a western sense, they co-exist as reality irrespective of each other. These biographies seek to acknowledge the life history and agency of the object, and the fluidity of cultural knowledge (Herle 2000; Turnbull 2000). This not only allows for the integration of first nation peoples' world views into the way objects are curated and exhibited, but more importantly acknowledges the idiosyncratic perspective of the 'knower'.

The multiple ontological approach acknowledges the multiple layers of knowledge held by the 'knower'; knowledge determined by and transmitted through an individual's gender, personal experience, family, community and wider society. However this does not render all knowledge as relative and adopting the concept of multiple ontologies does not imply that there is no knowable truth about the world (Colwell-Chanthaphonh & Ferguson 2006).

Boast et al (2007) state that multiple ontologies are not just alternative ways of expressing the same information, but more accurately imply that this method can be described as diverse ways of knowing about the world where multiplicities are fundamental to experiencing and creating faithful representations of knowledge. The application of the multiple ontological approach creates an intellectual space to include the entangled relationships of people and objects, the intangible knowledge of the 'knower' and external processes that generate knowledge about an object. The concept of multiple ontology is equally applicable to the concept of place, and thus may be utilised in the discipline of archaeology. It is the concept which satisfies Shanks and Tilley's' radical pluralism (Shanks & Tilley 1987:245).

In a more conservative form, this epistemological standpoint was advanced in the theory of 'multivocality' in contemporary archaeology (Hodder 2003). Hodder (2003) has long argued that the combination of 'many voices' can build richer archaeological accounts of the past. Yet as aptly noted by Nakata and David (2010:431), the many Indigenous voices in the archaeological record remain as supplementary knowledge complementing the 'expert' observations of the archaeologist. The narratives of Indigenous community participants remain on the 'periphery', much like the narrative of 'Njanjma' in our case study. The marginalisation of the diverse knowledges about a place, particularly those from Indigenous world views, is enabled through current archaeological practice. The way in which these diverse 'ways of knowing' are recorded, and how this information is stored (or not stored) allows for the separation of knowledge and the privileging of one knowledge group over another. Indeed, discussion circulating in current digital museum theory is precisely how, in practical terms, museums can action the concept of multiple ontologies in the museum catalogue. As the literature rightly notes, the diversity of knowledges and complex entanglement of objects and people is commonly recorded in the workshops, podcasts, educational programs, public lectures and exhibition labels in the museum space. Yet it is the museum catalogue, much like the archaeological site record, that retains the intellectual authority and control over the representations and interpretations of culture both now and in the future. The museum, much like contemporary archaeological practice, has continued to maintain the singular 'expert' nature of curatorial knowledge through the type of information encoded into the museum catalogue and the way in which the museum catalogue is managed. This is exacerbated through the use of specialised vocabulary and characterisation of objects which functions to perpetuate and maintain control and authority (Srinivasan & Huang 2005; Srinivasan et al 2009a; Srinivasan et al 2009b; Srinivasan et al 2010).

Much like the museum catalogue, for rock art and archaeological research it is the cultural site record and rock art motif records that become the primary 'expert' knowledge about the place. The data – rock art motif inventories describing mediums, painting techniques, stylistic and content diversity, abundance and distribution – are recorded in isolation from their meaning and function within the Indigenous world that it exists. This selection by the academic of what information is archaeologically relevant and classified as data is a subjective, value-laden and selective choice. As Lewis-Williams (1990:128) aptly states 'You cannot record everything. Items become visible only through the light that is thrown on them by some theory, hypothesis or expectation'. Furthermore the language used to describe and generate information regarding the rock art is specialised nomenclature that has no meaning or relevance to the Indigenous culture in which the art exists. Smith and Jackson (2006) have explored the politics of language that has been used and continues to be used as a colonial instrument reinforcing the authority of the academy in Australia. For the traditional owners of the Njanjma – Birrwilk djang the 'data' does not consist of archaeological categories and classifications but rather is comprised of diverse knowledges that are determined by Manilakarr ontology. The rock art and *djang* functions within a complex set of relationships and customary structures comprised of spirits, people (both past and present) and place. Much like the rock art of the Yanyuwa (Brady et al 2016), rock art in the Barunga region (Smith & Jackson 2016), and the Gummingurru stone arrangements in Wakka Wakka country (Ross 2016), the rock art of Njanjma and the Njanjma – Birrwilk *djang* has agency upon Manilakarr, and they continue to actively engage with their heritage. Furthering our point is that in all three examples listed above, the 'data' presented comprises of conversations and personal reflections between community participants and researchers undertaken in unstructured personal field interactions, oral testimonies and documentaries, observable community group activities and contemporary engagement with heritage places. These diverse knowledges have illuminated and enriched the archaeological record and our understanding of the material objects subjected to study. The major issue confronting the discipline is to develop systems of how this complexity of information is captured and stored. Decisions regarding which data sets form the core site record for these objects and places need to be made in conjunction with considering the legacy these recording projects create for both the Traditional Owners of this knowledge and the academic community.

It is our methods for recording rock art and the data legacy of our research that continues to reinforce the colonial inequities on which the discipline was founded. In order to 'decolonise' archaeology the diverse knowledges of a place need to be recorded and integrated collectively. The many ways of knowing about a place, ie the combination of data from different epistemological standpoints, will form the core information that becomes attached to the objects or places. This core record constitutes the legacy data of the future, subsequently impacting on all future archaeological interpretations. The way forward in the case of our research in Western Arnhem Land, has been to build recording methods in the digital space using accessible technologies, and by facilitating the recording of places by the Njanjma Rangers. Significant literacy and numeracy barriers can be circumvented with tablets and cameras which mark pictures with GPS data and can also record oral information. This enables Indigenous participants to record rock art in their own indigenous languages, create visual records with timestamps and GPS locations of sites. Integrating this type of information alongside cultural site recording forms and legacy data in databases managed by Indigenous associations is part of the current scope of works currently being actioned by the Njanjma Rangers (and indeed neighbouring Clan groups and Indigenous associations in Western Arnhem Land). Building the capacity of the Njanjma Rangers to manage their own knowledge repositories remains the core work of the research team. A repository where the Njanjma Rangers can continually add to the record of a place allowing them to direct and engage in research questions, ultimately enabling Indigenous people to do archaeology with, for and by themselves (Nicholas 1997:85).

## Conclusion

By reflecting on how the theoretical legacies and the historical trajectory of the discipline of rock art studies have shaped the contemporary theoretical and practical context we have gained a greater understanding of the methodological limitations governing current archaeological practice. Archaeological and museum practice operate within a similar postcolonial environment, with both disciplines sharing comparable theoretical and historical legacies. Museum practice has sought to navigate and rectify these shared theoretical and methodological concerns through applying the concept of multiple ontologies. Multiple ontologies offer an opportunity for rock art researchers to action theory into their archaeological practice. It provides an avenue to

> explore ways to create an ethical and socially just practice of archaeological research – one that is in synch with and contributes to the goals, aims, hopes and curiosities of the communities whose past and heritage are under study, using methods and practices that are harmonious with their own worldviews, traditional knowledges and lifeways. (Atalay 2006:284)

It ensures that the legacy data for a place which subsequently impacts on all future archaeological interpretations is representative of all diverse knowledge sets, particularly the Indigenous customary knowledge of those who own the culture and past. It may always remain true that 'culture collecting strategies are responses to particular histories of dominance, hierarchy, resistance and mobilisation' (Clifford 1997:213). However by actioning the theory of multiple ontologies and the way in which the past is recorded, archaeological practice can be decolonised, allowing for the creation of integrated archaeological narratives.

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# Chapter 3

**Radiocarbon age constraints for a Pleistocene-Holocene transition rock art style: The Northern Running Figures of the East Alligator River region, western Arnhem Land, Australia**

Authors: Tristen Jones, Vladimir A. Levchenko, Penelope L. King, Ulrike Troitzsch, Daryl Wesley, A Alan Williams, and Alfred Nayinggul.

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Tristen Jones: Developed the research question. Undertook the field work and recorded the data. Sampled rock art for radiocarbon dating. Undertook sample analysis using scanning electron microscopy-energy dispersive spectrometry (SEM-EDS), X-ray diffraction (XRD) and Fourier Transform Infrared (FTIR) Spectroscopy. Formulated the arguments in the manuscript. Drafted the majority of the manuscript, including introduction, background, cite description, discussion and conclusion. Assisted in production of the manuscript for the following sections: mineralogical characterisation and radiocarbon method and

Signed:

**Tristen Jones**

Vladimir A. Levchenko: Sampled rock art for radiocarbon dating. Developed radiocarbon method. Calibrated radiocarbon data. Drafted manuscript section titled 'radiocarbon method and age results'. Edited the discussion.

Signed:

28/03/17

**Vladimir A. Levchenko**

Penelope L. King: Led the processing of mineralogical characterisation of rock art samples in the lab using scanning electron microscopy-energy dispersive spectrometry (SEM-EDS), X-ray diffraction (XRD) and Fourier Transform Infrared (FTIR) Spectroscopy. Interpreted scanning electron microscopy-energy dispersive spectrometry (SEM-EDS), X-ray diffraction (XRD) and Fourier Transform Infrared (FTIR) Spectroscopy data. Drafted manuscript section titled 'mineralogical characterisation of samples'.

Signed:

Penelope L. King

**Penelope L. King**

Ulrike Troitzsch: Supervised and assisted in the processing of samples using X-ray diffraction (XRD). Interpreted X-ray diffraction (XRD) data. Assisted in drafting manuscript section titled 'mineralogical characterisation of samples'.

Signed:

24/3/2017

**Ulrike Troitzsch**

Daryl Wesley: Participated in field work and data recording.
Produced figures where acknowledged.

Signed:

27/03/2017

**Daryl Wesley**

Alan A. Williams: Developed radiocarbon method. Signed:

A.A. Williams 23/3/2017

**Alan A. Williams**

Alfred Nayinggul: Senior traditional owner for Manilakarr clan estate. Signed:

Alfred Nayinggul

**Alfred Nayinggul.**

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# Radiocarbon age constraints for a Pleistocene–Holocene transition rock art style: The Northern Running Figures of the East Alligator River region, western Arnhem Land, Australia

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ABSTRACT

In this article we present nine radiocarbon age determinations producing a minimum age and a minimum age range for a regionally distinct rock art style known as the Northern Running Figures from Red Lily Lagoon, western Arnhem Land Australia. These radiocarbon determinations provide age constraints for both Pleistocene and early Holocene rock art in western Arnhem Land. The radiocarbon age determinations are produced from extracting calcium oxalate contained within mineral crusts associated with the rock art. Significantly this study employs a novel separation technique, designed to effectively isolate the oxalate compounds from the mineral crust sample using chemical pre-treatment, and demonstrates significant time offsets between radiocarbon age determinations for the calcium oxalates and other carbon inclusions contained within mineral crusts.

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## 1. Introduction

The antiquity of the rock art in western Arnhem Land is largely based on a number of relative sequences, which are constructed using the superimposition of different 'styles' of art (Brandl, 1973; Chaloupka, 1993; Chippindale and Taçon, 1998; Lewis, 1988). These relative stylistic sequences have been assigned to temporal phases based on attributes depicted in the art. These attributes can be linked to known-age past events, for example ethnographically recorded paintings and styles, environmental changes or developments in technology (c.f. Chaloupka, 1993; Lewis, 1988; Taçon et al., 1996; Haskovec and Sullivan, 1989). Art that underlies these 'known-age' art styles in the relative sequence are commonly referred to as 'Mimi' art. 'Mimi' art as defined by Traditional Owners is composed of the old red paintings, predominately of human figures, not depicted in contemporary Aboriginal artistic traditions such as X-ray and is often suggested to be the work of the spirit peoples (Brandl, 1973:166; Chaloupka, 1993:64). Thus 'Mimi' art has been proposed to be of great antiquity, yet currently only one instance of the direct dating of pigment art has culminated in an age of Pleistocene antiquity (David et al., 2013b).

The lack of chronometric ages for north Australian rock art conforms to the wider pattern of rock art dating globally (Aubert, 2012; Aubert et al., 2014; David et al., 2013a; Taçon et al., 2014). Developments in the discipline of rock art dating continue to be limited due to two main factors. Firstly, the effects of a range of taphonomic processes, such as physical and chemical weathering of the painted rock surface increases with time, and mitigates against the survival of old art. Thus early art would only be anticipated to survive in exceptional circumstances (Bednarik, 1994). Secondly, in the Australian context most rock art pigments that have been preserved into the present are made from minerals such as iron oxides and therefore contain no organic materials suitable for radiocarbon dating. Compounding this is the fact that art made with organic materials, such as beeswax and charcoal, is more likely to be impacted by natural weathering processes. The result of these factors is that while there is an abundance of rock art styles largely assumed to be of Pleistocene age in northern Australia these assumptions remain unsupported by radiocarbon dates (Langley and Taçon, 2010). Subsequently the ability of rock art research to engage with and inform on more general archaeological debates regarding social and cultural changes in Indigenous communities throughout the Pleistocene and Holocene in Australia has remained limited.

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Uncovering the cultural and social information encoded in the rock art of past peoples, and placing these changes within the broader archaeological context remains at the core of rock art research. Yet as noted above, the ability of rock art research to extract this kind of information is hampered by the lack of absolute chronometric data. Developing existing chronometric techniques, such as radiocarbon dating, and combining radiocarbon age determinations with other 'indirect' methods of temporal analysis, such as motif superimpositions, stylistic analysis, degrees of preservation, and depiction of technology in art depictions for example, allows the rock art researcher to develop more robust estimations for the antiquity of rock art. This methodology, known as 'cabling' has often been suggested as a method to overcome the paucity of chronometric data in rock art research (Chippindale and Taçon, 1998; Bednarik, 2012). The radiocarbon dating capacity of mineral crusts, commonly containing calcium oxalate minerals (whewellite $CaC_2O_4 \cdot H_2O$ and weddellite $CaC_2O_4 \cdot 2H_2O$), encasing rock surfaces has been investigated by rock art researchers for decades, particularly in Australia (Bednarik, 1979, 1980; Watchman, 1990, 1991). However, the technique is widely criticised for two reasons (Gillespie, 1997; Rosenfeld and Smith, 1997; Bednarik, 1996, 2002, 2007; Aubert, 2012; David et al., 2013a). The origin for the growth of calcium oxalate minerals on rock surfaces remains unidentified, therefore raising ambiguity over the source of carbon and its age. However, investigations spanning differing geographic regions and climatic conditions generally support the hypothesis that calcium oxalate minerals most likely originate from micro-organisms residing on rock surfaces, and are not derived from the rock substrate on which they grow (Beazley et al., 2002; Lowenstam, 1981; Watchman, 1990; Russ et al., 1996, 1999, 2000; Bjelland et al., 2002; Hess et al., 2008). The second criticism is that initially early radiocarbon age determinations produced from calcium oxalate minerals were from bulk samples of mineral crust from over the art, and were dated without any attempt to remove possible carbon contaminants within the crust (Watchman, 2000). It is well known that mineral crusts encasing rock art contain carbon through the inclusion of lichen, bacteria, fatty acids, humic acids, traces of blood, pollen, charcoal and windblown and water-borne particles of rocks and minerals (Gillespie, 1997; Watchman, 2000). Early age determinations published in the literature were produced from an unknown carbon source and therefore their relationship to the rock art encased by the mineral crust could be compromised and thus the AMS radiocarbon ages were deemed unreliable (Gillespie, 1997; Aubert, 2012).

To overcome these methodological difficulties, we employ a novel compound targeted separation technique, designed to effectively isolate the oxalate compounds from the mineral crust sample using chemical pre-treatment. This new approach aims at providing a radiocarbon age on the calcium oxalate minerals only, resolving the bulk carbon issue that has been the cause of much of the critique of the prior calcium oxalate radiocarbon dating method (Watchman, 2000; Watchman et al., 2005). Thus, we may expect the accuracy of radiocarbon age determinations from calcium oxalate minerals to greatly improve. Furthermore we have produced radiocarbon ages of the isolated non-reactive extraneous carbon contained in the mineral crust samples. As noted above the extraneous carbon is formed by incorporated contaminates such as particles of lichen, bacteria pollen, and charcoal, in addition to terrestrial and marine particles such as windblown or water-borne particles. These radiocarbon age determinations provide further evidence of the robustness of the compound specific calcium oxalate radiocarbon dating. The results also demonstrate the likely significant deviations in the age determinations of rock art images for rock art dating samples that have not utilised the calcium oxalate compound specific radiocarbon method.

The pigment art style that is the focus of this dating project is known variably as Northern Running Figures, Oenpelli Figures or Mountford Figures (Chaloupka, 1993; Haskovec, 1992; Lewis, 1988) (herein referred to as NRFs). The NRFs style is geographically limited to the East Alligator River region of western Arnhem Land, occurring only on the edge of the sandstone escarpment and the outliers surrounding the floodplains of the East Alligator River. The NRF style is assumed to have been produced in the early to mid-Holocene and has been assigned to the 'Middle Period' (c. 10,000 to 6000 years ago) in the current broad stylistic chronology usually accepted for this region (Chippindale and Taçon, 1998:107). However, due to its limited distribution the NRF style has an ambiguous relationship to the other art styles thought to pre and postdate it, as well as to art styles assumed to be of similar antiquity (Haskovec, 1992:150). This has in turn limited the capacity of rock art researchers to assess the meaning of the circumscribed distribution or '*regionality*' of the NRF art style, and the social, cultural, economic and environmental drivers that motivated the proliferation of this particular type of artistic production.

In this study we present nine radiocarbon age determinations for NRF-styled art from two archaeological sites within the Red Lily Lagoon Cultural Precinct (RLLCP). The RLLCP is located within the traditional estate of the Manilakarr clan group of the Erre language group bordering the floodplains of the East Alligator River catchment, and is approximately 5 km northeast of Cahills Crossing on the main Oenpelli Road. Results presented in this case study provide a minimum age for the NRFs style, and a minimum age range for when the NRF style was in circulation.

## 2. The Northern Running Figure style

NRF styled art predominately depicts human figures. The motifs are usually shown in exaggerated movement, and are typified by elongated s-shaped bodies with legs commonly spread wide, as if running. While female gendered motifs do exist, male gender dominates the human depictions. Males are usually illustrated with a prominent penis, muscular legs, and a headdress, though the size and decorative attributes of these features are variable. NRF styled motifs are commonly shown in groups and in complex scenes with a variety of material culture and associated motifs. Frequently NRF motifs are depicted with boomerangs, spears and potential hooked sticks or spear throwers (Haskovec, 1992:152; Lewis, 1988:36–38). In some cases armlets and pubic aprons are also illustrated. Haskovec (1992:150) rightly noted that NRF styled art was commonly depicted in association with fish, in contrast to previous interpretations (Chaloupka, 1993:133) (Fig. 1). Both the NRFs and the fish are almost always painted in a combination of pigments, though in many cases the pigment has weathered and is no longer visible to the naked eye. The loss of pigment has created gaps in the figurative images. It has been suggested that the commonality of multiple pigments in motifs in the NRF style, signals the first widespread utilisation of multiple pigments as a decorative attribute in this region (Haskovec, 1992:150).

An extensive study investigating the NRF Style was undertaken by Ivan Haskovec in the early 1990s (Haskovec, 1992). He recorded 76 sites containing 331 paintings along the lower East Alligator River. These sites are all situated on the edge of the sandstone escarpment and on the outliers surrounding the floodplains. Haskovec showed that the spatial distribution of the NRF style was limited to the west of Gunbalanya (Oenpelli), with the south west border located approximately 5 km north of Magela Creek (Fig. 2) (Haskovec, 1992:149). This area incorporates the current clan estates of Bunitj, Mandjurlangunj, Mirarr Erre, Dadjbagu, Manilakarr and Mirrarr Gundjeihmi. This limited spatial distribution of the NRF art style is also supported by Chaloupka (1993:133).

The precise placement of the NRF style within the western Arnhem Land stylistic chronology is still unresolved. However the general time frame is broadly agreed upon by rock art researchers as being early to mid-Holocene in antiquity, and occurring in the Middle or Intermediate Periods (Brandl, 1973; Chaloupka, 1993; Chippindale and Taçon, 1998; Haskovec, 1992; Lewis, 1988). As noted above the Middle or Intermediate Period is argued to span the Holocene from about 10,000 to 6000 years ago (see Table 1) (Chippindale and Taçon, 1998:107).


**Fig. 1.** A) Scene of Northern Running Figures running with multiple painting events evident. The images are typically depicted in animated movement with headdresses. B) Highlighted catfish held by NRF figure (see mid-section of image above NRF figures running along line) showing rare example of intact white pigment which is often the fugitive pigment.
Photos by Tristen Jones, image enhancement by Daryl Wesley.

George Chaloupka (1993:89) assigns the NRF to the latter pre-estuarine period, the early Holocene before 8000 years ago. He also notes that motifs painted in NRF style superimpose one another, and that many of the motifs' are differentially weathered, suggesting that the figures were painted over a considerable period of time (Chaloupka, 1993:133).

Darrell Lewis (1988: 13), unlike researchers before him, developed a chronology based on technological change in the rock art determined by the presence and absence of weaponry types. Technological change, he argued, was a robust temporal indicator, as developments in stone tool technologies and spear types had been more comprehensively investigated in the archaeological literature. Lewis (1988:105) argues that the NRF styled art belongs to what he termed the 'Hooked Stick Period' postulated to have occurred between 9000 BP and 6000 BP. However, he also recognises that the categorisation of the NRF is problematic as it shares features with both 'early' and 'late' Mimi art (Lewis, 1988:38).

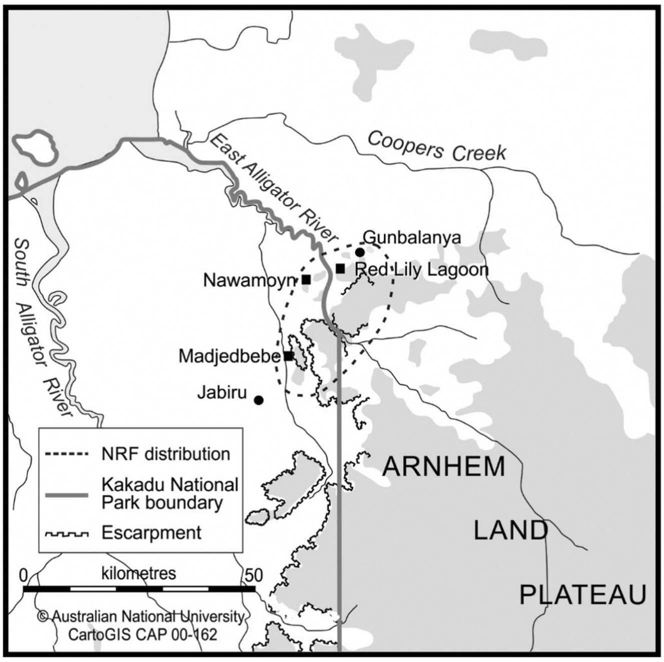


**Fig. 2.** Map of western Arnhem Land and significant archaeological sites. Area of NRF distribution highlighted.
Map by Daryl Wesley.

## 3. Red Lily Lagoon Cultural Precinct (RLLCP)

Red Lily Lagoon and nearby palaeo-channels form significant water features that parallel the north western edge of the western Arnhem Land Mamadewerre Sandstone (part of the Kombolgie Sub-Group) escarpment (Fig. 3).

The RLLCP first came to prominence for its rock art during the 1949 Anglo-American Scientific Expedition to Arnhem Land (ASSEAL) and features significantly in a number of publications by the expedition leader, Charles P. Mountford (1939, 1950, 1956, 1964, 1965, 1967, 1975). The group of sandstone outlier hills within the RLLCP was called Inagurdurwil by Mountford. Mountford was particularly attracted to the complex scenes of human figures in active poses, originally named in his honour, now referred to as NRFs and was the first person to record this art style in detail. Following the ASSEAL expedition interest in the rock art of western Arnhem Land, including the Red Lily area flourished (McCarthy, 1965; Jelínek, 1989; Lewis, 1988; Taçon, 1989; Gunn, 1992; Haskovec, 1992; Chaloupka, 1993). Despite the increase in rock art recording in the region, the RLLCP contains the most iconographic NRF scenes to have been recorded in western Arnhem Land.

### 3.1. Site RLL032 Area B

One site within the RLLCP known as Site RLL032 Area B (henceforth Red Lily 32B), was selected for detailed recording and for radiometric dating (Fig. 4). Site Red Lily 32B is located atop the plateau on the northern side of a shallow valley adjacent to the lagoon. The site is a large rock stack situated with an elevation of 50 m ASL. Erosion has generated three deep overhanging rock shelters in the south east face of the plateau (labelled Site A to C), two of which have shallow sandy floors, and isolated sandstone boulders and blocks. All shelters contain a remarkably high density of rock-art paintings (1000 + individual images) in a range of different known art styles. Art styles from Red Lily 32B span the Early, Middle and Late periods (Table 1). Types of paintings include Large Naturalistic figures, NRFs, early X-ray, and representations of the Complete Figure Style, including stick figures, simple energetic figures, full figures and recent X-ray figures. Painting methods, forms and pigment types are variable. Pigment colours present include red, orange, white, and yellow, with many complex images commonly bichromatic. Red Lily 32B contains the highest density of NRF styled art within the RLLCP with 140 individual human images recorded in active scenes, some in potentially aggressive poses, with images portrayed with a variety of weaponry and items of material culture. Red Lily 32B also contains a high density (estimated 800 +) of rock-art motifs with a high number of superimpositions. A total of eight art panels were identified

**Table 1**
Relative chronology of western Arnhem Land rock art (after Chippindale and Taçon, 1998:107).

| Age | | Nature | | Years before present |
|---|---|---|---|---|
| New | | Rare rock paintings + bark and paper paintings | | Present day |
| | | I | | About 4000–3000 up to the 1960 CE |
| | | 'Complete Figure Complex' rock paintings + some rock engravings + beeswax figures | | |
| | | I | | About 6000 |
| | | 'Simple Figures' + 'Yam Figures' + large human style + some large fauna + 'Early X-ray' rock paintings | | |
| Intermediate | 'Northern Running Figures' rock paintings | | 'Simple Figures with Boomerangs' + some large fauna rock paintings | Unknown |
| | I | | I | |
| | ? | | 'Post-dynamic Figures' rock paintings | Unknown |
| | I | | I | |
| Old | ?break | 'Dynamic Figures' rock paintings + '3MF' stencils | | ?10.000 years |
| | ?break | 'Large Naturalistic' fauna rock paintings | | Unknown |
| | | Panaramitee like rock engravings | | Unknown |
| | | Pigment in shelter deposits | | ≥30,000–50,000 |

Prints and stencils for which there is slight evidence of date are excluded except for the distinctive 3MF hand stencils which are associated with Dynamic Figures.

and selectively recorded. Individual motifs and a superimposition sequence of painted images were recorded for Panel 1 (244 individual motifs), Panel 4 (171 individual motifs), Panel 5 (148 individual motifs), and Panel 6 (67 individual motifs).

Art Panels 1 and 6 were identified for sampling because of the presence of mineral crusts assumed to contain calcium oxalate and therefore potential radiocarbon age determinations for NRF styled art. Panel 6 occurs on a sandstone block that has been dislodged from the original rock stack and is now situated on the shelter floor, towards the entrance of the site (Fig. 4). It measures 178 cm × 110 cm and contains 67 individual NRF motifs in a complex scene depicting two distinct and opposing groups running towards each other in an aggressive manner. In some cases NRFs are depicted with single shafted multi-barbed spears, while some spears are in flight directed at opposing human figures.

The presence of a white mineral coating encasing most of the rock surface of Panel 6 was identified and selected for sampling (Figs. 4, 6). A transect was established from the top face of the block to the bottom, with a total of five samples being removed. Samples RLL032-B-S1, RLL032-B-S2 and RLL032-B-S3 were collected from the lower section of the transect and all overlay NRF styled motifs (motif numbers 14, 24, 22 respectively). Samples RLL032-B-S4 and RLL032-B-S2011 do not overlay art and were selected to produce a transect of ages from

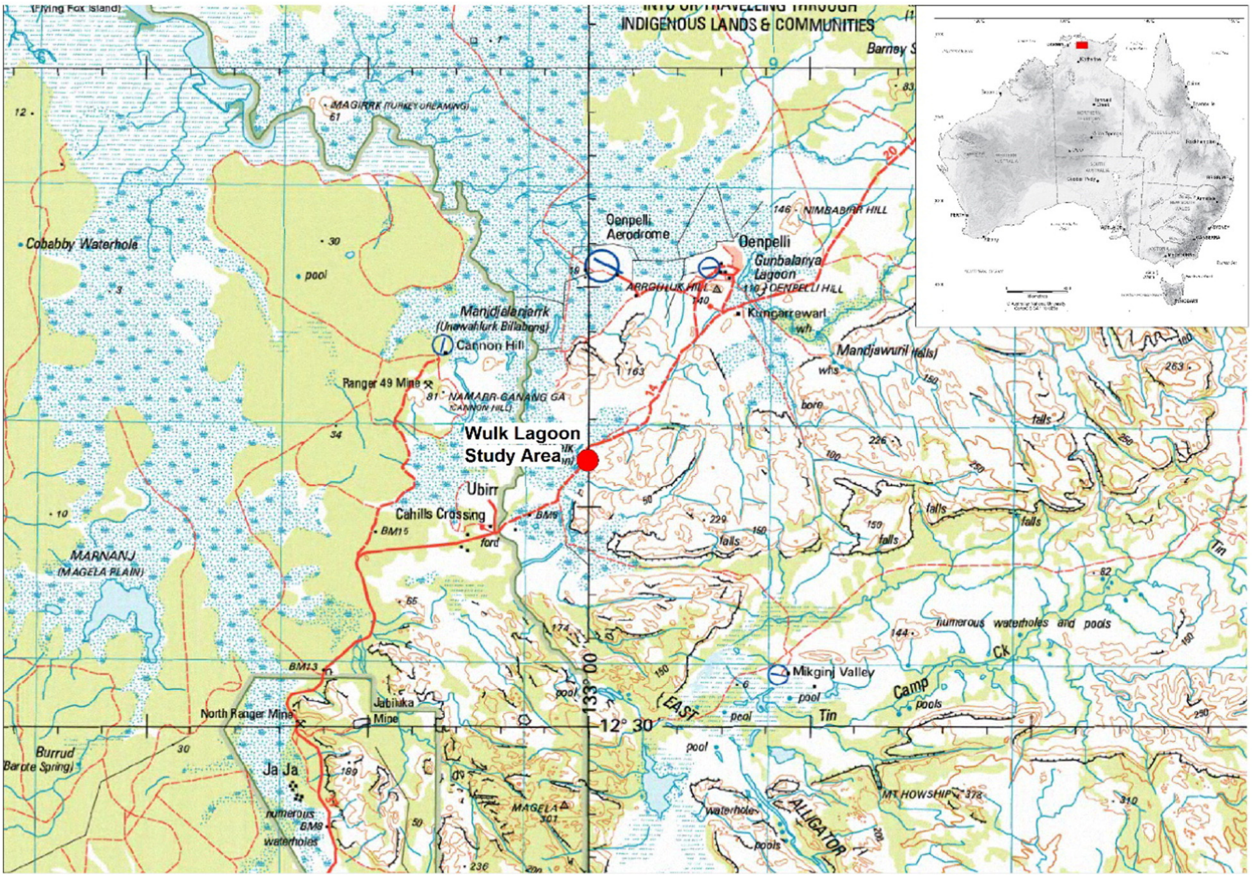


**Fig. 3.** Map of the study area, Red Lily Lagoon Cultural Precinct (RLLCP), western Arnhem Land, Northern Territory. Map by Daryl Wesley.

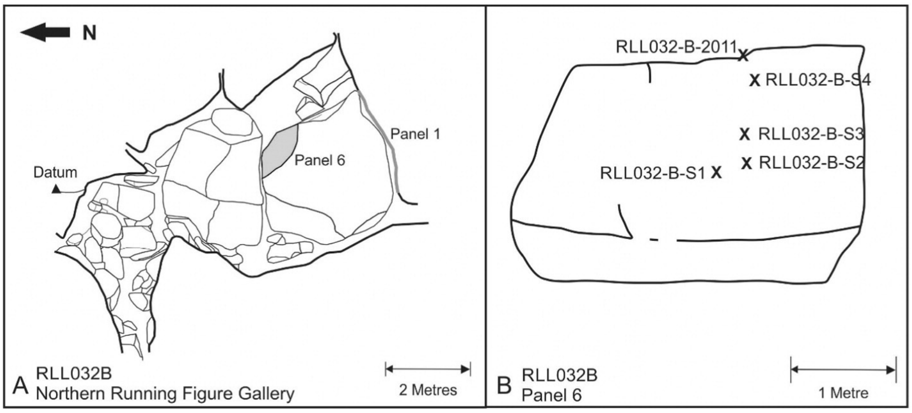


**Fig. 4.** Site plan of RLL032 depicting panel locations of radiocarbon age determinations.
Site plan by Katherine Seikel and Daryl Wesley.

the top to bottom of the rock face. Sample RLL032-B-S2011 was removed by applying pressure with a sterile surgical scalpel to an existing spalling feature, generating successful flake removal. Samples RLL032-B-S1, RLL032-B-S2, RLL032-B-S3 and RLL032-B-S4 were removed using a diamond disk Dremel® drill, producing bulk crust removal in powdered form. Powder was captured in individual sheets of aluminium foil, and emptied into clean centrifuge tubes.

Panel 1 is located on the back horizontal facing wall of the rock shelter (Fig. 4). Its surface was exposed when the sandstone block (containing Panel 5 and Panel 6) dislodged from the rock stack fell onto the shelter floor, thereby creating an alcove, which is only accessible by climbing over the sandstone block. Panel 1 has 244 individual motifs, most of which are only partial or obscured images due to the frequency of repainting. Two samples were collected from a single mineral crust associated with two NRF figures (Fig. 5). Sample RLL032-B-P1-S1 was removed from Motif #24, from the lower leg of a NRF figure. The pigment is painted on top of the mineral crust. Sample RLL032-B-P2-S2 was removed from Motif #23, from the mid leg of a NRF figure. The pigment is underneath the mineral crust. Samples were collected by applying pressure and percussion with a sterile geo pick and hammer and captured in individual sheets of aluminium foil, and emptied into clean centrifuge tubes.

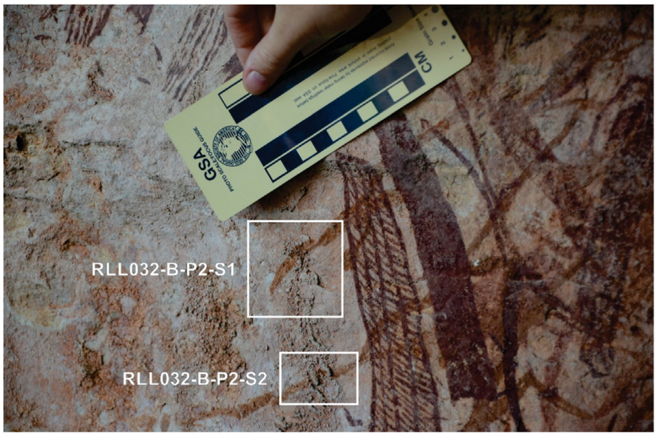


**Fig. 5.** Panel 1, Motif 23 (Sample RLL032-B-P2-S2) and Motif 24 (Sample RLL032-BP2-S1) both images sampled for radiocarbon dating. Image clearly depicts mineral crust over pigment (Motif 23) and under pigment (Motif 24).
Photograph by Tristen Jones.

### *3.2. Site RLL003 Area A*

Another site within the RLLCP known as Site RLL003 Area A (henceforth Red Lily 3), was selected for detailed recording and for radiometric dating. Red Lily 3 is situated on top of the plateau. It lies at an approximate elevation of 70 m ASL, 700 m west of the lagoon. The site is a large sandstone rock stack. On all sides of the rock stack, intensive weathering has generated the presence of deep overhanging shelters, typified by rock floors, some with shallow sandy deposits, and isolated sandstone boulders. Red Lily Site 3 rock shelter complex contains over 700 images in a range of different art styles. Art styles span the Early, Middle and Late periods (Table 1). Types of painting styles include: hand and foot stencils, Large Naturalistic figures, NRFs, early X-ray, and representations of the Complete Figure Style, including stick figures, simple energetic figures, full figures and recent X-ray figures. There is also European contact-period imagery. Painting methods, forms and pigment types are variable. Pigment colours include red, orange, black, white, and yellow, with many complex images commonly bichromatic or polychromatic. Notable are four recent images that are painted in Reckitt's Blue pigment.[1]

A mineral crust assumed to contain calcium oxalate and overlaying a group of four NFR figures located on the shelter roof of Red Lily 3 A was identified and sampled for radiocarbon dating. Three samples were collected in this location (samples RLL3-1-1 (OZR987U1), RLL3-1-2 (OZR988), RLL3-1-3 (OZR989)). Sample RLL3-1-1 was taken from a crust underlying a NRF figure. The remaining samples (RLL3-1-2 and RLL3-1-3) were taken from mineral crusts overlying the NRF figures (Fig. 7). Samples were removed using a diamond disk Dremel® drill, producing bulk crust removal in powdered form as described before.

Once removed from the field, all samples from sites Red Lily 32B and Red Lily 3 were taken to ANSTO research laboratories, registered and weighed. Aliquots taken from samples expected to contain calcium oxalate were sent to the ANU's Research School of Earth Sciences (RSES) laboratories for mineralogical characterisation. Samples RLL032B-P1-S1 and RLL032-B-P2-S2 collected from RLL32B Panel 1 were too small for mineralogical characterisation as the entire sample was used for radiocarbon age determinations.

[1] Reckitt's Blue is the commercial name given to a laundry product used to whiten clothing (Chaloupka, 1993:84). The use of Reckitt's Blue as a paint was first reported in the Alligator Rivers region in 1912 by Baldwin Spencer (1928: 831). Chaloupka (1993:84) suggests that the blue pigment finds widespread use after the introduction of Reckitts Blue by Oenpelli missionaries in 1925.

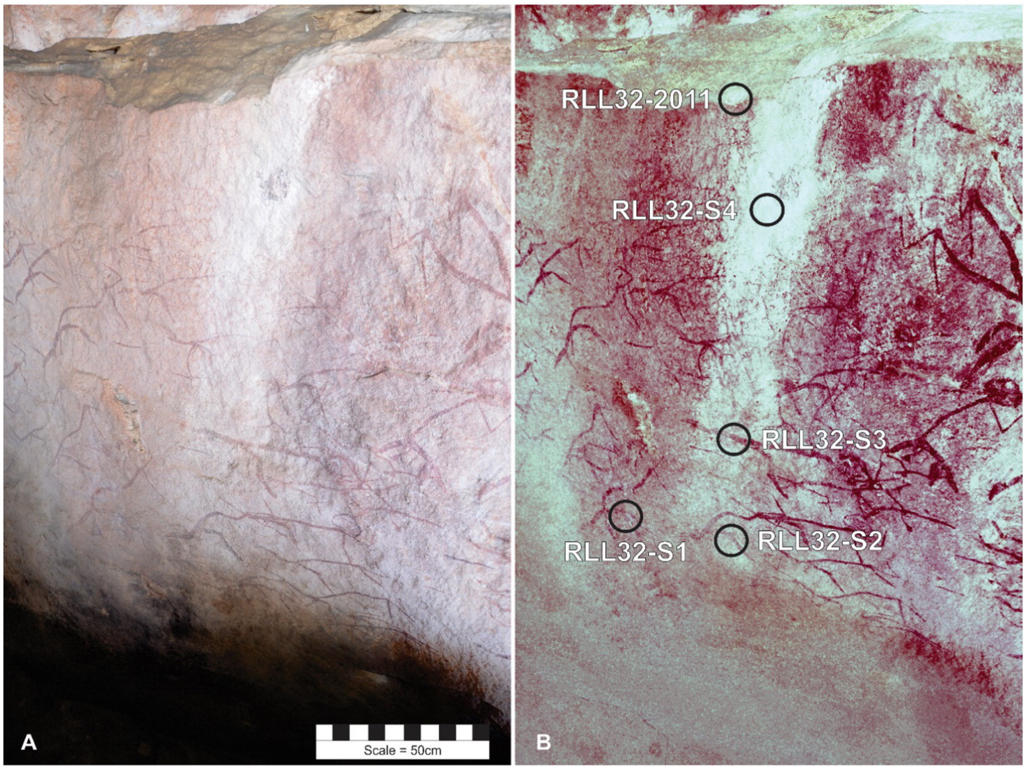


**Fig. 6.** Panel 6 depicting scene of two distinct groups NRF figures assumed to be engaged in some conflict. Note the white mineral coating descending down the rock face. Samples for radiocarbon dating highlighted.
Photograph by Tristen Jones, image enhancement by Daryl Wesley.

## 4. Mineralogical characterisation of samples

Samples of the mineral crusts were analysed by multiple techniques including, scanning electron microscopy – energy dispersive spectrometry (SEM-EDS), X-ray diffraction (XRD) and Fourier Transform Infrared (FTIR) Spectroscopy. Our results confirm that calcium oxalate is common in conjunction with minor phosphates and sulfate phases (crandallite, goyazite, tinsleyite, taranakite and gypsum) and crosscutting the sandstone and natural weathering products such as amorphous materials, quartz and illite/muscovite (Fig. 8).

Further details of both the data and methods for the mineral characterisation are presented in King et al. (submitted).

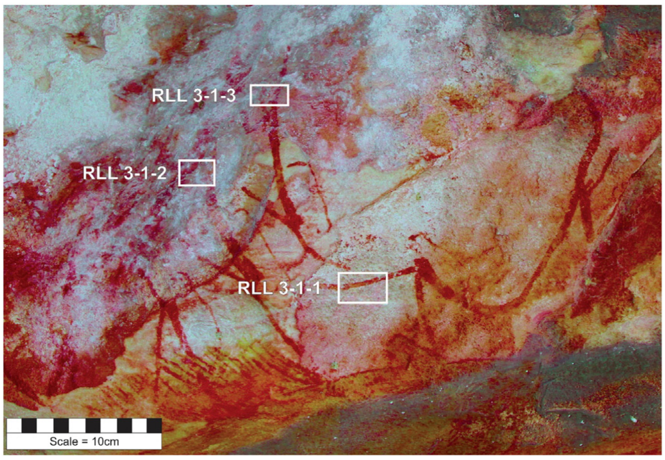


**Fig. 7.** RLL003 Area A depicting four NRF Figures on ceiling of shelter with locations of radiocarbon dating samples highlighted.
Photograph by Rose Whitau, image enhancement by Daryl Wesley.

## 5. Radiocarbon method and age results

All samples identified with traces of calcium oxalate were processed at ANSTO. The samples were pre-treated to remove potential carbon-bearing contaminants according to the following procedure. The powdered material was placed in a centrifuge tube with excess of 5% NaOH solution at 60 °C, agitated and left for one hour. At this step various organic acids and reactive biological components as well as non-acid soluble paint solids are transferred into the solution. The solution was centrifuged, the supernate decanted, and retained in case of further analysis. After extensive rinsing with Milli-Q® water, the samples were treated with 6 M HCl at 60 °C, to remove possible carbonates and to dissolve whewellite and weddellite. After one hour, the solution was centrifuged and supernate decanted and saved. This time the precipitates, possibly containing various more or less inert solids (silica, pollen, charcoal, probably some nonreactive residual organic matter) were retained for separate analyses. These inert solids are referred to as the "residue" in this paper. The decanted solutions containing oxalic and HCl acids and their salts were dried down (HCl volatilises), sealed in quartz combustion tubes and combusted at 900 °C, as described elsewhere (Hua et al., 2001). Separate solids fractions ("residues") were rinsed in Milli-Q® water multiple times, dried, and also sealed in combustion tubes and correspondingly combusted in the same conditions. Evolved $CO_2$ was cryogenically purified and collected, and its yield determined. Then it was converted to graphite following standard graphitisation procedures (Hua et al., 2004). Also, a number of separate blank samples were prepared on the same equipment from radiocarbon free material to assess the contamination in the course of samples handling.

Graphite targets were pressed into aluminium cathodes, and the $^{12}C/^{14}C$ ratio determined on ANSTO's STAR and ANTARES accelerator mass spectrometry (AMS) installations (Fink et al., 2004). $\delta^{13}C$ was determined on the graphite targets derived from the studied fractions after the radiocarbon measurements were completed. Measurements were performed on a separate elemental analyser Elementar

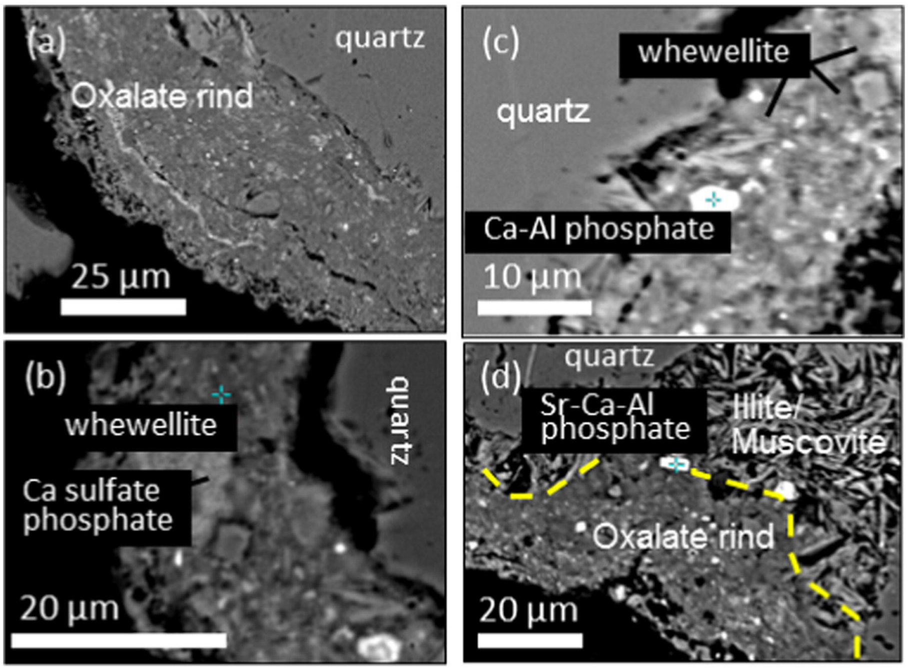


**Fig. 8.** Backscattered electron images of the sandstone substrate and coating of sample RLL032BS11. (a) Typical coating texture adjacent to quartz showing whewellite (medium-dark grey) with (Sr) Ca—Al phosphate (white) and porous outer edge. (b) Medium to dark grey whewellite in the surface coating on the sandstone with lighter Ca-sulfate-phosphate. (c) Ca—Al phosphate (white) in the coating with dark whewellite. (d) Sr—Ca—Al phosphate (white) has a typical blocky shape in the coating. Note how the coating cross cuts the illite muscovite grains in a vein in the sandstone (quartz).

varioMICRO CUBE coupled to a Micromass Isoprime IRMS machine. Some targets contained too little material for $\delta^{13}C$ determinations, so the value for isotopic correction was assumed as an average for other studied samples of the same type.

All samples that contained whewellite and/or wheddellite as per mineralogical characterisation produced good carbon yields in the oxalate fraction. On the other hand, the sample RLL3-1-1, which had no oxalate, as determined by mineralogical study, gave negligible carbon yield. These results support the selectiveness of our extraction and cleaning method. The carbon yields for the "residues" were at most the same as the yields for the oxalate fraction.

Results of blank corrected oxalates samples and inert residue fractions radiocarbon determinations are shown in Table 2.

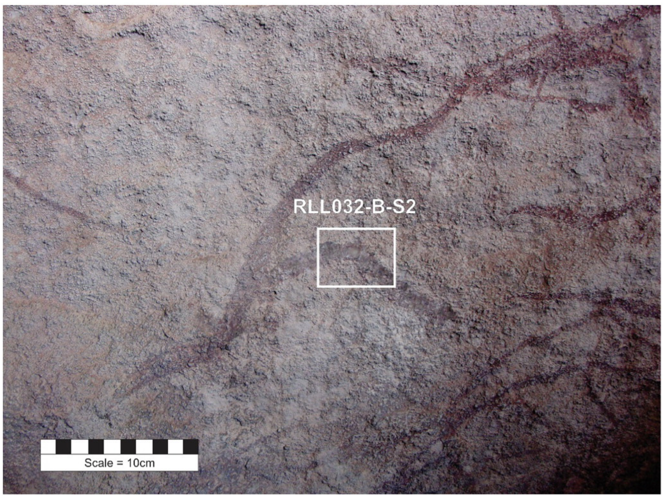


**Fig. 9.** Image of NRF figure (Motif 24) with a minimum age of 9034 cal. BP–9402 cal. BP (2σ range) clearly depicting evidence of sampling of mineral crust overlying upper thigh of the motif.
Photograph by Tristen Jones, image enhancement by Daryl Wesley.

The radiocarbon age determinations from site RLL032 Area B range from 5922 cal. BP (Sample RLL032-B-S3) to 9402 cal. BP (RLL032-B-S2). All samples from RLL032 Area B, excluding Sample RLL032-B-P2-S1, were collected from mineral crusts which encase the rock art (the images lie underneath the mineral crust). Therefore all radiocarbon age determinations from RLL032 Area B, excluding Sample RLL032-B-P2-S1 can be considered the *terminus ante quem* for the images underlying them. Sample RLL032-B-S2 is the oldest sample producing a calibrated age range of 9034 cal. BP–9402 cal. BP (2σ range) thus providing the minimum age for the circulation of the NRF art style (Fig. 9).

Sample RLL032-B-P2-S1 and Sample RLL032-B-P2-S2 were taken from the same mineral crust overlying two separate NRF images in close proximity to one another (Motif 23 and Motif 24) (Fig. 5). The first mineral crust sample (RLL032-B-P2-S1) was collected from underneath the painting (Motif 24, see Fig. 5). Therefore, the radiocarbon age determined from Sample RLL032-B-P2-S1 provides a maximum age for the image, and can be considered the *terminus post quem* for the overlying image. This sample (RLL032-B-P2-S1) produced a calibrated age range of 5937 cal. BP–6207 cal. BP (2σ range). The second sample (RLL032-B-P2-S2) is a sample from the same mineral crust as Sample RLL032-B-P2-S1, however the image is underneath the mineral crust (Motif 23, see Fig. 5). Sample RLL032-B-P2-S2 produced a calibrated age range of 6003 cal. BP–6277 cal. BP (2σ range). This result provides a maximum age for Motif 23. The two samples, Sample RLL032-B-P2-S1 and Sample RLL032-B-P2-S2, brackets the age of the circulation of the NRF art style to between 6000 cal. BP and 6200 cal. BP years old and produce ages in agreement with one another.

Sample RLL032-B-S3 produced the youngest age of the RLL032 Area B samples, with a calibrated age range of 5922 cal. BP–6177 cal. BP (2σ range). This age range represents the earliest minimum age for the NRF art style from the RLL032 Area B site.

Two radiocarbon age determinations from site RLL003 Area A were determined on mineral crusts with both the images lying underneath the mineral crust producing a minimum age range of between 3885 cal. BP (Sample RLL3-1-2) and 7675 cal. BP (RLL3-1-3). The age

**Table 2**
Radiocarbon determinations of both the calcium oxalate and inert residue fractions. *The value of $\delta^{13}C$ is assumed from determinations of similar samples. A measured value was not available due to the small size of samples. Results have been calibrated using CALIB 7.1 (Stuiver and Reimer, 1993) using Southern Hemisphere 2013 calibration curve (SHCal13) (Hogg et al., 2013).

| Field sample code | Laboratory code | Oxalate fraction | | | | Inert residue fraction | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Carbon as oxalate mg | $\delta^{13}C$ ‰ | Radiocarbon pMC (1σ error) | Conventional radiocarbon age BP (1σ error), $^{14}C$ years | Carbon in residue mg | $\delta^{13}C$ ‰ | Radiocarbon pMC (1σ error) | Conventional radiocarbon age BP (1σ error), $^{14}C$ years |
| RLL032B-2011 | OZP536 | 1.09 | −9.9 ± 0.2 | 51.04 ± 0.18 | 5400 ± 30 | 0.16 | −20.0 ± 0.5 | 62.52 ± 0.29 | 3775 ± 40 |
| RLL032-B-S1 | OZP841 | 0.50 | −7.6 ± 0.2 | 45.88 ± 0.19 | 6260 ± 35 | 0.63 | −11.0 ± 0.1 | 27.72 ± 0.15 | 10,305 ± 45 |
| RLL032-B-S2 | OZP842 | 1.20 | −9.2 ± 0.1 | 35.64 ± 0.16 | 8290 ± 40 | 2.25 | −7.8 ± 0.4 | 13.59 ± 0.09 | 16,030 ± 60 |
| RLL032-B-S3 | OZP845 | 1.30 | −11.1 ± 0.3 | 51.75 ± 0.20 | 5290 ± 35 | 0.73 | −10.0 ± 0.1 | 33.53 ± 0.15 | 8780 ± 40 |
| RLL032-B-S4 | OZP844 | 0.79 | −9.6 ± 0.1 | 47.42 ± 0.19 | 5995 ± 35 | 0.74 | −7.7 ± 0.1 | 21.52 ± 0.13 | 12,340 ± 50 |
| RLL032B-P2-S1 | OZS230 | 0.14 | −13.6 ± 0.2 | 51.44 ± 0.29 | 5340 ± 50 | 0.04 | −11.3* | 39.35 ± 0.79 | 7790 ± 170 |
| RLL032-B-P2-S2 | OZS231 | 0.27 | −12.1 ± 0.1 | 51.03 ± 0.26 | 5405 ± 45 | 0.04 | −11.3* | 30.14 ± 0.75 | 9630 ± 210 |
| RLL3-1-1 | OZR987 | <0.01 | | | | 0.06 | −11.3* | 48.45 ± 0.78 | 5820 ± 140 |
| RLL3-1-2 | OZR988 | 0.26 | −10.3 ± 0.2 | 63.01 ± 0.27 | 3710 ± 35 | 0.03 | −11.3* | 60.41 ± 1.07 | 4050 ± 150 |
| RLL3-1-3 | OZR989 | 0.10 | −9.1 ± 0.4 | 44.11 ± 0.79 | 6570 ± 195 | 0.03 | −11.3* | 63.40 ± 1.07 | 3660 ± 140 |

of Sample RLL3-1-2 is considerably younger than that of all the other samples from both rock art sites. However as the age determinations provide a minimum age, and considering the other results, the underlying image is likely to be much older.

Significantly, the radiocarbon determinations for 'residue' samples gave ages considerably older than the oxalate fraction in all but two cases.

## 6. Discussion

### *6.1. Contribution of the new radiocarbon dating method*

This study presents a novel carbon compound-specific separation technique, which effectively isolates the carbon in the calcium oxalate minerals (whewellite $CaC_2O_4 \cdot H_2O$ and weddellite $CaC_2O_4 \cdot 2H_2O$) in sample pre-treatment. Two separate age determinations are produced for each sample when possible. The first is produced from the carbon compound in the calcium oxalate mineral. The results are reported in Table 2. The second is a radiocarbon age determination, which we provide to demonstrate method quality control. This is a radiocarbon content measurement for the carbon residues contained within and on the mineral accretion, most probably containing silica, pollen, charcoal, and some organic matter non-reactive with both alkali and acids. These results are also presented in Table 2. The residue carbon is assumed to be integrated into the formation of the mineral growth throughout the mineral crust's life span, and may also incorporate carbon pollutants residing on the crust's surface. The radiocarbon age determinations for the residue samples generally gave ages older than the calcium oxalate fraction samples. Of nine samples, all but two residue ages are older than the oxalate fraction, with the age offset for residues approximately 4500 (disregarding the two younger residues). One sample which did generate a younger residue age (Sample RLL032-B-2011) was situated at the top of Panel 6, and was sampled from a surface area with clear signs of recent animal activity. The cause for the other younger residue age (Sample RLL3-1-3) is not so clear. The results from the RLL032 Area B and RLL003 Area A samples show a trend for older residue age determinations. The reason for such noticeable radiocarbon age offsets for non-reactive constituents of calcium oxalate mineral crusts remains unexplained, however a possibility highlighted by Watchman (2000:271) is that non-reactive residues may be generated from older materials included in the mineral crust such as dust aerosols. All interpretations into the causation of either younger or older age determinations of mineral crusts residues remain speculative at this point and require further investigation. To the best of our knowledge, no diagnostic classification or quantification of inclusions within carbon residues contained within mineral crusts associated with rock art has been attempted. Characterising the residue carbon and other materials contained within the mineral crusts may shed light on the developmental pathway of calcium oxalate mineral crusts and the rate of formation of calcium oxalate minerals. This would increase the robustness of the calcium oxalate radiocarbon dating method and increase the adoption of the dating method in rock art research globally. Observed large differences in ages of the calcium oxalate fraction and residue fraction demonstrates the efficiency of our sampling pre-treatment procedures and the targeted compound isolation method employed in this study. Additionally we have demonstrated that the source of carbon for calcium oxalate growth is not related to the carbon compounds in the residue material.

It is quite obvious that without the separation of the mineral crust residues from the calcium oxalate, the bulk mineral crust radiocarbon age determination would have been significantly older in most cases. Hence radiocarbon dating of minerals crusts for rock art studies performed with traditional acid-base-acid (ABA) pre-treatment techniques may not produce correct age estimates for the mineral crusts or the associated rock art imagery. Additionally, the traditional ABA technique carries some potential risk of removing oxalates from the sample, and as a result dating the wrong carbon fraction.

### *6.2. Archaeological significance of the radiocarbon age determinations*

Recent uranium-series dates for rock art imagery from Island Southeast Asia have confirmed the existence of art production from at least 40,000 years ago (Aubert et al., 2014), with similar antiquity for rock art in western Arnhem Land a plausible assumption. Indeed, Pleistocene antiquity of the rock art of western Arnhem Land has recently been confirmed (David et al., 2013b). This study has sought to further explore the potential for great antiquity in western Arnhem Land rock art. The results firmly place the NRF art style in the early Holocene, with a minimum age for the art style of c. 9400 years ago (Sample RLL032-B-S2). The NRF style occurs within the 'Intermediate Period' of the western Arnhem Land stylistic art sequence. A large corpus of art styles precedes the NRF style. 'Early Period' art styles such as 'Dynamic Figures', 'Large Naturalistic Figures' and 'Object and Hand Stencils' occur earlier in the art sequence than NRFs (Table 1) (Chaloupka, 1993; Chippindale and Taçon, 1998) Subsequently, the minimum age for the NRF art style, also produces a minimum age for earlier art styles that occur in the sequence. These results support commonly held assumptions by Australian rock art scholars that the 'Early Period' rock art of western Arnhem Land which underlies the figures which we have directly dated here, is of Pleistocene antiquity (Brandl, 1973; Chaloupka, 1993; Chippindale and Taçon, 1998; David et al., 2013b; Bednarik, 2014).

A large corpus of other 'Intermediate Period' art styles, particularly depictions of human figures, known as 'Post Dynamic Figures', 'Simple Figures with Boomerangs' and potentially 'Yam styled' figures are reported to occur alongside NRFs in the relative sequence. Additionally, the first representations of the Rainbow Snake is depicted in 'Yam' styled imagery (Taçon et al., 1996). Further investigations are required in order to clarify the relationship of other 'Intermediate Period' art styles, particularly human figures, to the NRF style, but assuming the validity of the current relative sequence it is proposed that the other 'Intermediate Period' art styles are of a similar antiquity to the NRF style. Recent radiocarbon dating of a painting of a snake depicted in early X-ray style produced an age range of 5068 cal. BP–6636 cal. BP (2 sigma) (Jones et al., 2017). Early X-ray is proposed to occur within the latter stages of the 'Intermediate Period' postdating the NRF style in the relative chronology. A minimum age of c. 6000 cal. BP for early X-ray styled art, coupled with the radiocarbon age determinations presented in this study again supports a minimum age of 9400 cal. BP, and the age range to 6000 cal. BP for the NRF art style and other associated 'Intermediate Period' rock art styles discussed herein.

In proposing an estimated maximum age for the NRF style it is statistically highly unlikely that our results fully constrain the earliest depiction of the NRF art as we have only sampled nine paintings, with hundreds of others having been recorded (Haskovec, 1992). Therefore, it can be assumed that the NRF style may still be significantly older than 9400 cal. BP. However further radiocarbon age determinations are required in order to ascertain a maximum age for NRF styled art.

Furthermore, our results establish that the NRF style was in circulation from 9400 cal. BP through to 6000 cal. BP (Sample RLL032-B-P2-S1 and Sample RLL032-B-P2-S2). Thus the NRF style was in circulation for a minimum of 3500 years and potentially for longer. Both George Chaloupka and Ivan Haskovec postulated that the NRF style was painted over a long period of time and our results confirm their observations (Chaloupka, 1993; Haskovec, 1992). Mapping the change in the manners of depiction across this 3500 year time span is now identified as a future research priority. The exact timing of the disappearance of the NRF styled art remains unknown. However, an early hypothesis in the literature argued that NRF styled art disappeared from the rock art record c. 5000 BP with the introduction of the dingo, canoe and fish hook (Haskovec, 1992:152). Indeed none of these are depicted in the NRF art of the RLLCP. The timing of the introduction of the (bark) canoe into Arnhem Land is currently unknown and there is currently no archaeological evidence for fish hook use in Arnhem Land until culture contact with Macassans (Warner, 1932:482). Fish hooks have been dated elsewhere in south eastern Australia to ca. 1000 BP (Attenbrow, 2010). Both the dingo and canoes (bark and dugout) are depicted in Late Holocene art styles in the stylistic sequence, such as in X-ray art (Chaloupka, 1993). Indeed the proliferation of other styles of art such as the 'Complete Figure Style' which incorporates 'X-ray' in western Arnhem Land from the mid Holocene is well documented (Taçon, 1989, 1992). The 'Complete Figure Style' in addition to containing 'X-ray' art also incorporates many different forms of art such as 'full figures', 'stick figures', stencils, beeswax images and prints. All of these art styles dominate the latter rock art record of the RLLCP. According to Taçon, the 'Complete Figure Style' is assigned an age range from 3000 to 2000 BP to present (Taçon, 1992:204,206). It can be assumed then that the NRF art style had disappeared from circulation by the mid to late Holocene.

## 7. Conclusion

Radiocarbon age determinations for the NRF art style have produced a minimum age of 9400 cal. BP. The maximum age for this art style is likely to be older. Additionally, the NRF art style appears to have been painted for at least 3500 years, with bracketed radiocarbon age determinations for two rock art images verifying this painting style was still in circulation at c. 6000 cal. BP.

The radiocarbon age determinations presented in this study are the result of the application of a novel compound separation technique, designed to effectively isolate the oxalate compounds from the mineral crust sample using chemical pre-treatment.

This new approach aimed to produce 14C on the calcium oxalate mineral only. Radiocarbon ages derived from non-reactive carbon residues contained within the calcium oxalate mineral crust have revealed significant deviations from the calcium oxalate ages. This indicates that radiocarbon age determinations produced from mineral crusts for rock art dating purposes using traditional acid-base-acid (ABA) pretreatment techniques may not yield reliable age estimations for the mineral crusts or the associated rock art imagery.

The early Holocene age determinations of this art style are significant for a number of reasons. Firstly, they provide a minimum age for not only the NRF art style, but also other associated art styles occurring concurrently within the 'Middle Period'. Secondly, the age determinations provide a minimum age for the 'Early Period' art styles of western Arnhem Land. Subsequently, these results confirm Pleistocene antiquity for 'Early Period' art styles in the relative chronology, until now a highly likely but unsubstantiated hypothesis. Finally, the NRF art style occurs during the Pleistocene–Holocene transition, a period which palaeoenvironmental research and archaeological modelling suggest was one of major transformation for Indigenous Australian societies.

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## Appendix A. Supplementary data

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# Chapter 4

**Rock art and ritual function: The Northern Running Figures of western Arnhem Land**

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Tristen Jones: Developed the research question. Undertook field work and recorded the data in the Red Lily study area. Formulated the arguments in the manuscript. Produced the data for the manuscript. Undertook the statistical tests. Drafted the majority of the manuscript, including introduction, site descriptions, methods, results, discussion and conclusion.

Signed:

**Tristen Jones**

Sally K. May: Undertook field work and recorded the data in the Mirrar study area. Refined the arguments and drafted revised copy in the manuscript. Edited the manuscript.

Signed:

**Sally K. May**

Keywords: material culture, Northern Running Figures, ritual behaviour, Ritual Form Model, rock art

# Rock art and ritual function: The Northern Running Figures of western Arnhem Land

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## Abstract

This paper explores the distribution, abundance and diversity of Northern Running Figure (NRF) rock art motifs and their archaeological contexts from two study areas in western Arnhem Land, Jabiluka and Red Lily. Motif design elements in the NRF style such as the inclusion of sex and material culture are indices used to explore social function in NRF art. The relationship between NRF archaeological contexts (i.e., distribution, abundance, diversity and overall rock art site contexts) and the variables of sex and material culture are explored via statistical analysis and suggest that NRF art performed a ritual function in the culture(s) of ancient Arnhem Land peoples.

## Introduction

The rock art of western Arnhem Land is often heralded as one of the most important assemblages in the world due to its abundance, long sequences and diversity. Argued to have been painted for over 28,000 years (David et al. 2013), this rock art corpus has the potential for much greater antiquity owing to the presence of modified ochre in some of the earliest dated stratified archaeological deposits (Clarkson et al. 2015). Thus, the rock art of western Arnhem Land offers researchers the opportunity to explore change in rock art depictions over a great time depth. This sequence includes a curious style that has been referred to as Mountford figures, Oenpelli figures and Northern Running Figures (henceforth NRFs) in popular and academic literature since the 1940s. The NRFs so inspired the ethnographer Charles Mountford that he used them to illustrate his popular writings, public lectures and exhibition brochures throughout his career. Later rock art researchers (including Chaloupka 1985, 1993, Chippindale and Taçon 1998, Haskovec 1992; and Lewis 1988) noted that this art style appeared to be one of the earliest regionally bounded rock art styles in the stylistic chronological sequence of western Arnhem Land rock art. However, the significance of the bounded distribution and the potential social function of the NRF art style has been underexplored in rock art research.

In this paper, we test the current hypothesised distribution of the NRF art style, and explore the abundance and diversity of NRF rock art motifs and their archaeological contexts from two study areas, Jabiluka and Red Lily. In particular, we utilise the presence — underpinned by the selected choices made by NRF artists — to depict motif design elements of sex and material culture as indices to explore the potential social function of NRF art in past Arnhem Lander culture/s. Combined, our analysis of NRF art style distribution, abundance and diversity and NRF archaeological site contexts, with the NRF motif variables of sex and material culture, suggest that NRF art performed a ritual function. The hypothesis of NRF art as identifying ritual behaviours and practice is then tested against the Ritual Form Model (RFM) (Ross and Davidson 2006, Whitley 2011). This RFM proposes seven criteria based on the universal structure of ritual in human populations (see Rappaport 1999) that, if present, confirm ritual function in rock art assemblages.

### The Northern Running Figures art style

NRF-styled art predominately depicts anthropomorphic figures. Definitions presented in the literature to date describe the anthropomorphic motifs as generally shown in exaggerated movement typified by elongated S-shaped bodies, with legs commonly widespread (see multiple examples in Figure 1). While female motifs do exist, it is frequently noted that males are dominant in this art style and are usually illustrated with a prominent penis, muscular legs, and a headdress, though the size and decorative attributes of these features are variable (Chaloupka 1993:132-137, Haskovec 1992:152, Lewis 1988:36-38). NRF-styled motifs are commonly portrayed in groups and in complex scenes with a variety of material culture items and occasionally include animal motifs such as fish.

*Figure 1. Scene of NRFs recorded on Injalak Hill. Left: Photograph from 2016 by Sally K. May. Right: Drawing of the scene made by Charles Mountford during the 1948 American-Australian Scientific Expedition to Arnhem Land (after Mountford 1958:114).*

Items of material culture depicted with NRF figures include boomerangs, spears, hooked sticks and spear throwers (Chaloupka 1993:132, Haskovec 1992:152, Lewis

1988:36-38). In some cases, armlets and pubic aprons are also depicted. Importantly, Chaloupka (1993:132) stresses the importance of the headdress depictions in this art style stating, 'the headdresses are of a variety of shapes and are adorned with feathers and other objects'. Also noted by Chaloupka is the widespread adoption of multiple pigment colours, commonly employed as a decorative tool in the headdresses. With the subsequent loss of some pigments due to poor preservation this has resulted in rendering some NRF styled motifs 'headless' (Chaloupka 1993:132, Figure 2). Some researchers have argued that it is with the NRF style that we first see the widespread use of multiple pigments as a decorative attribute in this region (Haskovec 1992:150).

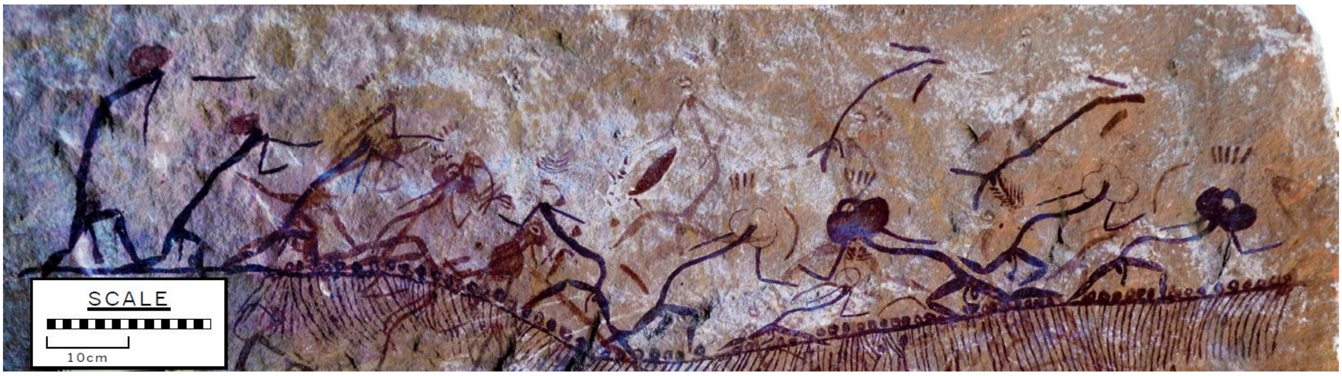


*Figure 2. A NRF scene depicting a series of motifs running — projecting the essence of movement. The NRF motifs display archetypal stylistic attributes including the single delineation S shape body line, headdress (mushroom type), pronounced musculature of the legs and male genitalia. Note also the sequence of repainting of NRFs with newer motifs overlying older NRF styled motifs and the lack of other styles obscuring the NRF art or present on the panel (photo: Tristen Jones, enhancement: Meg Walker).*

The art style now known as NRFs was first identified and recorded by Charles Mountford during the 1948 American Australian Scientific Expedition to Arnhem Land (AASEAL). He described the style as ' … figures are in deep red. The large legs and thighs and the positions of the bodies of the running figures bear a strong resemblance to South African Bushman paintings' (Mountford 1956:113). He also observed that they expressed coherence and rhythmic movement and he noted that the 'heads' on motifs were missing (Mountford 1956:113-181). These early observations regarding the conventions of NRF art were greatly expanded by later rock art researchers (Chaloupka 1993, Haskovec 1992, Lewis 1988).

It was George Chaloupka, who coined the name ‘Mountford Figures’ (to perpetuate the legacy of AASEAL), to describe the NRFs and also offered a more comprehensive description of this style (Chaloupka 1985, Chaloupka 1993:132-137). Chaloupka made attempts to explore the stylistic diversity present in NRFs and the types of material culture depicted. He was also the first researcher to assign a place for the art style in a relative stylistic chronology and pose a theory for its regional distribution (Chaloupka 1985:275).

To date, the only study solely focussed on the NRF style was undertaken by Ivan Haskovec in the early 1990s (Haskovec 1992). Haskovec recorded 76 rock art sites containing 331 paintings. The sites recorded by Haskovec are all situated on the edge of the sandstone escarpment and on the outliers surrounding the floodplains of the East Alligator River, and conform to the hypothesised distribution of the NRF style in the literature by Chaloupka (Chaloupka 1985:275, Haskovec 1992:149). Haskovec’s work suggested the spatial distribution of the NRF style was limited to the west of Gunbalanya, with the south west border located approximately 5 km north of Magela Creek (Figure 3) (Haskovec 1992:149).

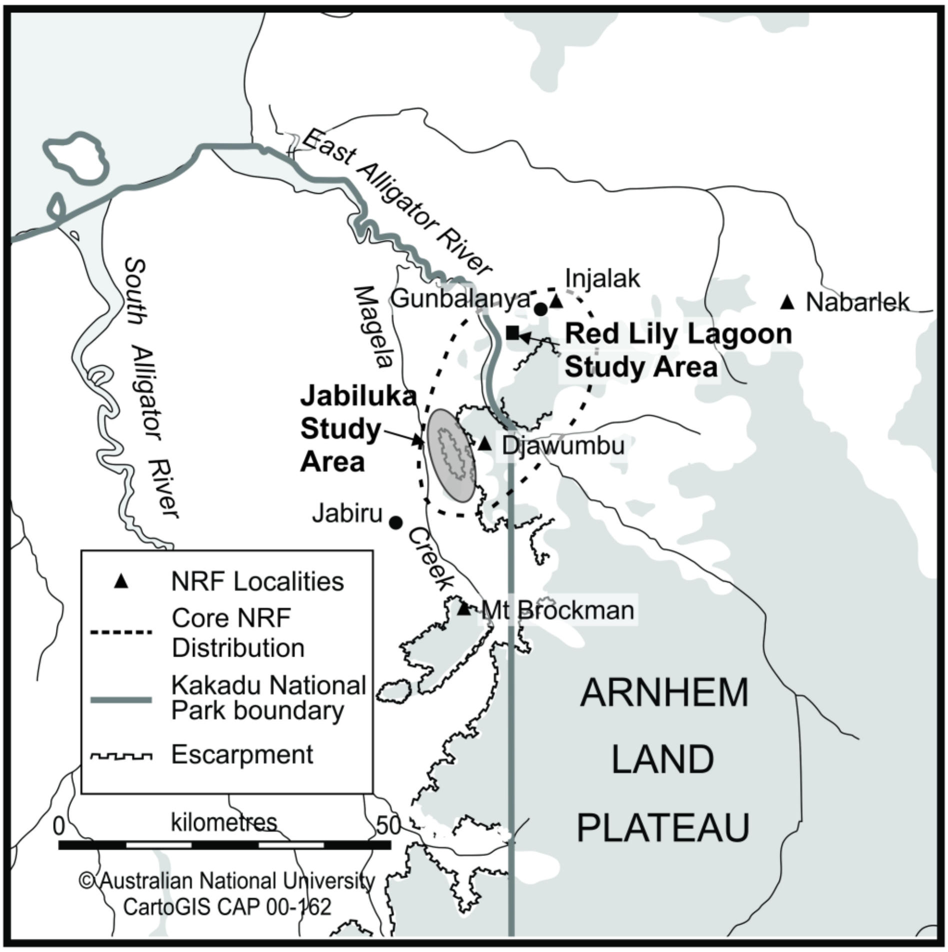


*Figure 3. Map of western Arnhem Land highlighting key named locations and sites in text and the area of assumed NRF distribution (source: CartoGIS and Daryl Wesley).*

Recent radiocarbon age determinations producing minimum ages and bracketed ages for the NRF art style have greatly altered the assumed age for the introduction of this art style (Jones et al. 2017). Jones et al. (2017:80-89) have argued for a minimum age of 9,400 cal. BP for the NRF art style, producing ages that verify that this manner of depiction was still in circulation up to 6,000 cal. BP. Furthermore, they argue that it is highly likely that this art style may be significantly older than 9,400 cal. BP, arguing potentially for a terminal Pleistocene antiquity for the NRF style. This suggests a slightly earlier timeframe than proposed in the largely utilised relative stylistic chronology (Chippindale and Taçon 1998:107) where the NRF art style is assumed to be of early to mid-Holocene antiquity, and is assigned to the Middle or Intermediate Periods. The relationship of the NRF art style to other art styles occurring in the same temporal bloc is now identified as a research question of significant interest, as the radiocarbon age determinations suggest an earlier age for all art occurring in the Middle or Intermediate Periods.

These radiocarbon age determinations have confirmed an observation made by Chaloupka that the anthropomorphic motifs painted in the NRF style may have been painted over a considerable timeframe. Chaloupka (1993:132) states that NRFs '…appear in a number of stylistic variations… — they vary in size, degree of elongation, relative width of body, and internal decoration used'. Haskovec (1992:150) similarly argues that they '…range in elaboration and complexity of decoration… the style has undergone marked changes'. The radiocarbon ages affirm that the NRF art style was painted for a minimum of 3,400 years which would account for the range of stylistic variability. This range of variability had perplexed previous researchers and their interpretation of the potential antiquity of the art style. For example, Lewis had previously argued that the NRF art style belonged to the 'Hooked Stick Period' (postulated to have occurred from 9,000 BP until 6,000 BP); however, he conceded that this categorisation of the NRF art style was not definitive as the art style shares similarity to both 'early' and 'late' Mimi art (Lewis 1988:38).

To detail the stylistic diversity of the NRF art style and any temporal changes in the manners of depiction is beyond the scope of this paper. Indeed, the primary focus for future research on the NRF art style should be an exploration of this stylistic diversity, and the NRF art style's relationship to other concurrent modes of artistic representation, particularly the plethora of other anthropomorphic types such as Post Dynamic Figures and Simple Figures with Boomerangs styles, providing a definition of the art style outlining the temporal transitions.

This research adopts a generalised working definition of the NRF style based upon the commonly occurring design elements and that have been collectively identified in the literature and are present in our assemblages. As such we identify motifs to be of the NRF style if they possess the majority of the following attributes (Figure 1, 2):

- Unbroken sinuous delineation of the body, commonly a single line that represents the head, neck, mid body to groin of the anthropomorphic figure;

- This body line is classically in an S shape with upper torso angled forward thus expressing movement;
- Pronounced musculature of the legs, in particular the calves;
- The dominance of a headdress, very rare for the separate depiction of a head;
- The dominance of male sex with genitalia commonly depicted; and,
- Motif colour is predominately red and/or purple ochres, with the use of other colours (white, yellow and orange) at times utilised for the bi or polychromatic depiction of the headdress.

**A macro and micro scaled analysis of Northern Running Figure art distribution**

This paper utilises rock art site and motif data generated from two study areas. The first area is located within the bounds of the Mirarr clan estate. Areas of sandstone outcrop within both study areas were chosen for systematic survey with the objective of capturing 100 percent of rock art sites located within these geographic zones. The Jabiluka Leasehold area (Mirarr Country) was systematically surveyed as part of the Mirarr Gunwarddebim project led by one of the authors, Sally K. May from 2011 to 2015. This survey identified and recorded 528 rock art sites across an area of 11.7 $km^2$. Some of these sites (including some of the NRF motif data used in this study) also come from just north of the Jabiluka Leasehold border in a region known Ngarradj Bawarddedjobkeng (Kundjeyhmi spelling). However, for ease we refer to them collectively as the Jabiluka sites. The second study area (Red Lily) is located within the bounds of the Manilakarr clan estate. The area was systematically surveyed and recorded from 2011 to 2014 by an Australian National University (ANU) research team led by Tristen Jones. A total of 86 rock art sites were identified and recorded across 3.5 $km^2$.

The survey strategy for both research areas was generalised, meaning that all cultural site features were recorded at a place, including rock art, utilising a rapid site recording strategy. This strategy produces baseline data for a rock art place and estimates ranges of total motifs, motif form, method and content, and the presence and absence of identifiable art styles; however, while in both survey areas the survey methodology and recording methods were the same, in Red Lily the recording teams undertook higher resolution recordings of sites with NRF art, as this art style became the focus of targeted research questions. This may account for the higher Minimum Number of Individuals (MNI) of NRF motifs in the Red Lily (Table 1). The different research aims and recording methodologies between the two projects allows for a complimentary analysis of presence or absence of NRF art (i.e., distribution).

*Table 1. Northern Running Figure Site MNI and complex size for both study areas.*

| | **MNI NRF** | **Complex Size** | | **MNI NRF** | **Complex Size** |
|---|---|---|---|---|---|
| Red Lily 1 | 4 | Small (1-5) | Jabiluka 1 | 1 | Small (1-5) |
| Red Lily 2 | 8 | Medium (6-20) | Jabiluka 2 | 41 | Large (20-50) |
| Red Lily 3 | 4 | Small (1-5) | Jabiluka 3 | 26 | Large (20-50) |
| Red Lily 4 | 1 | Small (1-5) | Jabiluka 4 | 1 | Small (1-5) |
| Red Lily 5 | 7 | Medium (6-20) | Jabiluka 5 | 6 | Medium (5-20) |
| Red Lily 8 | 67 | Massive (51+) | Jabiluka 6 | 6 | Medium (5-20) |
| Red Lily 10 | 11 | Medium (6-20) | Jabiluka 7 | 1 | Small (1-5) |
| Red Lily 11 | 11 | Medium (6-20) | Jabiluka 9 | 3 | Small (1-5) |
| Red Lily 12 | 1 | Small (1-5) | Jabiluka 10 | 2 | Small (1-5) |
| Red Lily 13 | 29 | Large (21-50) | Jabiluka 17 | 5 | Small (1-5) |
| Red Lily 14 | 5 | Small (1-5) | Jabiluka 11 | 3 | Small (1-5) |
| Red Lily 15 | 2 | Small (1-5) | Jabiluka 15 | 2 | Small (1-5) |
| Red Lily 16 | 30 | Large (21-50) | | | |
| Red Lily 17 | 172 | Massive (51+) | | | |
| Red Lily 18 | 9 | Medium (6-20) | | | |
| Red Lily 23 | 69 | Massive (51+) | | | |
| Red Lily 24 | 1 | Small (1-5) | | | |
| Red Lily 26 | 10 | Medium (6-20) | | | |
| **TOTAL** | **434** | | | **109** | |

In Jabiluka only 2.2 percent of rock art sites contained NRF styled art (n=12), while at Red Lily 20.9 percent of rock art sites contained NRFs (n=18). Furthermore, the frequency of NRFs in Red Lily was much higher (MNI n=434) than the Jabiluka NRF assemblage (MNI n=109). NRF density is also much higher in the Red Lily assemblage than in Jabiluka. In the Jabiluka study area there is an average of 45.1 rock sites per $km^2$, however NRF art is only present in 1.0 rock art sites per $km^2$. In comparison, at Red Lily there is an average of 24.5 rock sites per $km^2$, with NRF art present in 5.1 rock art sites per $km^2$. In summary, while there is a greater number of rock art sites and more densely populated rock art landscape in the Jabiluka study area, there is both a higher frequency and a higher density of NRF styled art in Red Lily.

Additionally, a trend was observed in the data that NRF styled art commonly (57 percent) occurred in major rock art shelters. Major rock art sites are defined as containing in excess of 100 motifs in total. In Red Lily three sites with NRF MNI exceeding 51+ were recorded, in comparison to Jabiluka where there were no recorded rock art sites that contained more than 50 NRF styled motifs.

To explore difference in the distribution, frequency, abundance and diversity of the two NRF motif populations the following variables were recorded from the study areas site and motif data:

- Site information: NRF MNI per site, NRF complex size, site elevation, site geomorphology and total number of paintings in the site; and,
- Motif information: Sex, headdress presence, headdress type, material culture presence/absence, and material culture type.

Following the recording of these variables a number of statistical tests were undertaken for both study areas. In particular, we wanted to explore the *conscious decision of painters in the selection of place* in depicting NRF styled art in this landscape. In order to understand this relationship, we posed the following questions:

a) Where do painters choose to depict NRF styled art both in the landscape and in rock art sites?
b) Does NRF art increase with the total number of motifs in a site?

In order to test the relative abundance of NRFs to the total number of motifs in a rock art site, the MNI of NRFs were allocated to a corresponding complex size group. A

MNI of one to five is grouped as a 'small NRF complex'; a MNI of five to 20 is grouped as a 'medium NRF complex'; a MNI of 20 to 50 is grouped as a 'large NRF complex', and an MNI of 50+ was grouped as a 'massive NRF complex'. NRF complex size was then tested against the total number of motifs in both study areas using a Pearson's chi-squared test (χ test), as the data is non-normally distributed. The χ test for both study areas revealed there is no significant difference between NRF complex size, and the corresponding total number of motifs in each site (Jabiluka $\chi=11.250$, $df=8$, $p=0.188$; Red Lily $\chi=16.543$, $df=18$, $p=0.555$). This suggests that in both the Jabiluka and Red Lily areas the number of NRF motifs were not related to the overall total of motifs painted in each rock art site, and suggests that the number of NRF motifs depicted is related to choice (and not chance).

To understand trends in the location of NRF styled art the number of motifs present in a site was compared to site geomorphology. Site geomorphology was selected as a variable instead of site elevation due to the unreliability and large margin of errors in handheld GPS units. The most dominant site geomorphology type for both study areas is 'outlier top' followed by 'outlier slope' (Figure 4). Outlier top is the geomorphological group with the highest elevation in sandstone escarpment and rock art sites situated in this landscape are often situated in weathered rock stacks on top of the plateau. Outlier slope is the geomorphological group encompassing the steeply eroded sides of the sandstone escarpment. This finding mirrors the findings of Wesley et al. (in press) which revealed that Middle Period art styles at Red Lily most commonly occur on hillside or hilltop contexts, and interpret this as potentially a result of changing mobility and occupation patterns in the landscape or a result of taphonomy.

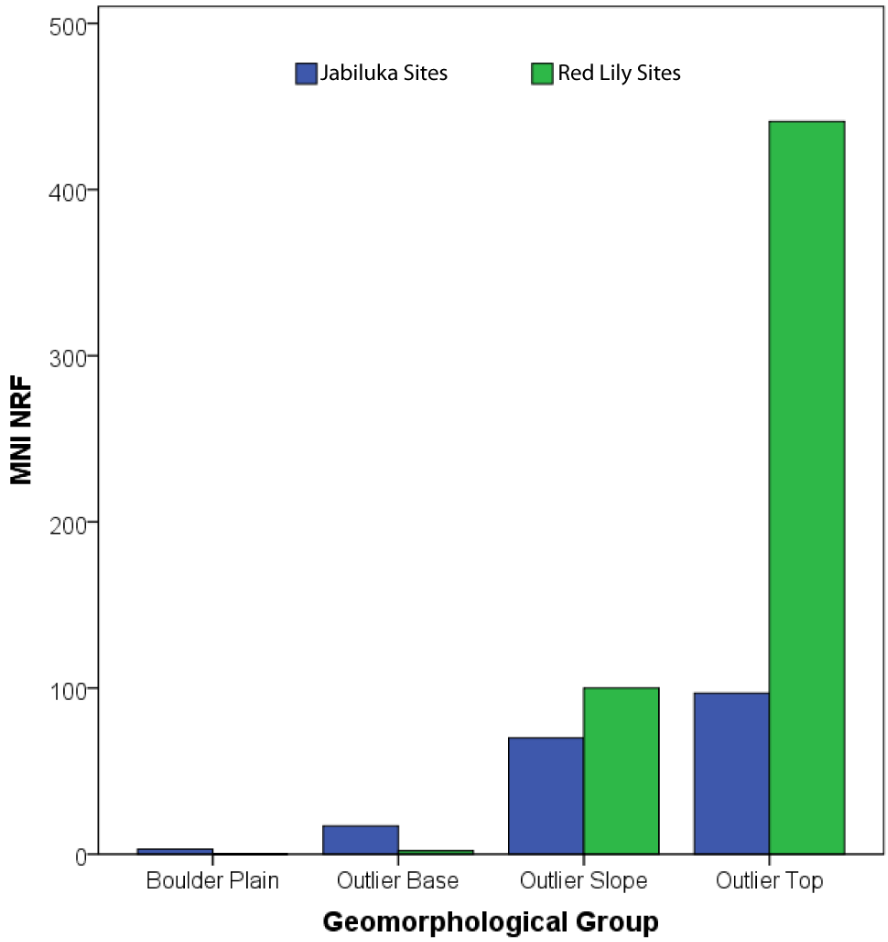


*Figure 4. MNI of Northern Running Figure rock art motifs according to rock art site geomorphology type.*

The core distribution of NRF art is from Injalak Hill (Gunbalanya) in the north to the south of the Djawumbu massif in the current Jabiluka Leasehold area. However, some outliers have been recorded such as examples from a site 30 km east of Gunbalanya at Narbalek (Wesley, pers. comm., 20/12/16) and some examples from Dangurrung (Mt Brockman area) that contain some attributes that conform to the NRF manner of depiction but that do not conform to the definition of the style overall. These figures could be considered 'transitional' in NRF form, and may be either very early or very late NRFs, or indeed may be crude imitations of the art style outside of the core distribution zone. Our core zone matches well with Haskovec's (1992:149) argument for the geographical range of the style. This argument is further strengthened by the work of Taçon across western Arnhem Land and Kakadu National Park who states that, apart from the Dangurrung examples, he has not seen examples south of the

Djawumbu massif (Taçon pers. comm., 14/12/16). In short, the NRF art style is abundant in the Red Lily area, slowly reducing in numbers as you head north or south.

In both study areas a Pearson's chi-squared test ($\chi$ test), revealed there is no significant difference between NRF complex size, and the corresponding total number of motifs in each site. This statistical test suggests that the number of NRF motifs depicted in a site is related to choice and there is a general trend observed in the data that NRF styled art commonly (57 percent) occurred in major rock art sites. Major rock art sites are defined as containing in excess of 100 motifs in total. Additionally, there seems to be a correlation between the presence of NRF styled art and higher elevation (hillside/hilltop geological contexts). Yet, it is important to note that these findings also suggest a change over time in the placement of rock art generally in these study areas with NRFs not being overpainted and obscured at these higher elevations. The results of the NRF site distribution data and statistical tests support the observation by previous rock art researchers for a limited regional distribution, and that the place and number of NRF motifs depicted is determined by choice.

**Exploring the role of material culture and sex in Northern Running Figure art**

NRF art is often painted in rock art sites that contain high rock art densities and in some instances NRFs are painted in high frequencies, meaning that the NRF art style was and remains highly visible in these rock art sites. In order to explore then the potential social function of this visible placement, the variables of sex and material culture were selected for further statistical analysis. These variables form the dominant characteristics for NRF manner of depiction excluding the other variables of NRF motif dimensions and the angle of the mid-body line. The variables of sex and material culture may then have the ability to impart both symbolic and practical information that can inform etic observations in rock art.

*Table 2: Northern Running Figure motif data for frequency (n) of sex, headdress and other material culture types in both study areas.*

| | Sex (n) Red Lily | Sex (n) Jabiluka | | Red Lily Headdress (n) | Jabiluka Headdress (n) | | Red Lily other material culture (n) | Jabiluka other material culture (n) |
|---|---|---|---|---|---|---|---|---|
| **Male** | 222 | 49 | **Yes** | 122 | 36 | **Yes** | 38 | 17 |
| **Female** | 8 | 2 | **Indeterminate** | 312 | 73 | **Not depicted** | 384 | 65 |
| **Not depicted** | 178 | 17 | | | | **Indeterminate** | 12 | 27 |
| **Indeterminate** | 26 | 41 | | | | | | |
| **TOTAL** | **434** | **109** | | **434** | **109** | | **434** | **109** |

First, the presence and absence of both sex, headdress and other material culture types were recorded (Table 2). At Red Lily male sex (in the form of a penis) was depicted in 51.1 percent of motifs (n=222), in comparison to female sex (in the form of breasts or a vulva) which was only depicted in 1.8 percent of motifs (n=8). No depiction of sex occurred in 40.9 percent (n=178) of cases, with 'indeterminate' (unable to identify presence or absence of sex) accounting for 6.2 percent of the assemblage (n=26). In the Jabiluka study area the percentage of selected sex representations generally correlated with the Red Lily assemblage (male=45.0 percent, female=1.8 percent, not depicted=15.6 percent, indeterminate=37.6 percent).

The presence and absence of headdress and other material culture was also recorded and analysed. At Red Lily identifiable headdresses were depicted in 28.1 percent of motifs (n=122), in comparison to 'indeterminate' headdresses which represents 71.9 percent of motifs (n=312). Other material culture types (boomerangs/hooked sticks, spears, spear throwers, body adornments, hand axes) were depicted in only 8.8 percent (n=38) of cases, with no other material culture depicted (88.5 percent, n=384) most of the time, and 'indeterminate' types accounting for 2.8 percent of the assemblage (n=12). In comparison, the study of the Jabiluka area found that identifiable headdresses were depicted in 33.3 percent of motifs (n=36), with 'indeterminate' headdresses representing 66.9 percent of motifs (n=73). Other material culture types were depicted in higher instances than at Red Lily (15.6 percent, n=17), with no other material culture still the dominant selection representing 59.6 percent (n=65) of the assemblage, with 'indeterminate' 24.8 percent of the assemblage (n=27).

Thirteen individual headdress types were identified in the NRF assemblages from both study areas. Headdresses were classified according to shape, with decorative infill elements, colour combinations and decorative additions (such as protruding/radiating lines from the main shaped headdress potentially representing feathers) recorded in the assemblage, but disregarded as determining characteristics in classifying headdress types. Of a total of 543 motifs from both study areas, 158 motifs possessed a headdress. Percentage of headdress types per study area were then calculated (Table 3). In Red Lily the most common headdress type was 'circular' (5.5 percent, n=24), followed by 'mushroom' type (5.1 percent, n=22), and 'crescent' type (3.2 percent, n=14). In the Jabiluka study area the 'crescent' headdress type was by far the most common (13.8 percent, n=15) with the 'circular' type second most prevalent (3.7 percent, n=4) (Figure 5). In order to explore the role of the NRF headdresses further, the following research questions were posed:

(a) Does headdress diversity increase with NRF complex size?

(b) Are some headdress types only found, or increasingly found, in particular NRF complex sizes?

(c) Are there types of headdresses that are only depicted with other particular forms of material culture?

*Table 3. Northern Running Figure headdress type frequency (n) and percentages (%) for both study areas.*

| Headdress Type | Red Lily (n) | Red Lily (%) | Jabiluka (n) | Jabiluka (%) |
|---|---|---|---|---|
| **Circular** | 24 | 5.5 | 4 | 3.7 |
| **Bell** | 4 | .9 | 0 | 0 |
| **Beehive** | 2 | .5 | 1 | .9 |
| **Mushroom** | 22 | 5.1 | 0 | 0 |
| **Lasso** | 1 | .2 | 1 | .9 |
| **Crescent** | 14 | 3.2 | 15 | 13.8 |
| **Clover** | 9 | 2.1 | 2 | 1.8 |
| **Bullet** | 1 | .2 | 2 | 1.8 |
| **Butterfly** | 6 | 1.4 | 0 | 0 |
| **Half circle** | 2 | .5 | 1 | .9 |
| **Feathers** | 8 | 1.8 | 0 | 0 |
| **Curved rectangle** | 5 | 1.1 | 1 | .9 |
| **Long invert C** | 1 | .2 | 1 | .9 |
| **Indeterminate*** | 40 | 9.2 | 8 | 7.3 |
| **Not Applicable*** | 295 | 67.8 | 73 | 67 |
| **TOTAL** | **434** | **100** | **109** | **100** |

* The category of 'Not Applicable' refers to motifs that possessed an 'Indeterminate' headdress presence, whereas the category of 'Indeterminate' refers to a positive identification of a headdress but due to weathering or overpainting the headdress type cannot be identified.

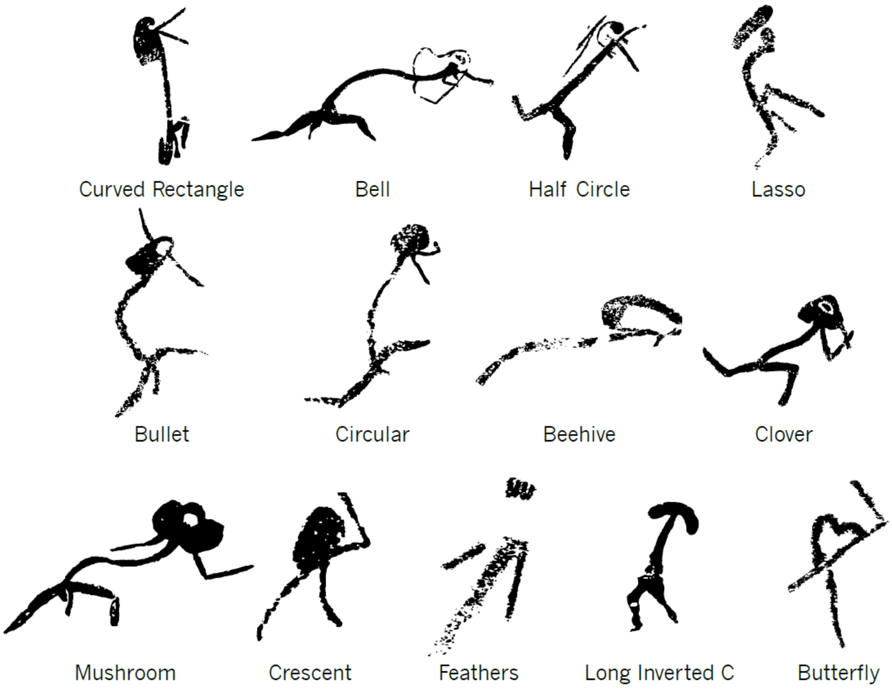


*Figure 5. Examples of each of the identified Northern Running Figure headdress types (digital tracings: Meg Walker, not to scale).*

In order to test whether there was a correlation between NRF headdress diversity and NRF complex size a Pearson's chi-squared test (χ test) was employed as the data is non-normally distributed. The χ test for both study areas revealed there is a significant relationship between the two variables (Jabiluka *χ=33.885, df=20, p=0.027*; Red Lily *χ=69.440, df=42, p=0.005*), meaning that headdress diversity increases with higher NRF frequencies (NRF complex size). In order to test whether there was a significant difference in headdress diversity between the two assemblages (Red Lily and Jabiluka) a paired sample t-test was undertaken. The test revealed no statistically significant difference between headdress variability between the two study areas (*t*=-0.767, *df*=108, *p*=0.445), meaning that the same types of headdresses are likely to be painted in either study area.

Interestingly, when testing the preference for headdress types in relation to NRF complex size, at Red Lily there was no discernible pattern (Table 4). However, in contrast to Red Lily, in the Jabiluka study area, in all but one instance, the most prevalent headdress type, the 'crescent' type headdress, was found only in 'large' NRF complex sizes (Table 5).

*Table 4. Headdress type frequency (n) and percentages (%) per NRF complex size for Red Lily (for most dominant headdress types).*

| NRF Complex Size | Red Lily 'Circular' Headdress (n) | Red Lily 'Circular' Headdress (%) | Red Lily 'Crescent' Headdress (n) | Red Lily 'Crescent' Headdress (%) | Red Lily 'Mushroom' Headdress (n) | Red Lily 'Mushroom' Headdress (%) |
|---|---|---|---|---|---|---|
| **Small (1-5)** | 1 | 4.2 | 0 | 0 | 1 | 4.5 |
| **Medium (6-20)** | 5 | 20.8 | 0 | 0 | 2 | 9.1 |
| **Large (21-50)** | 6 | 25 | 2 | 14.3 | 0 | 0 |
| **Massive (51+)** | 12 | 50 | 12 | 85.7 | 19 | 86.4 |
| **TOTAL** | **24** | **100** | **14** | **100** | **22** | **100** |

*Table 5. Headdress type frequency (n) and percentages (%) per Northern Running Figure complex size for Jabiluka (for most dominant headdress types).*

| ***NRF complex size*** | ***Jabiluka 'circular' headdress (n)*** | ***Jabiluka 'circular' headdress (%)*** | ***Jabiluka 'crescent' headdress (n)*** | ***Jabiluka 'crescent' headdress (%)*** |
|---|---|---|---|---|
| ***Small (1-5)*** | *3* | *75* | *1* | *6.7* |
| ***Medium (6-20)*** | *0* | *0* | *0* | *0* |
| ***Large (21-50)*** | *1* | *25* | *14* | *93.3* |
| ***TOTAL*** | ***0*** | ***100*** | ***15*** | ***100*** |

The frequency and percentages of the other material culture types depicted with NRF motifs are described in Table 6. The overall presence for other material types (i.e., boomerangs/hooked sticks, spears, spear throwers, wearable adornments, hand axes) in NRF at both Red Lily and Jabiluka is quite low (8.8 percent and 15.6 percent respectively). At Red Lily the most common other material culture types were single shaft spears (n=12, 2.8 percent) and boomerangs/hooked sticks (n=8, 1.8 percent) respectively. In contrast at Jabiluka, hand axes (n=10, 9.2 percent) were the most common other material culture type followed by single shaft spears (n=2, 1.8 percent) and boomerangs/hooked sticks (n=2, 1.8 percent). In order to test whether there was a significant difference in the diversity of other material culture types between the two assemblages a paired samples t-test was undertaken. The test revealed no statistically significant difference between other material culture type variability between the Red Lily and Jabiluka assemblages ($t$=-5.862, $df$=108, $p$=<0.000), meaning that the same types of other material culture are likely to be painted in either study area.

*Table 6. Northern Running Figure frequency (n) and percentages (%) of the other material culture types for both study areas.*

| Other material culture type | Red Lily (n) | Red Lily (%) | Jabiluka (n) | Jabiluka (%) |
|---|---|---|---|---|
| **Single shaft spear** | 12 | 2.8 | 2 | 1.8 |
| **Single barbed spear** | 3 | .7 | 1 | .9 |
| **Wearable adornments** | 2 | .5 | 1 | .9 |
| **Boomerang / Hooked stick** | 8 | 1.8 | 2 | 1.8 |
| **Hand axe *** | 3 | .7 | 10 | 9.2 |
| **Indeterminate** | 248 | 57.1 | 1 | .9 |
| **Not applicable** | 158 | 36.4 | 92 | 84.4 |
| **TOTAL** | **434** | **100** | **109** | **100** |

* In a singular instance at Red Lily a hand axe was depicted in combination with a boomerang, this instance has been counted as an axe. This was the only combination of multiple depictions of other material culture types (excluding headdresses). Note: This table present presence and absence of other material culture types not the MNI of instances of other material culture types.

As the presence of other material culture was low in both assemblages, in order to test the relationship between particular headdress types and other material culture types, a test was undertaken on the frequency and percentages of headdresses absent of other material culture (Table 7). The data reveals that there is no significant difference between the frequency and percentage of the headdress types not depicted with other material culture types in comparison to NRF motifs with headdresses depicted with other material culture types.

*Table 7. Northern Running Figure motif headdress type frequency (n) and percentage (%) absent of other material culture types.*

| Headdress type | Red Lily (n) | Red Lily (%) | Jabiluka (n) | Jabiluka (%) |
|---|---|---|---|---|
| **Circular** | 18 | 4.7 | 4 | 4.3 |
| **Bell** | 2 | .5 | 0 | 0 |
| **Beehive** | 1 | .3 | 0 | 0 |
| **Mushroom** | 20 | 5.2 | 0 | 0 |
| **Lasso** | 1 | .3 | 0 | 0 |
| **Crescent** | 14 | 3.6 | 12 | 13 |
| **Clover** | 7 | 1.8 | 2 | 2.2 |
| **Bullet** | 1 | .3 | 1 | 1.1 |
| **Butterfly** | 4 | 1.0 | 0 | 0 |
| **Half circle** | 1 | .3 | 1 | 1.1 |
| **Feathers** | 6 | 1.6 | 0 | 0 |
| **Curved rectangle** | 2 | .5 | 1 | 1.1 |
| **Long invert C** | 0 | 0 | 0 | 0 |
| **Indeterminate** | 37 | 9.6 | 6 | 6.5 |
| **Not Applicable** | 270 | 70.3 | 65 | 70.7 |
| **TOTAL** | 384 | 100 | 92 | 100 |

### Identifying ritual behaviours in rock art

There are many different definitions and understanding of ‘ritual’ and ‘ritual behaviours (Bell 1992). However, in this paper we define ‘ritual’ as representing the non-secular aspects of past Arnhem Land life, meaning in this case that the symbolism projected in the rock art and the physical act of rock art production and/or rock art viewing communicates belief systems of a higher order or religious/mythological nature. The term ‘ceremony’ on the other hand, is defined in this context as social group activity which may or may not be founded upon religious/mythological belief systems and thus may or may not be considered ritual behaviour.

The presence of material culture such as headdresses and other body adornments, i.e., pubic aprons and tassels, necklaces, hair belts, have been identified as an index of ceremonial or ritual activity that could potentially have been used by artists to also indicate the sex of the subjects (Johnston this volume, May et al. in press). For example, Johnston (this volume) argues that material culture as depicted in Dynamic Figure rock art such as ‘dancing skirts’, combined with the abundance and variability in headdresses signal that the anthropomorphic figures are male. It is the combination of material culture types and their abundance and variability that Johnston argues lends support to an interpretation that Dynamic Figure art is ceremonial or ritual in nature and is male dominated, even though the sex is not often represented anatomically.

While it is outside the scope of this paper to present an ethnography of headdresses in Aboriginal and Torres Strait Islander culture, it is important to note that material culture such as headdresses were (and in many cases continue to be) used by Aboriginal groups as part of ceremony. For example, Berndt and Berndt (1988:274) note the central place that material culture plays in ritual with bullroarers, ceremonial boards, stones, ceremonial poles and headdresses as key ceremonial items. In western Arnhem Land there are a range of sacred objects used in ritual, and given that many of these ceremonies are still actively practiced, much of this cannot be discussed. It can be stated however, that headdresses were used in some ritual performances in western Arnhem Land with ethnographic records illustrating this clearly[1] and our own contemporary observations at some minor ceremonial performances in Gunbalanya. Headdresses are iconic elements of ritual behaviour in the recent past and, we would argue, the rock art suggests this is a very long-held tradition throughout the Holocene. Indeed, radiocarbon age constraints for the NRF art style supports this assertion (Jones et al. 2017). Thus, such material culture is key to identifying and exploring ritual in rock art studies.

It is clear from both the descriptive statistics and the statistical tests that in both the Jabiluka and Red Lily NRF assemblages the stylistic variables of both sexes and

[1] We have chosen not to reference these publications due to local Aboriginal community concerns regarding the publication of sacred images in them.

material culture are significant. Both variables have the potential to communicate symbolic messages that inform interpretations of the social function of the rock art. The ethnographic literature strongly suggests that the presence of male figures and the material culture types in NRF art supports a ceremonial and or ritual-social function. However, most of the ethnographic recordings were made by non-Aboriginal men and cannot be said to represent a complete account of ceremonial life in this region.

In NRF styled art from both study areas the male sex is depicted in 49.9 percent of motifs, with female sex depicted in only 10 cases (1.8 percent) (Table 2). This is a marked change from earlier art styles such as Dynamic Figures where sex is not indicated for most of the figures (see, for example, May et al. in press). In fact, May et al. (in press) found that more of the Dynamic Figure anthropomorphs in Jabiluka featured breasts than a penis. Similarly in both NRF art and Dynamic Figure art, the human body is predominately depicted with a headdress, with both rock art styles showing great stylistic diversity in headdress types (Johnston this volume, May et al. in press). While the presence of headdresses in the NRF motifs in the assemblages presented in this paper are low (29 percent) in comparison to the total number of motifs, this is a reflection of the impact of taphonomic factors on the sample size. Generally, headdresses in NRF art are integral components of the motif. This can be argued due to two main factors: (1) there are no recorded depictions of a head, or separated head shape/form, in both assemblages, to the unbroken sinuous delineation which represents the mid body of the NRF motif, and (2) there is only 1 example in the motif assemblage from both study areas where the body of an NRF is not formed by a single line (i.e., has multiple lines indicating body). In some cases the upper end point of the body line of an NRF may be rounded or circular in shape (Figure 6) but there are no examples where a separate head shape is added, or incorporated into the end of the body line.

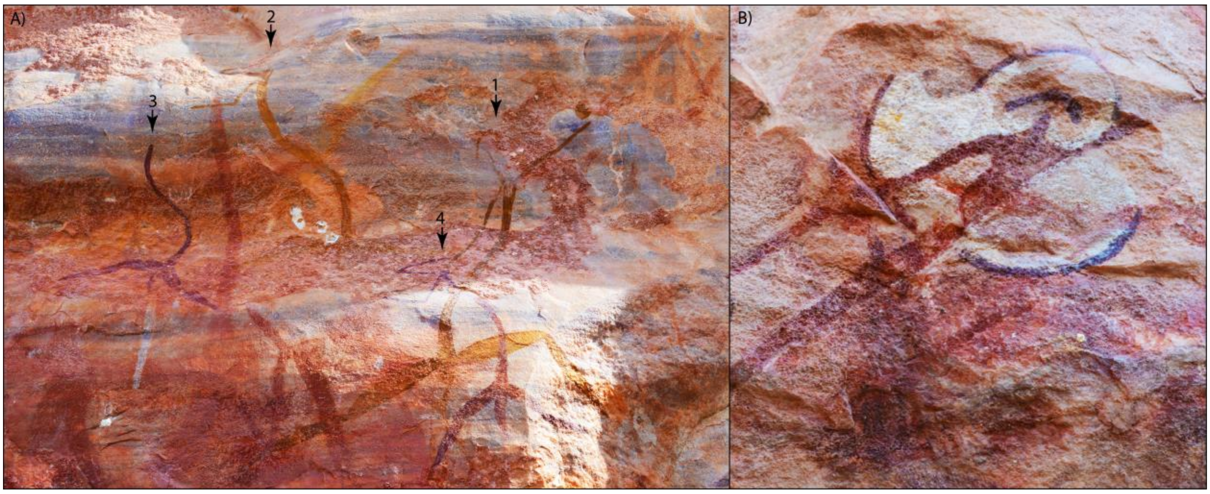


*Figure 6. A) A scene of NRF art featuring 4 discernible motifs (1-4), all with fugitive headdresses and a single body line. B) An example of an intact bichrome Bell type NRF headdress. There is no scale depicted due to panel location difficulties (photos: Tristen Jones, digital enhancement: Meg Walker).*

In lieu of a clear and defined head form being depicted at the top end of the unbroken sinuous delineation mid body line, a headdress is discernible in 29 percent (n=158) of NRFs. In 71 percent (n=385) due to taphonomic factors a headdress type cannot be clearly determined. This is most likely be a result of weathering due to the use of multiple pigments, which are not as long lasting as red ochres, thus creating figurative gaps in the motifs. This phenomenon has been noted by all other researchers who have studied NRFs (Chaloupka 1993:132, Haskovec 1992:150, Lewis 1988:37). There are multiple instances of intact uses of multiple pigments particularly in the design elements of the headdresses. Therefore, we have interpreted the 71 percent of 'indeterminate' headdresses as highly likely to have originally included headdresses. This is further supported by the fact that there were no instances of a NRF motif with a head and no headdress being depicted.

A ritual or ceremonial interpretation for the NRF art style is also supported when assessing art according to the criteria set out in the Ritual Form Model (RFM). The RFM identifies seven criteria that if present function as positive indicators of ritual behaviour communicated in rock art. These criteria are shaped by the universal structural form of ritual according to Rappaport (i.e., Rappaport 1999, Ross and Davidson 2006). The seven criteria are: *invariance; repetition; specialised time;*

*specialised space; stylised behaviour or form; performance and participation*; and *form which holds a canonical message* (Ross and Davidson 2006:312). In most categories, the NRF art style meets these criteria rigorously, particularly the criteria of invariance, repetition; specialised place and time, and stylised behaviour and form.

The definition of a singular art style in some manner confirms the RFMs criteria of invariance, repetition and stylised behaviour and form. More clearly, for a population of motifs to be considered an art style, there must be repeated form, methods, mediums and manners of depiction/design elements (e.g., Francis 2001, Sanz and Fiore 2014). These variables are determined by the choices of the individual artists producing the art, which in some way is influenced and determined by the social norms of the group to which the artists belong and the symbolic rules determined by the social function of the art and iconography itself.

In the case of NRF art, invariance, repetition and stylised behaviour and form is demonstrated in the dominant variables that classify this art type as an individual style. These variables primarily include:

- The unbroken sinuous delineation of the body of the anthropomorphic motif; commonly a single line that represents the head, neck, mid body to groin of the anthropomorphic figure. This body line is classically in an S shape with upper torso angled forward thus expressing movement;
- The depiction of indicators of male or female sex in the anthropomorphic form, with a dominance of male genitalia depicted; and,
- The presence of material culture namely the consistent depiction of a headdress, in combination with the occasional depiction of other material culture types such as boomerangs/hooked sticks, hand axes, spears and wearable adornments.

Combined with the placement of motifs on the rock surface the invariance and repetition of the stylistic variables produce a stylised form depicting stylised behaviour. NRF styled motifs are commonly depicted in groups (e.g., Figure 1, Figure 2, Table 1). The arrangement of motifs in groups, and the repeated occurrence of the NRF motifs on the same rock surface (panel) generates figurative ‘scenes’ that can inform interpretations of social structure and behaviours in rock art (May and Sanz 2010). The common essence of the NRF scene is movement (Figure 2). The impression of movement in NRF art is commented on by all previous rock art researchers who have studied the NRF art style (Chaloupka 1993:132, Haskovec 1992:150, Lewis 1988:36-38). Whether the motifs are running, dancing, falling or floating is irrelevant, but consistent depictions of a recurrent form and behaviour conforms to the criteria of the RFM. Additionally, invariance and repetition is again reinforced by the limited distribution of the art style (discussed further in specialised place).

The recent radiocarbon age constraints produced by Jones et. al. (2017) provides a minimum age for the continued production and circulation of the NRF art style and establish that the NRF art style was in production for at least 3,400 years. This is an exceptionally long time frame for transmission of information between individuals/groups of a set of social and cultural rules which govern the way in which NRFs are depicted. Thus, adhering to the invariance and repetition RFM criteria. Additionally, these results demonstrate NRFs were produced according to a specialised time. Higher resolution timing — such as calendrical or cyclical time constraints for NRF production at this time is unknown. There may be a possibility of deducing higher resolution specialised timing from excavated deposits. Chronometric age determinations for this rock art style have only been recently recorded, and at this time no excavations within the NRF distribution zone have sought to answer questions regarding the links between site occupation, seasonality and ritual behaviour at such high temporal resolution for the early to mid-Holocene.

The limited distribution of NRF art (i.e., the regional boundary) and the placement of NRF art in sites with very high rock art densities (Table 1) conforms to the RFM criteria of specialised place (and strengthens the other criteria of invariance and repetition). The criteria of specialised place is also supported by the non-significant results of the two $\chi$ tests which revealed that there is no significant difference between NRF complex size (MNI), and the corresponding total number of motifs in each rock art site, meaning that the number of painted NRFs depicted in a large rock art site, is not merely a reflection of increased total mass of rock art motifs. Rather the number of NRF motifs depicted, along with the arrangement and placement of the NRF motifs and the way they are depicted are selective choices made by the artist.

The importance of the criteria of specialised place in identifying ritual behaviours is also noted from observational data in the repeated selection of the same rock surfaces for NRF motifs, and the repeated selection of alternative rock surfaces for the painting and repainting of other art styles. This ‘clustering’ of NRF styled motifs on the same rock surfaces or in separated areas in large occupation sites may highlight the role of art practice in ritual behaviour itself. As does the occurrence of NRF repainting on the same rock surfaces and the choice by artists (whether they are NRF painters or otherwise) not to paint over the NRF friezes (Figure 2). For example, in both study areas the rock art sites with the highest frequency of NRFs (Jabiluka Site 2: n=41, and Red Lily Site 17: n=172) the majority of the motifs are painted on a single or limited number of rock surfaces (Figure 2). Additionally, in these sites there is evidence of repainting over the existing NRF depictions with new painting events solely depicting NRF art. Other localities recorded as having NRF presence and located within the proposed boundary of NRF distribution, such as Injalak Hill, also conform to this observational trend (Figure 1).

These NRF scenes have in the many instances not been painted over by more recent art styles. This again indicates not only individual but also collective choices of painting groups as it is extremely common for late Holocene art styles to overlay earlier art (this phenomenon has been quantified in the Red Lily study area by Wesley et al. 2017). Why then has complex arrangement of NRF motifs on the same rock surfaces not been painted over in many prominent sites and places? And why do they repaint the NRF style over older forms of the same art style on the same rock surfaces? These invariant and repetitive behaviours denoting choice in the selection of place for art styles may signify the practical role that NRF art practice may have played in the performance and participation of ritual. For example, Ross and Davidson (2006:325) in their discussion the RFM category of performance and participation hypothesise that rubbing, repainting, outlining and abrading may in fact serve as the strongest evidence of participation of people in ritual behaviour, and is supported in the ethnographic literature. Indeed, Mountford himself recorded instances in western

Arnhem Land where chanting at rock art motifs formed an integral part of increase ritual (Mountford 1956:262).

NRF styled art from both our study areas occurs in 57 percent of cases within major occupation sites with high density rock art assemblages (100+ motifs). This again heavily supports an interpretation that this rock art style is attached to specialised place, and that the content of this art style is not socially restricted. In fact the occurrence of NRF within a restricted distribution zone with a trend of occurring in sites with high assemblage density may be an example of how a rock art style has a ritual and or ceremonial function in large aggregations (Conkey 1980). In this instance we have not calculated overall rock art assemblage diversity in addition to NRF and rock art motif density, so a strong argument for NRF styled art and the styles' role in aggregation places remains a hypothesis.

The final RFM category — form which holds a canonical message — is the most challenging to identify in ancient rock art assemblages in specific terms. Rappaport (1999:51) defines the canonical as '… represent[ing] the general, enduring or even eternal aspects of universal orders'. The role of the canonical message in ritual then is to communicate a message of the higher order, above the present and with a greater meaning than limited to the individual act. This message is indexed through symbols that are encoded in the invariant aspects of the ritual (Rappaport 1999:58). All rock art motifs have the potential to carry canonical messages as they themselves are symbols whose social function is foremost to communicate with others. In the case of NRF art, the canonical message may lie in the stylised form (body line) and behaviour — the depiction and essence of movement. The canonical message may also be imparted to the viewer via the included material culture, in NRF styled art via the headdress. Colour range and order and size or shape of headdress may encode messages about the individual ritual status or rank of the wearer, or alternatively the identity or rank of the group whose role in the ritual communicates the higher order message. Assessing and comparing headdresses within and between NRF figure groups may allow an assessment of whether individual or group identity is being signalled, and may offer insight into the possible function of the symbol itself. The loss of some pigments from the headdresses made this difficult to discriminate from such a small sample size (for the Jabiluka assemblage), but with further recordings is an aspect of NRF art that may be explored in future research.

Ross and Davidson (2006:326) stress the value of persistence in demonstrating form which holds a canonical message in the RFM. The persistence of the ritual form is demonstrated in NRF art through the selection of place: limited landscape distribution; the repeated presence of NRF in high density rock art sites; and the painting and repainting of NRF art on selected rock surfaces. Persistence in the ritual form is also exhibited in the stylised form and behaviour expressed in the stylistic conventions of NRF art, which are known to continue for at least 3,400 years.

**Conclusion**

Our analysis of two NRF assemblages from both the Jabiluka and Red Lily study areas has confirmed that the core distribution zone previously hypothesised in the literature seems to be correct. However, our survey has also identified sites with NRF art style that are outliers from the core distribution zone. Additionally, we have identified a range of transitional styled motifs that contain some design elements that conform to the NRF manner of depiction, but in other cases do not. This study highlights the need for further research to disentangle the relationship between the NRF art style and other anthropomorphic human figures being painted during the same temporal phase, and to map the abundance and diversity of these concurrent anthropomorphic manners of depiction in the landscape. Furthermore, the rock art assemblages from both Jabiluka and Red Lily indicate that the frequency and abundance of NRF art within the distribution zone is much greater than has previously been reported (Haskovec 1992).

A ritual social function in NRF art is signalled in many ways but most poignantly through the marking of *specialised place*. By analysing the distribution, abundance and diversity and the archaeological site contexts of NRF art places, we have revealed that NRF art is commonly located in rock art sites with high motif densities, and that the selection of painting surfaces, the figurative narratives and essence, method and the mode of depiction appears to be a choice made by NRF artists to communicate a ritual message. The design elements of sex and material culture play an important communicative role in signalling this ritual function.

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# Chapter 5

**How old is X-ray art? Minimum age determinations for early X-ray rock art from the Red Lily' (Wulk) Lagoon rock art precinct, western Arnhem Land**

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Tristen Jones: Developed the research question. Undertook field work and recorded the rock art data in the Red Lily study area. Formulated the arguments in the manuscript. Drafted the majority of the manuscript, including introduction, site descriptions, methods, results, discussion and conclusion.

Signed: 27/3/17

**Tristen Jones**

Vladimir Levchenko: Sampled rock art for radiocarbon dating. Drafted radiocarbon methods. Calibrated radiocarbon data. Reviewed the discussion.

Signed:

28/03/17

**Vladimir Levchenko**

Daryl Wesley: Participated in field work and data recording. Produced figures where acknowledged.

Signed:

27/03/2017

**Daryl Wesley**

# How old is X-ray art? Minimum age determinations for early X-ray rock art from the 'Red Lily' (Wulk) Lagoon rock art precinct, western Arnhem Land

by

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## Introduction

A central and fundamental issue in rock-art research is where the art is placed in space and time (David et al. 2013). Discovering and applying new techniques to understand motif styles and their chronology will provide us with this information. Here we use a 'cabled' methodology (see Chippindale and Taçon 1998:93), where multiple lines of evidence are developed together, by combining absolute and relative dating techniques. Absolute radiocarbon dates are made on two different substances that have been related with relative dates derived by assessing motif superimpositions, the stylistic analysis of motifs, and degrees of preservation. Combined the absolute and relative methods provide reliable dates for the painted motifs on a rock art panel at Red Lily Lagoon Site 3 (see Figure 2.1). Radiocarbon dates were obtained for mineral accretions suspected to contain the minerals whewellite and whedellite (both are hydrated forms of calcium oxalate $CaC_2O_4$, and called hereafter 'calcium oxalate'), and from preserved non-reactive organics contained within ancient mud-wasp nest stumps. This is the first attempt to apply radiocarbon dating to these two different materials, calcium oxalate and mud-wasp nests, directly associated with the same rock art.

A combination of radiocarbon dating and optically stimulated luminescence (OSL) dating on mud-wasp nests has proved fruitful in dating rock art in the Kimberley (see Roberts et al. 1997). A previous Australian study used radiocarbon determinations for a calcium oxalate crust encasing rock fall within excavated deposits. Those results were compared with radiocarbon ages for charcoal samples in the same stratigraphic units (Watchman et al. 2005). These studies show the potential of both calcium oxalate and mud-wasp nests for radiocarbon dating of rock art. While both calcium oxalate and mud-wasp nest samples each have limitations for radiocarbon dating (cf. Aubert 2012; Bednarik 1996, 2000, 2002, 2007; David et al. 2013; Gillespie 1997; Rosenfeld and Smith 1997), our study has found that multiple radiocarbon age determinations from these two different substances can together generate robust dates for rock art.

**Red Lily Lagoon Site 3**

Red Lily (Wulk) is a coastal freshwater lagoon within the vast floodplains of the East Alligator River catchment area. The lagoon is found c. 5 km northeast of Cahill's Crossing on the main Oenpelli Road (Figure 2.1). The region falls within the territory of the Gagudju/Erre/Mangereridju language group, and forms part of the Manilakarr clan estate. Red Lily Lagoon is bordered on its eastern side by the western Arnhem Land Proterozoic Kombolgie Sandstone massif. This most western section of the plateau converges with Red Lily Lagoon, and the adjacent Kakadu wetlands, as a steep escarpment, varying in elevation from 50 m to 400 m above sea level (ASL).

The floodplains that surround the escarpment are annually inundated , re-filling permanent lagoons and billabongs, and at times submersing the majority of the land surface. It is within this landscape that the major archaeological site complex of Red Lily is situated (for a more comprehensive environmental and historical background for Red Lily Lagoon, see Chapter 2).

Red Lily Lagoon Site 3 is situated on top of the plateau at an approximate elevation of 70 m ASL, 700 m west of Red Lily Lagoon. The site is a major sandstone rock stack On all sides of the rock stack, intensive weathering has generated deep overhanging shelters with rock floors, some with shallow sandy deposits, and isolated sandstone boulders. (For a description of the formation of rockshelters in Arnhem Land's quartzitic sandstone stacks, see Chapter 13.)

Each side of the rock stack is reported as a separate section, termed Areas A–D; each is a distinct and major rock art shelter in its own right. As field time was limited, all art panels were mapped, but not all individual motifs recorded. Overall, the Red Lily Site 3 rockshelters contain over 700 rock art images in a range of different art styles. These span the Early, Middle and Late periods outlined in Chippindale and Taçon's regional stylistic chronology (Chippindale and Taçon 1998:107). For example, rock art includes hand and foot stencils, 'Large Naturalistic' figures, Northern Running / Mountford figures, early X-ray, and representations of the Complete Figure Style, including stick figures, simple energetic figures, full figures, and recent X-ray figures. There is also European contact-period imagery. Painting methods, forms and pigment types are variable. Motifs range from full-bodied, intricately detailed figurative representations of animals, applied with fine brushwork, to rudimentary-lined human figures. Pigment colours include red, orange, black, white, and yellow, with many complex images bichromatic or polychromatic. Notable motifs include four painted in Reckett's Blue pigment in Area B, and a high number of hand, forearm and foot stencils in Area C. Reckett's Blue is the commercial name given to a laundry product used to whiten clothing (Chaloupka 1993:84). The use of Reckett's Blue as a paint was first reported in the Alligator Rivers region in 1912 by Baldwin Spencer (1928:831). Chaloupka (1993:84) suggests that the blue pigment found widespread use after the introduction of Reckett's Blue by Oenpelli missionaries in 1925.

The panel here studied is in Area D (Figure 7.1). Area D consists of three panels with Panel 2 containing the majority of rock art images. The rock wall surface, facing northwest, measures 6 m in width by 1.2 m in height. The rock surface is well sheltered from the elements, with the dripline more than one metre from the panel surface. However, the condition of the panel is quite poor: it is affected by both mud-wasp nests and termites; mineral crusts and some parts of the rock face are spalling. The recording team perceive about 40 highly weathered rock paintings, some superimposed on the rock wall. Nonetheless, some images, and a basic sequence of superimposition of the clearest motifs on the rock wall, can be deciphered (Figure 7.2).

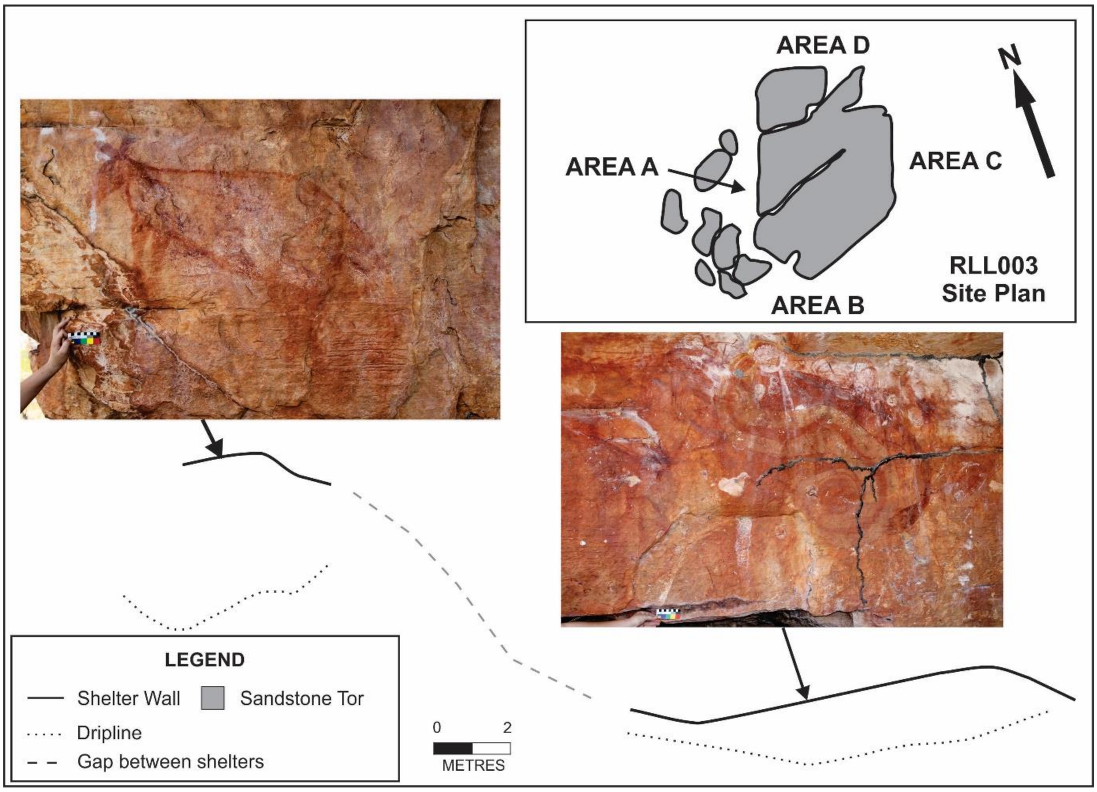


**Figure 7.1**. Plan of Red Lily Lagoon Site 3, Area D (site map: Rose Whitau and Daryl Wesley).

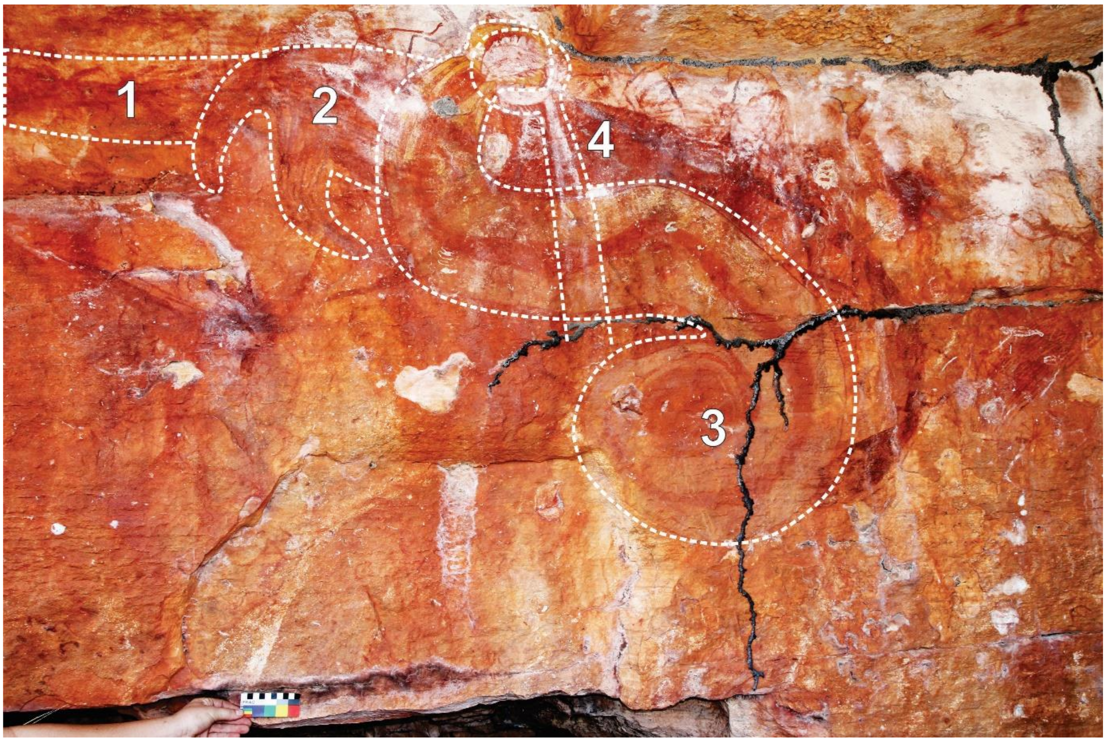


**Figure 7.2**. Red Lily Lagoon Site 3, Area D Panel 2, highlighting the sequence of rock paintings. The numbers of the highlighted sections 1–4 refer to the motifs 1–4 contained within them (photograph: Damien Finch).

*Motif 1*

Motif 1 is a very large red motif, composed of distinct sinuous line. It spans much of the rock wall. Parts of the motif are solid infilled with protruding lines that are suggestive of spines. The motif spans left to right, across and down the rock surface. It is unknown where this motif lies in the relative sequence of artworks on this panel. The image is not clear enough to determine its exact shape, or indeed its corresponding style. The “spines” are reminiscent of those common in ‘Yam’ style Rainbow Serpents (Taçon et al. 1996). The image is superimposed by others, as outlined below.

*Motif 2*

Motif 2, in the upper left hand section of the panel, is a red unidentifiable animal with hind limbs and the remnants of a tail. It is delineated by a solid line, and decorated with the linear infill characteristic of ‘Large Naturalistic’ figures (Chaloupka 1993:94). Motif 2 overlies Motif 1.

*Motif 3*

Motif 3, the predominant image on the panel, is the best preserved. It is a red outlined bichrome S-shaped motif, clearly depicting a snake. The motif is large, measuring 110 cm in length and 90 cm in width. The red pigment is better-preserved than the yellow. The head of the snake is segmented, and is red and solid. Throughout the length of the body, a solid red segment also features, outlined by yellow pigment on either side. Starting from the head of the snake two parallel red lined segments following the curved S-shape of the snake border the main solid infill. The decoration features areas of solid infill, creating a block yellow to red patterning. This feature is lost throughout most of the snake’s body due to weathering. There are also early X-ray features, such as a characteristic main body cavity with a thick line running through it representing a backbone (e.g. Taçon 1989: Figure 18; see Figure 7.3). Motif 3 overlies Motif 2.

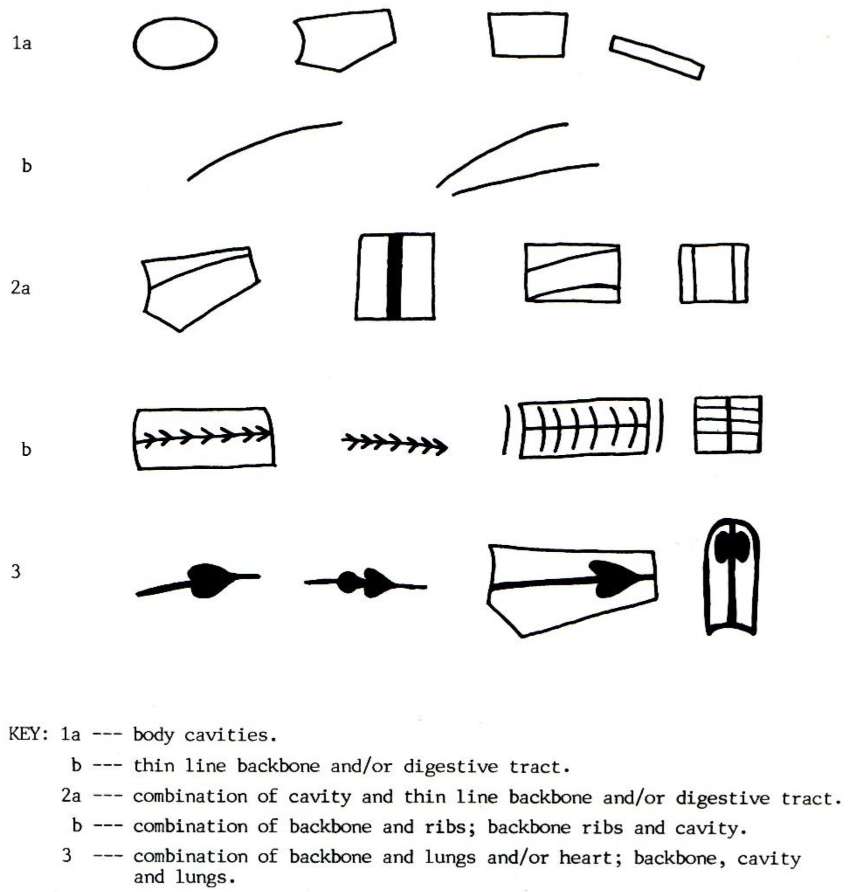


**Figure 7.3**. Early X-ray attributes, some of which are depicted in Motif 3 (reproduced with permission: Taçon 1989: Figure 18).

*Motif 4*

The topmost layer in the painting sequence is comprised of a white anthropomorphic figure. Extensive weathering has resulted in only part of the motif remaining on the rock wall, that of the head and upper body. The bichrome figure consists of a red outline, infilled with white pigment. The figure is depicted in profile, as is common in human-like representations, with the head a hollowed C-shape. Chaloupka (1993:148-149) refers to such depictions as 'hooked face' figures. These types of human figures have been categorised as part of the 'Complete Figure Style' (Taçon 1992:204-205). Motif 4 overlies Motif 3.

**Style and preservation as indicators of antiquity**

For many decades rock art researchers have utilised the method of grouping rock art motifs into 'styles' or manners of depiction, creating a relative sequence of change in artistic depiction over time. For western Arnhem Land, the original stylistic sequence proposed by George Chaloupka in various publications, including his hallmark *Journey in Time* (Chaloupka 1993:89), was modified and further developed by Chippindale and Taçon (1998:107), which is referenced in this study.

The classification of motifs according to style at Red Lily Lagoon Site 3 Area D Panel 2 is problematic. While the shape of Motif 1 is uncertain, the presence of spines suggesting a backbone signals some kind of zoomorph. While the decorative attribute of spines has previously been categorised as typifying 'early X-ray' art (Figure 7.3), the spines feature on the outside of the painting. Therefore the spines are more likely to indicate decorative features seen in 'Yam'-style Rainbow Serpents (Taçon et al. 1996). Taçon (1989), defines the internal attributes that constitute the 'early X-ray' style (see Figure 7.3), some of which are present in Motif 1, but also occur in Motif 3 of Panel 2.

Motif 2 is a depiction of a naturalistic macropod, as the motif is drawn with a free-flowing outline and is textured with linear infill (Chaloupka 1993:94). Chaloupka's categorisation of 'Large Naturalistic' animals as one discrete category of painting type that only appears at the beginning of the Arnhem Land sequence is inaccurate. Lewis succinctly summarises the issue as follows: "the style of large naturalistic animals and humans is ill-defined and it may actually consist of a number of similar styles present throughout the entire sequence of Arnhem Land art" (1988:72). Indeed, the depictions of large animals are very common, many researchers having identified paintings in a 'Large Naturalistic' manner throughout the entire sequence, particularly throughout the Early and Intermediate period (cf. the Large Fauna Style of Chippindale and Taçon 1998).

The predominant motif in Panel 2 – Motif 3 – is a large snake. This motif is better preserved than any other rock painting on the panel. The segmentation of the head and the inclusion of both solid and patterned infilled segments clearly denote this image as an X-ray painting. The X-ray painting tradition has been argued to span some 8000 years (Taçon 1989, 1992) and therefore the categorisation of the motif according to 'style' does not provide a high resolution age estimation for the motif. The use of two colours, red and yellow in combination, suggests that the motif may have been painted in the late Holocene. Instances of bichromatic early X-ray are uncommon, accounting for only 5.7% of the total number of paintings recorded by Taçon (1989:121-122). On the other hand, in recent X-ray art, which Taçon defines as occuring from 3000 BP to present, bichromatic representations are the most common, making up 60.2% of the samples (Taçon 1989:124). Additionally, the combination of red and yellow pigment is the second-most popular extant pigment combination after red and white in recent X-ray rock art (Taçon 1989:126). Differentiation of motifs as either early or recent X-ray in style may also rely on the subject matter of the motif. Many researchers have argued that changes in faunal depictions through time signal changing environmental conditions (Chaloupka 1993:88). Taçon rightly notes that freshwater animal species begin to predominate in early X-ray paintings. As such, the commencement of early X-ray art is thought by many researchers to correspond with mid to late Holocene environmental conditions, such as are evident in the Kakadu wetlands of today (Brockwell 1996; Taçon and Brockwell 1995). As the subject matter of Motif 3 is formally a generic depiction of a snake, and as snakes are known to exist in both wet and dry environments, the faunal taxon cannot itself be used as an indicator of the painting's age. The snake's depiction in this instance does not have any characteristic features of a 'Rainbow Serpent'. Rainbow Serpents are commonly depicted with elaborately detailed tails, and plant and animal appendages, macropod-like heads, and cross-hatching decorative features (Taçon et al. 1996). Motif 3 does not feature any of these attributes.

'Indirect' dating methods place Motif 4 in the late Holocene. While the full diversity of human-like representations in western Arnhem Land art remains a topic of ongoing research (Chippindale and Taçon 1993), the attribute of a hooked face, or C-shaped head, is akin to the facial features of 'Energetic' stick figures. 'Energetic' stick figures are commonly depicted in the rock art record of the wider Red Lily Lagoon area. Typically, these figures are frequently painted with material culture, particularly weaponry (Chaloupka 1993:148-9). The presence of weaponry in rock art paintings has previously been used as an indicator of the relative age of depictions (Lewis 1988). However, poor preservation of the painting has eliminated any potential evidence of material culture, and as such cannot be used to assist in estimating the age of Motif 4. It is assumed that the condition of the painting is due to the fact that the motif is painted in white pigment, which is acknowledged to have the least permanency of all pigment types perhaps apart from charcoal (Chippindale and Taçon 1998:103-104). According to Taçon 'Energetic' stick figures are a sub-category of the 'Complete Figure Style'. This style incorporates many different forms of art, including 'full figures', 'stick figures', stencils, beeswax images and prints. He argues that the 'Complete Figure Style' co-existed with 'Recent X-Ray' and is assigned an age range from 3000-2000 BP to present (Taçon 1992:204-206). On this basis, we assume that Motif 4 was painted during this period and has a maximum age of 3000BP.

**Sample selection and methodology**

The rock surfaces and panels of Area D were surveyed for radiocarbon sampling, with particular attention concentrated on the white accretions and mud-wasp nests present along sections of the rock wall. The presence of a mineral coating possibly containing calcium oxalate (whewellite $CaC_2O_4.H_2O$ and weddellite $CaC_2O_4.2H_2O$) was identified and in areas the whitish growth was covering part of Motif 3. Additionally, remnants of an ancient mud-wasp nest were also present in close proximity to the mineral crust and located adjacent to Motif 3 (Figures 7.4, 7.5). Three samples of coating material were collected from the rock surface (Sample 3-4-1, Sample 3-4-2 and Sample 3-4-3) (Figures 7.4, 7.5). Sample 3-4-1 is of the mineral accretion that overlies part of Motif 3. The accretion covers the red and yellow segment patterning depicted in the upper neck of the snake (Figure 7.5). Sample 3-4-2 is from the remnant mud-wasp nest. The mud-wasp nest is situated adjacent to the right of the main body of the snake painting (Figure 7.5). Sample 3-4-3 is a mineral accretion that overlies the red outline of the mid-body of the snake painting (Figure 7.4). All samples were removed using a diamond disk Dremel® drill, producing bulk crust removal in powdered form. Powder was captured in clean individual sheets of aluminium foil, and emptied into clean centrifuge tubes.

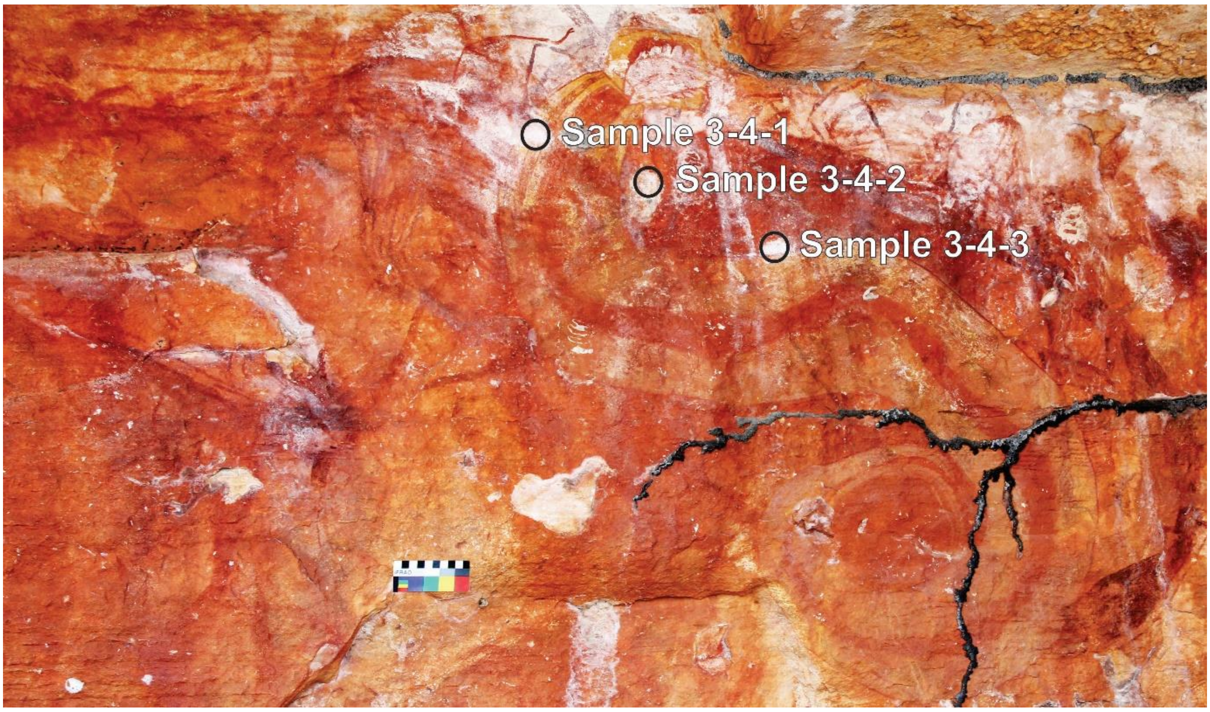


**Figure 7.4**. Panel 2 showing sample locations for radiocarbon age determinations (photograph: Damien Finch).

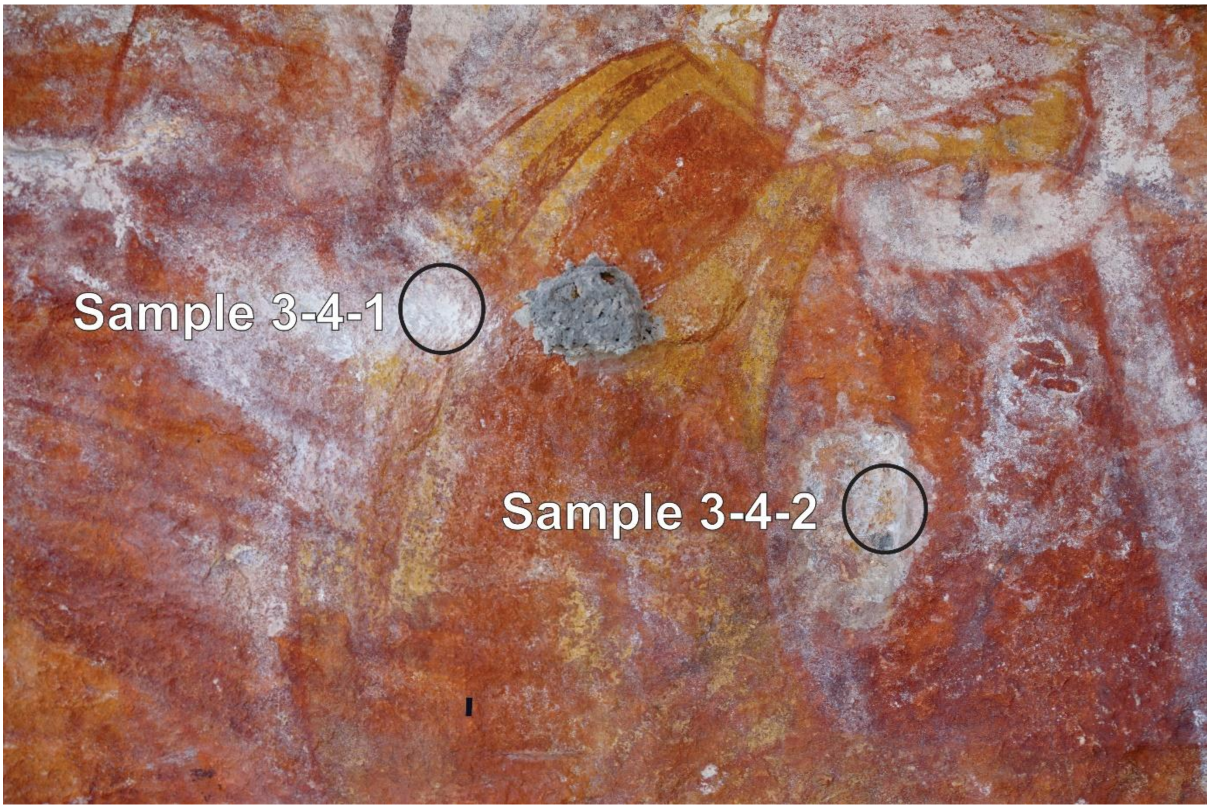


**Figure 7.5**. Location of samples collected for radiocarbon dating (photograph: Vladimir Levchenko).

Once removed from the field, all samples were taken to the Australian Nuclear Science and Technology Organisation (ANSTO) research laboratories. Samples were registered and weighed, and aliquots taken from those expected to be of oxalate origin (RLL3-4-1 and RLL3-4-3). Aliquots were sent to the Australian National University's (ANU) Research School of Earth Sciences laboratories to test for the presence of calcium oxalate using Fourier Transform Infrared Spectroscopy (FTIR) and X-Ray Diffraction (XRD). The latter two mineralogical methods did not detect calcium oxalate suggesting that any oxalate that might be present was below the level of a few percent. Additionally, the FTIR and XRD results confirmed the presence of minor phosphates (tinsleyite, taranakite), sulfate (gypsum) and natural weathering products such as amorphous materials, quartz and mica / kaolinite.

Sample RLL3-4-1 was processed at ANSTO. The sample was pre-treated to remove potential carbon-bearing contaminants according to the following procedure. The powdered material was placed in a centrifuge tube with excess of 5% NaOH solution at 60°C for one hour. At this step various organic acids and non-acid soluble paint solids were transferred into the solution. Solution was centrifuged and the supernates decanted, and retained in case of further analysis. After rinsing with Milli-Q® water, the samples were treated with 6M HCl at 60°C, to remove possible carbonates and to dissolve whewellite and whedellite minerals. After one hour, the solution was centrifuged and supernates decanted and saved. This time the precipitates, possibly containing various more or less inert solids (silica, pollen, charcoal, some non-reactive organic matter) were retained for separate analyses; these are referred to as the 'residue' in this chapter. The decanted solutions containing oxalic and HCl acids and their salts were dried down (HCl volatilises), sealed in quartz combustion tubes and combusted at 900°C, as described elsewhere (Hua et al. 2001). Separate residue fractions were rinsed in Milli-Q® water multiple times, dried, and also sealed in combustion tubes and correspondingly combusted in the same conditions. Evolved $CO_2$ was cryogenically purified and collected, and its yield determined. Then it was converted to graphite following standard graphitisation procedures (Hua et al. 2004).

Sample RLL3-4-2, the remnants of the mud-wasp nest, was pre-treated at ANSTO following standard ABA procedures (Hatté et al. 2001). As per the following, the weighed powder was placed in a centrifuge tube and treated with 2M HCl for 2 hours at 60°C, followed after centrifuging by multiple Milli-Q® rinses. The next step included multiple treatments of 0.5% up to 10.0% NaOH for 2 hours each at 60°C (until two consecutive treatment solutions remained clear). After another Milli-Q® rinse the third step consisted of 2M HCl at room temperature overnight and multiple Milli-Q® rinses until a near-neutral pH of the solution was achieved. The sample was oven-dried at 60°C. This treatment effectively removes all carbonates, humic and fulvic acids, fats and lipids, leaving behind pollen, charcoal dust (soot), and possible powdered macrofossils material. The dried sample was placed in a sealed quartz combustion tube similar to the oxalate sample, combusted to $CO_2$, which was again cryogenically purified and collected, and converted to graphite.

Graphite targets were pressed into aluminium cathodes, and the $^{12}C/^{14}C$ ratio determined on ANSTO's STAR and ANTARES accelerator mass spectrometry (AMS) installations (Fink et al. 2004). In parallel with real samples, a set of chemistry procedural blanks was prepared to determine the level of possible contamination through the preparation process and corrected for this in data evaluations. Smaller samples are more likely to be contaminated, resulting in relatively large error bars of radiocarbon determinations for the smallest sample sizes.

Determinations of $\delta^{13}C$ were done on the residue of graphite targets derived from the studied fractions after the radiocarbon measurements were completed. Measurements were performed on a separate elemental analyser Elementar varioMICRO CUBE coupled to a Micromass Isoprime IRMS machine. If graphite residues were too small for a measurement the average value for the same type of samples from the area was used for isotope fractionation correction.

### Radiocarbon age determinations

The radiocarbon calibrated age determinations of the calcium oxalate and mud-wasp nest samples fall within c. 210 years between their median values. They both indicate an early to mid-Holocene age of somewhere between 5068 cal BP and 6636 cal BP, taking the 95.5% probability calibrated age ranges into account (Table 7.1). That the ages of two different dated material types converge – calcium oxalate and the mud-wasp nest – is very encouraging. Each of these sample types has a different kind of formation history, has been subject to different pre-treatments, and has a different dated fraction. This suggests the robustness of radiocarbon method for both of the dated materials, particularly in the utilisation of calcium oxalate minerals for radiocarbon dating.

In this study we have reported two radiocarbon age determinations for sample RLL3-4-1. The first date is produced from the carbon contained within the calcium oxalate mineral only, isolated in sample pre-treatment. The second radiocarbon age determination is produced from the mineral crust residues (inert solids such as silica, pollen, charcoal, some non-reactive organic matter) contained within the sample. The calcium oxalate mineral crust returned an age of 5068-6636 cal BP which, judging by the median age probability, precedes the mud-wasp nest formation on the rock wall by a few centuries (Table 7.1). The calcium oxalate mineral crust has produced the oldest age, and as such it can be considered the *terminus ante quem* for the underlying snake image (Motif 3). The radiocarbon determination for the calcium oxalate sample was produced as a bulk measurement. Therefore all calcium oxalate mineral deposits which relate to mineral formation events and are stratified temporally in the crust have been combined into one sample. Hence the produced age of the calcium oxalate represents an averaged result.

The mineral crust residue radiocarbon age, 4445-5446 cal BP, is determined from the carbon contaminates contained within and on the mineral crust (Table 7.1). The younger age of the residue may be due to the continual integration of carbon contaminants throughout the growth history of the crust, in conjunction with a build-up of carbon pollutants on the rock surface. Mineral crusts are known to grow sporadically over a period of time dependent on micro-environmental conditions. Considering the age spread between the coating minerals

**Table 7.1**. Radiocarbon determinations.

| ANSTO code | Sample Type | Submitter ID | Extracted carbon, µg | $\delta^{13}C$ ‰ | Radiocarbon pMC (±1σ) | Radiocarbon age BP | Cal BP age (2σ range) | Median probability |
|---|---|---|---|---|---|---|---|---|
| OZR994U1 | Mineral crust: oxalate | RLL3-4-1 | 9 | -10.0* | 52.40 ± 2.02 | 5190 ± 310 | 5068-6636 | 5906 |
| OZR994U2 | Mineral crust: residue | RLL3-4-1 | 23 | -11.3* | 57.94 ± 1.15 | 4380 ± 160 | 4445-5446 | 4953 |
| OZR995 | Mud-wasp nest | RLL3-4-2 | 520 | -6.7 ± 0.1 | 53.56 ± 0. 21 | 5015 ± 35 | 5605-5875 | 5697 |

* Results have been calibrated using CALIB 7.1 (Stuiver and Reimer 1993) using Southern Hemisphere 2013 calibration curve (ShCal13) (Hogg et al. 2013). The value of $\delta^{13}C$ is assumed from determinations of similar type samples. A measured value is not available due to the small size of samples. For explanations of two dated fractions for mineral crust sample, see text.

and the mineral crust residue, we can assume that the calcium oxalate mineral has been growing over a considerable length of time (Hassiba et al. 2012).

The radiocarbon age determination for the mud-wasp nest is 5605-5875 cal BP (Table 7.1). This date is interpreted as representing the moment of mud-wasp nest construction, as the organic components, such as pollen, spores, phytoliths and charcoal dust, are gathered and integrated into the structure of the nest by mud dauber wasps during the construction process (Bednarik 2014; Roberts et al. 1997). While some mud dauber wasps prefer to construct nests on the remnants of pre-existing nests, visual inspection upon sampling the mud-wasp nest residue in the field indicated that in this instance there was only a single nest-building event. Therefore, carbon age averaging from multiple nest-building events is unlikely. Contrary to the calcium oxalate sample, the mud-wasp nest does not overlie Motif 3 or Motif 4. The mud-wasp nest is located adjacent to the snake motif. As the mud-wasp nest is younger than the calcium oxalate crust, it must have developed on the rock surface after the painting of Motif 3.

**Discussion**

A paucity of chronometric ages directly dating rock art remains an ongoing issue in rock art research worldwide (Aubert 2012; David et al. 2013). In Australia, a recent review of direct dates revealed that while there is a substantial number of age determinations for rock art, particularly in the Northern Territory (244 age determinations accounting for 56.4% of the national data-set), the majority (74%) of the age determinations are from beeswax rock art designs (Langley and Taçon 2010). The ages produced from beeswax figures are predominately of late Holocene antiquity; indeed 81% of the age determinations generated from beeswax samples in the Northern Territory are less than 500 years old (Langley and Taçon 2010). The predominance of chronometric age determinations from beeswax motifs is largely due to the fact that the material generally contains the most $^{14}C$ for radiocarbon dating. Additionally, dating beeswax motifs produces age determinations for the actual art object and the material is far less likely to be affected by carbon contamination, carbon recycling and sampling issues that plague the use of calcium oxalate and mud-wasp nest substances for radiocarbon dating (Bednarik 2012). Langley and Taçon conclude of western Arnhem Land: “The dominance of dated beeswax figures in this region means that while the chronology of this medium is now quite well understood, three remaining media (paintings, engravings and cupules) remain largely disarticulated from a regional chronology” (Langley and Taçon 2010:71).

Concerns in the literature regarding the use of calcium oxalate minerals for radiocarbon dating rock art have focussed on the unclear nature of the mineral's developmental pathway, the unknown rate of mineral formation and the technical sample processing limitations in the separation of carbon-bearing components. These issues have previously stalled the widespread use of calcium oxalate as a substance for radiocarbon dating and acceptance of published radiocarbon age determinations generated from calcium oxalate minerals. The sample preparation methodology utilised in this study is a novel carbon compound-specific separation technique, which effectively isolates the carbon compound in the calcium oxalate minerals in sample pre-treatment (refer to methodology above). The result is two separate age determinations produced from the calcium oxalate mineral, and the carbon 'residues' contained within the mineral crust respectively. The residue carbon is assumed to be integrated into the formation of the mineral growth throughout the mineral crust's life span, and may also incorporate carbon pollutants residing on the mineral crust's surface. The refinement of this sampling procedure and the ramifications for the interpretation of radiocarbon age determinations is the subject of ongoing research and will be discussed in future publications (Jones et al. 2017). For this study, however, the considerably younger age of the mineral crust residue is proposed to be a result of the continuing build-up of carbon pollutants on the crust's surface. While the calcium oxalate mineral crust at some unknown point in time ceased growing, accumulation of carbon pollutants has remained ongoing to the present day.

The younger age of the mineral crust residue demonstrates the efficiency of the sampling pre-treatment cleaning procedures and compound-specific isolation method employed in this study. Previous radiocarbon age determinations using traditional acid-base-acid (ABA) sampling pre-treatment techniques may have failed to remove some carbon contaminants present in calcium oxalate mineral crust samples, like charcoal dust, pollen, etc. This previously unresolved reliable pre-treatment issue has been the cause of much of the critique of the calcium oxalate radiocarbon dating results. The radiocarbon age determinations produced in this study highlight the potentially significant impact that carbon pollutants can have on radiocarbon age determinations. In this example, it can be assumed that without the separation of the mineral crust residues from the calcium oxalate, the mineral crust radiocarbon age determination would have been significantly younger.

Recent discussions in rock art dating have noted the rich organics contained within mud-wasp nests, and their suitability for radiocarbon dating has remained an under-exploited resource in rock art dating (Bednarik 2014). While previous studies have assessed radiocarbon ages from organics within mud-wasp nests in comparison to OSL ages (Roberts et al. 1997, 2000), the potential to exploit other methods, such as calcium oxalate radiocarbon dating, for comparative analysis in determining age estimations for rock art has been identified as a growing area of research (Bednarik 2014). The fact remains that problems persist for all 'direct' dating methods in rock art research, placing significant constraints on our ability to generate chronometric age estimates for rock art. However, while we have only presented three age determinations in this study, the results demonstrate that robust age determinations using both radiocarbon dating approaches can be produced. The resolution of questions surrounding the validity of methods in this case is in the combination of multiple radiocarbon age determinations generated from different substances. This methodology has been suggested previously on many occasions by rock art researchers (e.g. Bednarik 2012). In this instance, generating age determinations from multiple sources also lends weight to the potential of dating both calcium oxalate and mud-wasp nests, and advocates for the ongoing adoption of both approaches. It also highlights the substantial opportunity for rock art researchers to date both materials more frequently, due to the common occurrence of both calcium oxalate mineral accretions and mud-wasp nests overlying rock art in northern Australia.

The radiocarbon ages indicate that the minimum age (median probability) for the snake painting (Motif 3) is 5906 cal BP (Table 7.1). The painting has been interpreted as being of the early X-ray style, due to the presence of linear and segmented infill features. These decorative features are highlighted by the use of yellow and red pigments. While the poor preservation of both Motif 1 and Motif 2 render it difficult for a complete description to be established for either motif, they must be older than Motif 3 as they occur beneath it.

According to Chippindale and Taçon's stylistic regional chronology, early X-ray style is positioned between the Intermediate and Late period, and is assumed to appear *c*. 6000 years ago, co-existing with 'Simple Figures', 'Yam Figures' and 'Large Human' and 'Large Fauna' styles. The radiocarbon age determinations produced in this study supports the assumed ages for this art style in the relative regional chronology. Furthermore, our new age determinations compliment the previous proposition by Taçon (1989:119, 1992:203) who, by utilising motif superimpositions and stylistic analysis, estimated an upper age limit for the introduction of the early X-ray technique to between 8000-6000 BP. His reasoning for this time frame was the existence of early X-ray attributes appearing underneath the 'Yam' and 'Simple Figures with Boomerang' styles, while acknowledging that the upper age limit may be open to further investigation. It is important to note that the radiocarbon age of Sample 3-4-1 is a minimum age for the underlying painting, as the calcium oxalate mineral crust overlies the snake painting (Motif 3). The age gap between the Motifs 1-3 painting events, and both the growth of the calcium oxalate mineral crust and mud-wasp nest, is not known and the actual painting event may have taken place many years before.

Most rock art researchers have discussed the problems associated with generating age estimates for rock art by employing indirect dating methods. Yet in-depth discussions addressing the implications of *underestimating* style age ranges has to date been missing in the literature. The radiocarbon age determinations produced in this study demonstrate that X-ray attributes occur in rock art motifs from the mid-Holocene. In fact, they may potentially occur much earlier. In this instance, the painted rock art surface (Panel 2) occurring at Red Lily Lagoon Site 3 is well protected from environmental decay, particularly water erosion. The dripline above Panel 2 is at some points nearly 2 m from the painted rock wall, providing a micro-environment that has produced greater conservation outcomes than normally would occur at other rock art sites.

It must be noted that the appearance of early X-ray rock art during the early to mid-Holocene corresponds with major environmental and climatic changes that occur in the East Alligator River region after sea-level stabilisation *c*. 8000 to 6000 BP (for further discussion, see Chapter 2, this volume). Significant changes occur in archaeological assemblages during this period, such as the appearance of shell middens at Ngarradj Warde Djobkeng (Allen and Barton 1989; Kamminga and Allen 1973), major changes in stone artefact technologies (Hiscock 1999, 2011) and the occupation of Birriwilk to the south of Red Lily Lagoon Site 3 (Shine et al. 2013). Taçon and Brockwell (1995) and Taçon et al. (1996) suggest that these archaeological changes in the early to mid-Holocene parallel the development of new rock art traditions. The radiocarbon age determinations produced in this study support that proposition.

## Conclusion

This study has undertaken radiocarbon dating on different types of materials in order to complement and test relative methods of assessing motif antiquity. First, the relative methods of motif superimposition, stylistic analysis of motifs and motif preservation were employed. Then radiocarbon dating was utilised on mineral accretions containing calcium oxalate, and carbon-bearing material contained within ancient mud-wasp nests. This is the first attempt in rock art research to apply radiocarbon dating utilising these two different types of datable materials, calcium oxalate and mud-wasp nests, directly associated with a single item of rock art. Novel developments in sampling pre-treatment for calcium oxalate mineral crusts have resolved some of the previous criticisms of this method of radiocarbon dating, increasing the confidence of age determinations. Combined with supplementary radiocarbon ages produced from mud-wasp nests, the results of this study have demonstrated that the adoption of multiple radiocarbon age determinations generated from different substances can greatly assist rock art researchers to generate robust radiometric data regarding the antiquity of rock art. Coupled with an 'indirect' dating analysis, evaluating the painting sequence, stylistic and preservation attributes of the rock art, this study reliably proposes a minimum age of 5068-6636 cal BP for the introduction of early X-ray art in western Arnhem Land rock art. This mid-Holocene age determination is supported by previous chronological schemas, and parallels the changes evident in other archaeological assemblages occurring during this period in the region.

## Acknowledgements

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## Chapter 6

**Rethinking large naturalistic animal forms in early western Arnhem Land rock art**

Authors: Tristen Jones, Sally K. May, Daryl Wesley, Iain G. Johnston, Clare McFadden and Paul S. C. Taçon.

Publication: Australian Archaeology

Current status: In Review

Tristen Jones: Developed the research question. Undertook field work and recorded the data in the Red Lily study area. Formulated the arguments in the manuscript.

Produced the data for the manuscript. Drafted the majority of the manuscript, including introduction, site descriptions, methods, results, discussion and

conclusion.

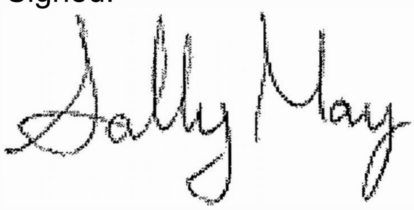
Signed:

27/8/17.

**Tristen Jones**

Sally K. May: Undertook field work and recorded the data in the Jabiluka and Dangurrung (Mt Brockman) study area. Refined the arguments and drafted revised copy in the manuscript. Edited the manuscript.

Signed:



**Sally K. May**

Daryl Wesley: Undertook field work and recorded the data in the Mikinj study area. Edited the manuscript. Produced figures where acknowledged. Signed:

27/03/2017

**Daryl Wesley**

Iain G. Johnston: Undertook field work and recorded the data in the Jabiluka and Dangurrung (Mt Brockman) study area. Produced the data for the manuscript. Edited the manuscript.
Signed:

**Iain G. Johnston**

Clare McFadden: Produced data for the manuscript. Assisted in the production of manuscript tables. Copy editing and style-guiding reference list.
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**Clare McFadden**

Paul S. C. Taçon: Undertook field work and recorded the data in the Jabiluka and Dangurrung (Mt Brockman) study area. Refined the arguments and drafted revised copy in the manuscript. Edited the manuscript. Provided extra data.

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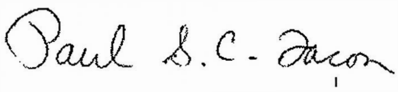

**Paul S. C. Taçon**

Research Article

# Rethinking large naturalistic animal forms in early western Arnhem Land rock art

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**Keywords:** macropods, rock art, Arnhem Land, naturalistic style, superimposition, chronology

**Abstract**
In this paper we report on the distribution, frequency and nature of early naturalistic macropod paintings from 861 rock art sites across western Arnhem Land. The results map the stylistic design elements used by artists in the depictions of early naturalistic animal forms that occur through the Early and Middle Periods (from Pleistocene to mid Holocene) in western Arnhem Land. We present the first reported quantifiable data set of attributes for this regional art type. The results provide an opportunity to re-evaluate the existence and coherence of a class of rock art termed the Large Naturalistic Style as originally proposed by rock art researcher George Chaloupka in the 1970s (1977; 1979; 1985; 1993).

**Introduction**
Depictions of animals in large naturalistic forms are reported to dominate some of the earliest figurative rock art assemblages from around the globe (Aubert et al. 2014; Clottes 2008; Pike et al 2012; Taçon et al. 2014). Indeed in other major Australian rock art complexes such as the Kimberley, depictions of large naturalistic forms are argued to occur earliest in the art sequence (Akerman and Willing 2009; Mulvaney 2013; Walsh 1994; Welch 1993). It is essential for archaeologists to understand the nature, context and function of these early figurative art styles in order ascertain how Australian rock art assemblages can inform and engage with international debates on the development of prehistoric hunter gatherer ritual and religious behaviours signalled in rock art reflecting belief systems such as animism and totemism (e.g. see Sauvet et al. 2009).

We seek to reignite the scholarly debate in Australian rock art research on the emergence, development and enduring nature of early naturalistic animal forms in rock art by providing evidence from a study of naturalistic depictions of macropods in western Arnhem Land. These macropod depictions may have been originally classified as 'Large Naturalistic Style' (LNS) in the relative stylistic chronology (Chaloupka 1993; Chippindale and Taçon 1998).

Figurative depictions of animals and humans in large naturalistic forms have been argued to be the earliest surviving figurative rock art depictions in western Arnhem Land (Brandl 1973; Chippindale and Taçon 1993; 1998; Chaloupka 1993). The earliest absolute chronometric age for the production of rock art in this region is 26,913 – 28,348 cal. BP produced from a sandstone tablet painted with pigment (David et al. 2013a, David et al. 2013b). The antiquity of rock art production in the region is likely to be much older owing to the presence of modified ochres found in the earliest cultural layers of archaeological deposits (Clarkson et al. 2015; David et al. 2013b). Furthermore, the known ages of rock art in island South East Asia have also been shown to be up to at least 40,000 years old, with the earliest yet dated animal depictions about 36,000 years of age (Aubert et al. 2014). Yet, despite regular reference to the potential antiquity of the early large naturalistic animal forms it remains one of the least understood assemblages of rock art in northern Australia.

In this paper we use newly recorded information from 861 rock art sites in western Arnhem Land to critically assess the nature of the large naturalistic animal forms by focusing on depictions of macropods. Paintings depicting macropod forms were selected for this analysis over other potential animal and human subjects as they dominate the proposed LNS and provided the best opportunity to characterise depictions of large naturalistic fauna (Brandl 1973; Chaloupka 1977; 1985; 1993; Chippindale and Taçon 1993; 1998; Lewis 1988). It was, therefore, necessary to characterise the manner of depiction through mapping the presence of design elements contained within large naturalistic form macropod depictions across the four following study areas: Red Lily, Mikinj Valley, Jabiluka and Dangurrung (Mt Brockman area). The rock art from these four zones provides the largest collection of paintings of early naturalistic macropod forms yet recorded, enabling the first quantitative analysis to test the coherence of a distinctive class of painted art in the western Arnhem Land stylistic chronology.

Additionally, the timeframe for the production of large naturalistic macropods is re-examined in light of recent radiocarbon age determinations providing minimum ranges for figurative anthropomorphic art styles such as Northern Running Figures (Jones et al. 2017). This new chronological data provides an opportunity to anchor early large naturalistic form animal motifs into chronological groupings according to superimposition sequences.

**The Large Naturalistic Style Rock Art of Western Arnhem Land**

According to Chaloupka (1979:246-252; 1985:273; 1993:89) the LNS constitutes the earliest figurative depictions in the rock art of western Arnhem Land. He argued the LNS occurs in the earliest horizons of the painted art sequence (the Pre-Estuarine Period) and that the art style is up to 20,000 years old (Chaloupka 1985:271; 1993:91-95). The Pre-Estuarine Period has been tentatively argued to have its onset at the height of the last glacial maximum (LGM) 21,000 to 18,000 years ago, and concluded by sea level stabilisation at 8000 years ago (Woodroffe 1988; 1993). The LNS style has also been identified underlying later art styles such as Dynamic Figures which are argued to be of terminal Pleistocene antiquity (Chaloupka 1977; 1985; 1993; Chippindale and Taçon 1993; 1998; Johnston 2017; Jones et al., 2017; Lewis 1988; May et. al. in press; Taçon and Brockwell 1995:676,684). In his first written account detailing the LNS Chaloupka (1977:247-248) characterises the style of large naturalistic animal and anthropomorphic motifs depicted in the following manner:

a) in red lines;
b) in red lines and a wash;
c) as in (b) with parts of the design emphasised by darker wash;
d) with the design painted as a flat wash; and
e) any of those above, but outlined in white as well.

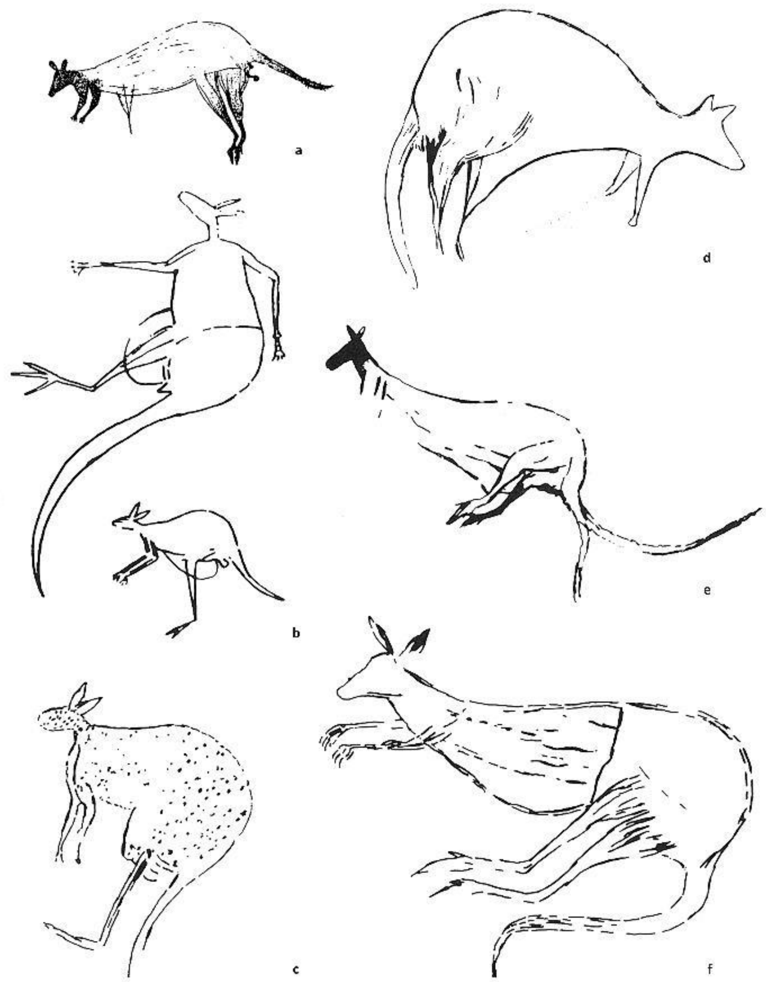


*Figure 1. Different stylistic macropod depictions according to Chaloupka (after Chaloupka; 1979: 248, 250): (a) Example of the LNS macropod, (b & c) Dynamic Figure styled macropods, (d-f) later occurring naturalistic forms. Tracing by Clare McFaddon.*

Chaloupka's definition of the LNS also noted the presence of lined infill (our term), where animals were depicted by an outline, with the entire figure then filled with lines that follow the contour of the body (see Figure 1 a & e). Additionally, Chaloupka (1979:248) describes other decorative features included in LNS as; *'*Some of the designs were filled in with a transparent wash, others had a darker wash emphasising particular parts of the body. Most of the designs were executed in a variety of shades of red, with one shade predominating'*.* In later definitions he describes the style as *'*usually drawn in outline and were textured, or infilled with contour lines, stipples, patches and occasionally ochre wash' (Chaloupka 1985:273). Chaloupka (1985:273) also states that often the animals are painted in profile, larger than life, and that they contain sufficient detail to allow positive identification of the species depicted. He notes that macropods are the main subjects of this art style (Chaloupka 1993:94-95) and identifies the dominant macropod species to be the antilopine wallaroo (*Macropus antilopinus*), Black wallaroo (*M. bernardus*), Common rock wallaroo (*M. robustus*) and Agile wallaby (*M. agilis)* (Chaloupka 1985:273; 1993:94). Other species he includes in this style include the rock possum (*Pseudocheirus dahli*); northern brown bandicoot (*Isoodon macrourus*); echidna (*Tachyglossus aculeatus*); rock python (*Morelia oenpelliensis*); freshwater crocodile (*Crocodylus johnstoni*); and various extinct fauna and potential megafauna[1] (Chaloupka 1993:95-100). While Chaloupka's identification of macropod species in the rock art may align with the known distributions of Macropodidae in the region, his identification methodology is not explained and macropodidae species extant during the LGM during the region are currently unknown owing to poor palaeontological evidence.

The stylistic category of the LNS has been noted as problematic by researchers working on western Arnhem Land rock art chronologies (Chippindale and Taçon 1993; 1998; Haskovec 1992; Lewis 1988). Chaloupka (1993:88) himself noted there is 'considerable stylistic diversity' in the LNS, stating that the term should be regarded as generic. He argues that the LNS occurs over a period of many thousands of years and that within the LNS a number of divergent art forms existed. Furthermore, Chaloupka (1993:94) concedes that the placement of these divergent stylistic forms have not been adequately described as a result of weathering and obscuration due to more recent art styles being painted over LNS depictions.

Chaloupka (1984:13) states that he recorded 32 instances of Dynamic Figure art superimposing LNS figures. Haskovec (1992) also comments on the presence of lined infill in the art argued to belong within the LNS. Chaloupka (1977:248) goes on to describe the lined infill as the 'oldest representations executed as line paintings, in which the whole of the figure is filled with lines which follow the contour of the body, its appendages and contours'. Chippindale and Taçon (1993) confirm the early position of the LNS with examples of superimpositions of Dynamic Figure art overlying LNS macropods in two rock art sites, Kungurrul and Mt. Brockman, both located in Kakadu (Chippindale and Taçon 1993:35, 38). They also identify a number of issues with the LNS.

The main issue they identify is that there is no clear definition of the LNS style, and it seems the LNS class encompasses a large range of variability in the manners of depiction found in this class of rock art. For example, in both the Kungurrul and Mt. Brockman panels a number of early macropods contain both partial block infill and lined infill. Chippindale and Taçon raise the prospect that a new style exists, which they label 'Stroke-infill manner'. 'Stroke-infill manner' is postulated to occur between LNS and Dynamic Figure art (Chippindale and Taçon 1993:38, 46). Yet, they concede that explicit stylistic differences (other than the changing infill) between the LNS and 'Stroke-infill manner' are not clear, and that the distinction and classification of the macropods as either LNS or 'Stroke-infill manner' is arbitrary. There is little doubt then that the LNS has proven to be a problematic way to classify the early depictions of fauna in western Arnhem Land rock art.

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[1] In this paper we avoid discussions relating to the identification of megafauna, or any other animal species in rock art hypothesised to be represented in the LNS. The interpretative difficulties in positively identifying megafauna have warranted more detailed discussions, and are detailed elsewhere (Lewis 2017).

## Study Areas and Methodology

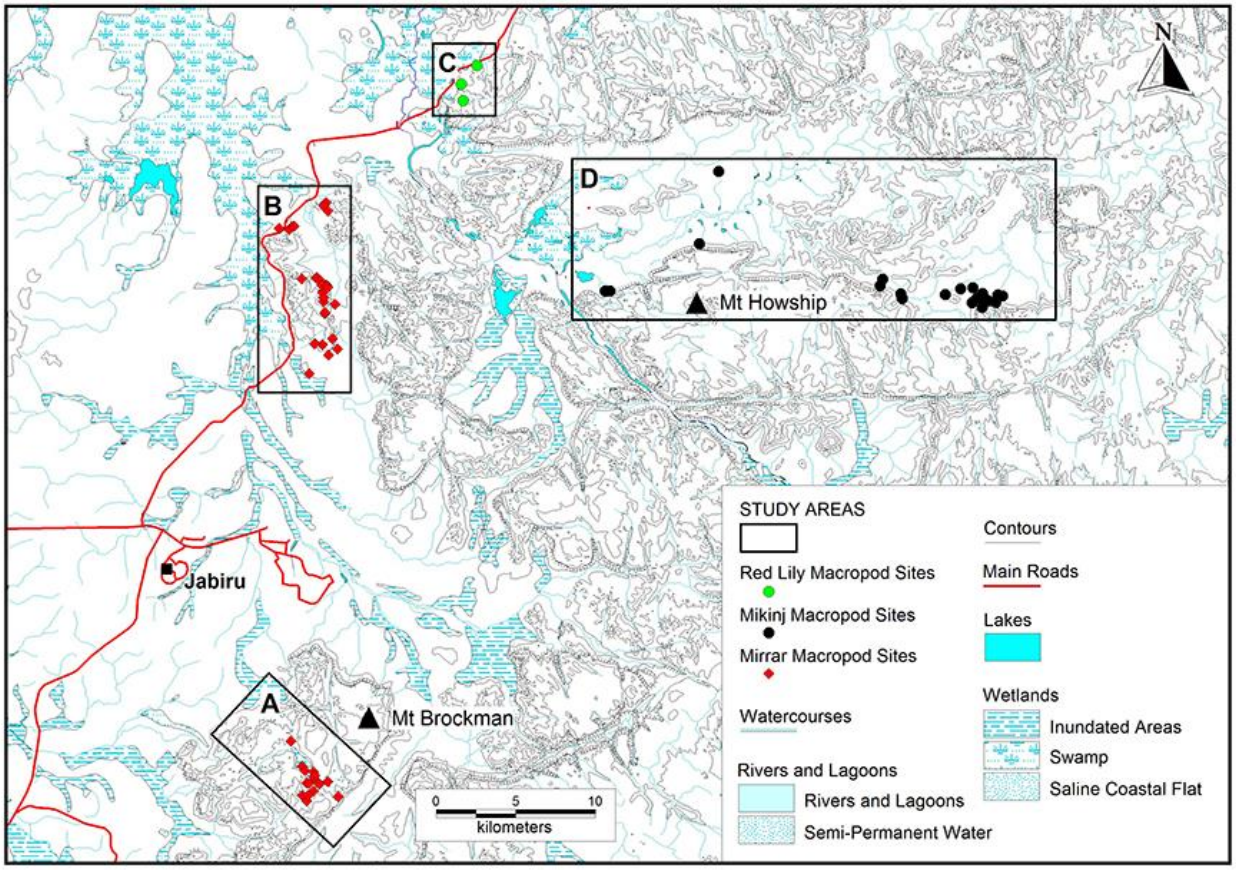


*Figure 2: Map of western Arnhem Land highlighting the study areas and site locations. Map by Daryl Wesley.*

This study is informed by recent site recordings from four study areas in western Arnhem Land and Kakadu National Park which include Red Lily, Mikinj Valley, Jabiluka and Dangurrung (Mt Brockman area) (Figure 2). The first study area (Red Lily) is located within the bounds of the Manilakarr clan estate. The area was systematically surveyed and recorded from 2011 to 2014 by an Australian National University (ANU) research team led by co-author Tristen Jones. A total of 86 rock art sites were identified in the study area, with 14 sites containing depictions of large macropods across an area of 3.5 km$^2$. The second study area, Mikinj Valley, is located across the East Alligator River from Kakadu National Park and sites in this area were documented during mineral exploration clearance surveys between 2005 and 2010 by co-author Daryl Wesley. The recording method of the Mikinj Valley sites was of lower resolution than the other study areas. Only geospatial information, photographs of cultural site features including rock art and notes were available from this study area. The Mikinj survey identified a total of 91 rock art sites. Of these 21 sites contained depictions of large macropods, totalling 47 individual motifs across an area of 15 km$^2$.

The third (Jabiluka) and fourth (Dangurrung, Mt Brockman) study areas were documented as part of the Mirarr Gunwarrdebim Project between 2011 and 2015 led by co-author Sally K. May. These sites form part of the Mirarr clan estate and sit within the Jabiluka Leasehold area and Kakadu National Park. This survey identified and recorded 528 rock art sites within Jabiluka across an area of 11.7 $km^2$. Some of these sites also come from just north of the Jabiluka Leasehold border in a region known Ngarradj Bawarddedjobkeng (Kundjeyhmi spelling), however, for ease we refer to them collectively as the Jabiluka sites. A total of 29 sites within Jabiluka contained paintings of early large macropods with 47 individual examples. For Dangurrung at total of 156 sites were recorded in 14 days during 2015 with the team led by co-authors Paul Taçon and Iain Johnston covering an area of approximately 8 $km^2$. Of these sites, 24 included depictions of large macropods with 48 individual examples documented. It should be noted, however, that surveys of Dangurrung and surrounds have only just begun with numerous rock art sites still to be recorded. Collectively, these study areas provide a large sample from which to explore the nature of early depictions of macropods and the characteristics of large naturalistic depictions of fauna in Arnhem Land rock art more generally.

***Selection and Identification of Macropod Paintings for this Study***

While macropods continued to be painted throughout the western Arnhem Land rock art sequence (including contact period examples), our focus was on the early forms of large naturalistic macropods. Site records and photographs from the study areas were assessed by the authors to identify large depictions of macropods and allocated a motif number if they met the following criteria:

(1) They were greater than approximately 50 cm in maximum dimension.
(2) They contained any of the known design elements as described by Chaloupka (1977; 1985; 1993) and Chippindale and Taçon (1993).
(3) They occurred early in any of the painting sequences (as indicated by superimposition).

Metric analysis was not included in this study owing to a number of factors. This included some photographs not containing scales, thereby limiting analytical capacity. Additionally, using metric data in this case is problematic as in our assemblages the majority of paintings are incomplete. For a painting to be considered complete it must contain a combination of body parts in order to allow a measurement such as maximum length (measurement = tip of ears or snout to base of feet) or maximum dimension (measurement = tip of ears or snout to end of tail). Painting completeness was quantified in order to demonstrate the impact of weathering and obscuration by over painting or mineral coatings on our sample size (Figure 3).

Furthermore, in order for a painting to be identified as a macropod and to be included in our sample the painting must include two key body elements. This method adopted from Tasire and Davidson (2015) includes: an arched back, snout, ears, limbs on one side (profile view), front legs shorter than the back, and a tail. In a small number of cases more than two minimum shape requirements were present but the painting was still disregarded. For example, some paintings had macropod-like heads and contained both a snout and ears yet the tail was pointing straight and upwards, or curled; and thus depicted incorrectly for positive macropod identification. The only other instances where large naturalistic styled macropods were eliminated from our sample was if they contained explicit recent X-ray features. Recent X-ray conventions are confined to the mid to late Holocene in the Arnhem Land sequence with the conventions still being painted in contact times. X-ray features are defined as the inclusion of any internal anatomical feature in the painting (Taçon 1987:43; Taçon 1989:18). The differences between early and recent X-ray have been detailed at length by Taçon (Taçon 1987:43; Taçon 1989:119-133). Early X-ray is relevant to this study with its presence confirmed in a painting with the inclusion of the following attributes (Figure 4):

(1) Early X-ray are relatively simple in form and are mostly monochromatic.

(2) Early X-ray usually only depicts one or two internal features

(3) Most commonly depicted internal elements are the backbone and body cavity (see Figure 4).

(4) Macropods and fish are the dominant subject matter. In contrast, recent X-ray is commonly bi or poly chromatic, with a thin to moderate outline to delineate the motif. They are commonly very large in size. The dominant internal elements depicted are backbones and some aspects of digestive tracts, with four or more internal elements often depicted in developed X-Ray form.

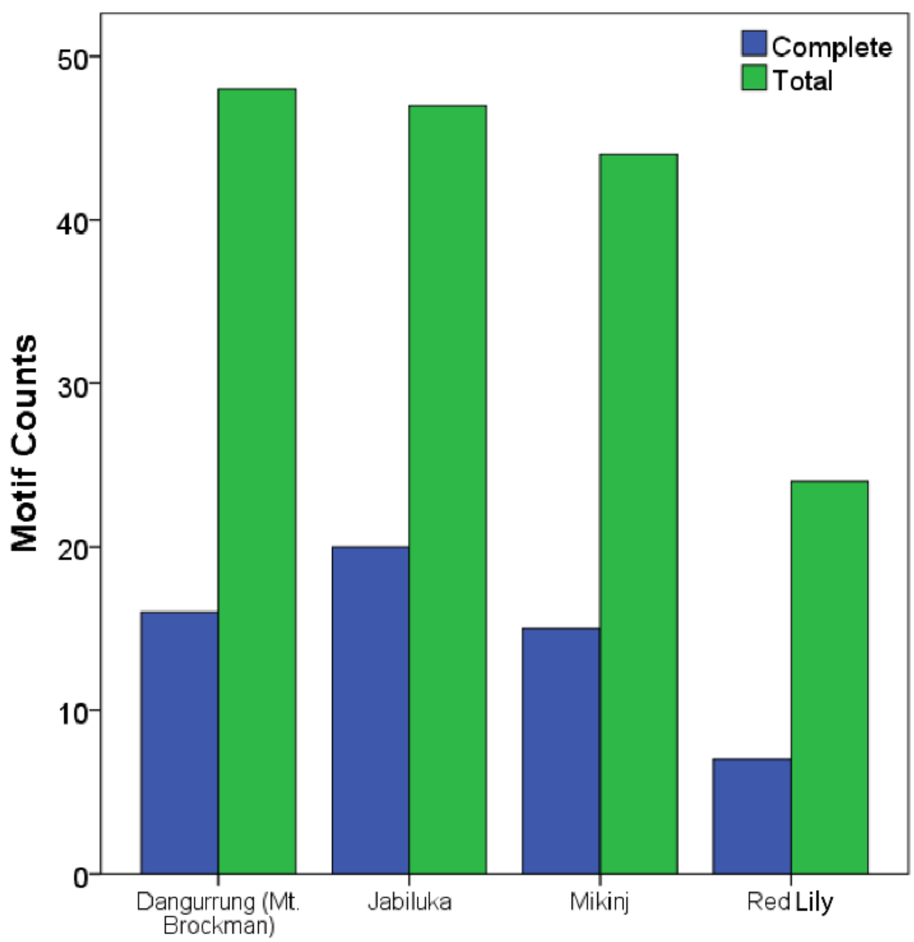


*Figure 3. Frequency of painting completeness per study area.*

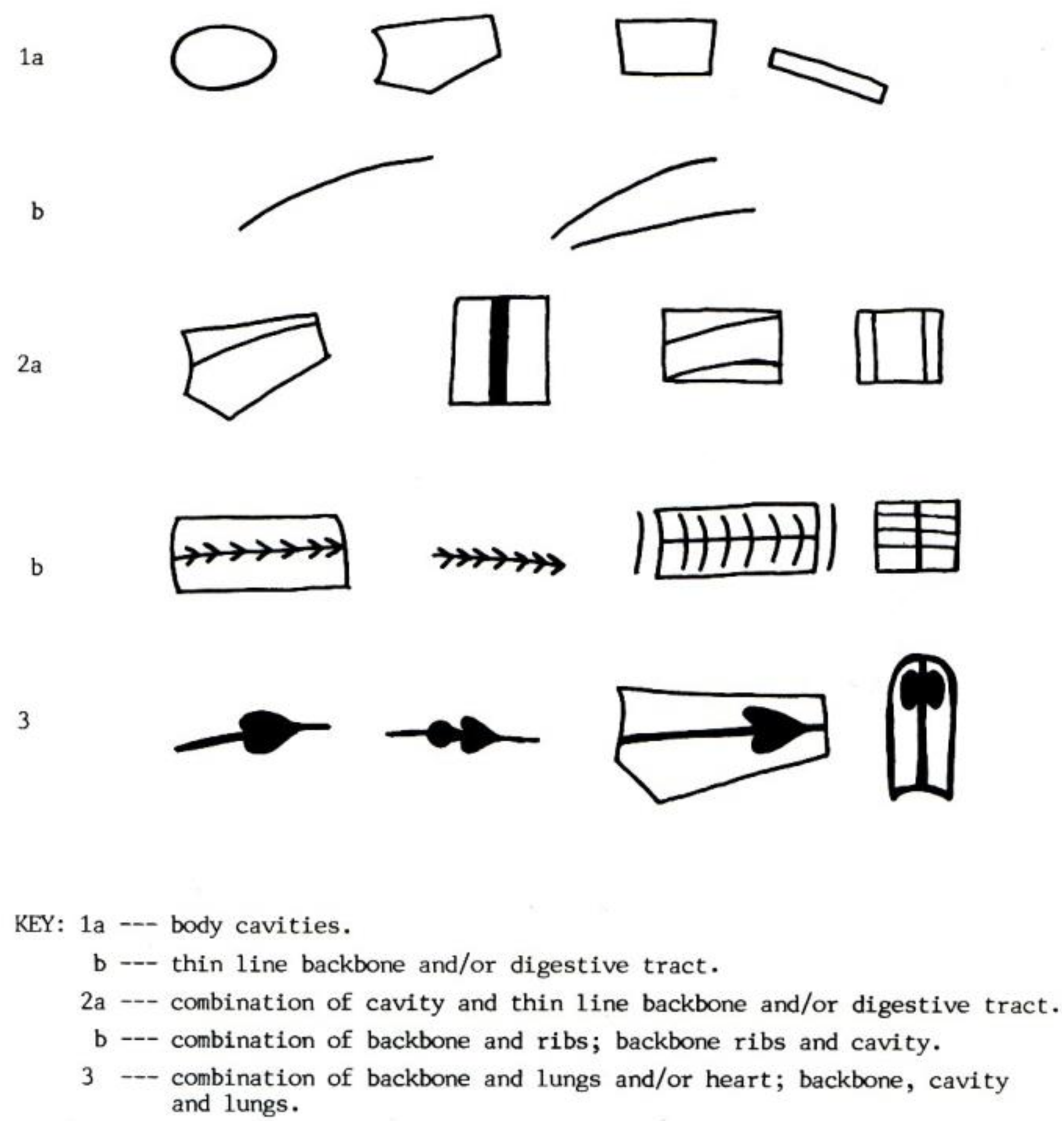


*Figure 4: Early X-ray attributes some of which are present in the macropod assemblages as defined by Taçon 1989 (1989: Figure 18).*

Detailed stylistic and superimpositions analysis of paintings containing X-ray convention design elements identified by Taçon (1989:119; 1992:203) have led him to propose an estimated age limit for the emergence of the early X-ray convention to between 8000-6000BP. This minimum age for the X-ray convention is supported by radiocarbon age determinations reported by Jones et al. (2017). Recent X-ray follows the emergence of early X-ray in the rock art sequence and denotes a mid to late Holocene antiquity, and subsequently is assigned to the 'New' (or Late) rock art chronological period (Chippindale and Taçon 1998: 107).

The presence of recent X-ray design attributes in macropods could then be used as a methodological tool to disqualify a painting from our sample. Following a similar logic, if a macropod painting was depicted in the latter sequences (i.e. the most recent painting events on a rock art panel) in association with recent X-ray paintings and/or contact imagery the macropod painting was also disqualified from our assemblage. This included macropods that were bichromatic, polychromatic and those that contained recent infill design elements such as *rarrk*. Bichrome and polychrome design elements are reported to be indicators of more recently produced paintings (Jones et al 2017; Taçon 1989:121-126).

***Recording of Attributes for Analysis***
Following a positive identification of a painting as a macropod the following characteristics were recorded: Ears, Face/Snout, Back, Body, Arms, Paws, Legs, Feet, Toes and Tail. Toe count was included owing to the hypothesis that it may help to identify the species of macropod and, importantly for this study, changing toe depictions may be a temporal stylistic indicator.

Design elements were selected for quantification as they may be used as a stylistic indicator to analyse homogeneity or difference in rock art assemblages. For example, variation in animal forms as a stylistic indicator has been demonstrated in depictions of horses in Palaeolithic European rock art (Pigeaud 2007). An abstraction of musculature is also commonly present as a stylistic signature in the depiction of Dynamic styled macropods, discussed later in this paper (Figure 1b).

Accordingly, the manner of depiction in the musculature of the animal was quantified into four categories: muscle flat, muscle rounded, muscle defined and indeterminate. Muscle flat denotes the use of straight lines along the limbs rendering a visual that depicts a lack of muscle in the animal form (Figure 1b). Muscle defined demarcates pronounced bulbous musculature in the arms and leg limbs of the macropod (Figure 1a). The presence of pronounced bulbous musculature is typical in some macropod species, particularly males engaged in particular behaviours (Clancy and Croft 2008:346; Poole 1983:250). In comparison, muscle rounded is represented by curved lines on the arm and leg limbs without the muscle being overtly pronounced (Figure 1c). These design elements were selected for quantification as they may be used as a stylistic indicator.


*Figure 5: (a) Infill X-ray, (b) Infill Lined, (c) Infill Outline (d) Infill Block (e) Infill Bobbles (f) Infill Hatch, and (g) multiple infill types.Tracing by Meg Walker.*

Seven types of infill were recorded: Outline, Infill Block, Infill Partial, Infill Lined, Infill Hatch, Infill Bobbles, and Infill X-ray (Figure 5). Another potential infill type category, 'Infill Shaded' was disregarded as a valid infill category as the presence or absence of shading is considered too subjective. This subjectivity is due to the fact that this phenomenon was observed only in photographs of macropods, rather than in the field. Additionally, when considering the potential antiquity of the macropod assemblage, the shading could also be a result of taphonomic impacts dependent on unknown factors such as differential weathering of different types of pigment and variable micro environmental impacts, thus creating a visual illusion of shading infill. Generally, it is impossible for infill type classes Outline and Block to contain additional infill types due to their definition. Outline Infill type is the representation of a macropod by silhouette by a single line only, whereas Block Infill type is the representation of a macropod by silhouette in block pigment producing a macropod shape. Therefore these infill types cannot contain another infill type such as X-ray for example, as the painting would then be classified as belonging to the other group.

Finally, we recorded the presence and absence of superimpositions. The variables included the presence and absence of anthropomorphic figures and material culture such as weaponry and implements, and their relationship to the macropod paintings. Some of the superimpositions are based only on photographic observations and have therefore been classified as having an 'indeterminate' relationship between paintings. Only superimpositions that have been confirmed by visual inspection in the field, and those superimpositions that are exceptionally clear, are used to anchor early macropods into chronological groupings in this study. The difficulty of observing the sequence of painting present in superimpositions has been acknowledged by other researchers where photographic evidence has been questioned as a reliable method to decipher superimpositions (Chippindale and Taçon 1993:43; Haskovec 1992:64). Identified superimpositions are then utilised as chronological anchors, which may or may not correlate to groups of particular stylistic variables.

**Results**

Our results are presented in five key areas. First, we explore distribution and frequency focusing on the spread of large naturalistic macropod forms across the four study areas. Second, we explore the presence and absence of particular parts of the macropod to address the issue of the visibility and completeness of macropod paintings. Third, we present results from an analysis of musculature in the depictions. Fourth, our findings from an analysis of infill types in the macropod paintings are presented. Finally, we look at the evidence for superimposition of both anthropomorphic motifs of identifiable styles and material culture items in order to better understand the chronology of these depictions. Together these results give us the most comprehensive overview of the dominant manners of depiction for early macropods in Arnhem Land.

***Distribution and Frequency***

From the four study areas a total of 163 macropod paintings were identified from a total of 88 rock art sites. In the Mikinj study area, 21 rock art sites contained early large macropod depictions consisting of 23.0% of the total number of rock art sites. At Red Lily only 16.3% of rock art sites contained early large macropods (n=14). While at Jabiluka 5.5% of rock art sites contained early large macropods (n=29), and at Dangurrung 24 rock art sites had early macropods present (15.9% of the total number of rock art sites). These results demonstrate that early large macropod form paintings are not uniformly present in high numbers across this section of Arnhem Land.

Table 1. Frequency and percentages of body parts depicted.

| Study Area and total number of motifs | Ears | | Face Snout | | Back | | Body | | Arms | | Paws | | Legs | | Tail | | Feet | | Toes | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | n | % | n | % | n | % | n | % | n | % | n | % | n | % | n | % | n | % | n | % |
| Mikinj (n = 44) | 36 | 81.8 | 35 | 79.5 | 40 | 90.9 | 38 | 86.4 | 33 | 75.0 | 10 | 22.7 | 19 | 43.2 | 18 | 40.9 | 10 | 22.7 | 5 | 11.4 |
| Red Lily (n = 24) | 21 | 87.5 | 22 | 91.7 | 20 | 83.3 | 16 | 66.7 | 14 | 58.3 | 9 | 37.5 | 10 | 41.7 | 8 | 33.3 | 8 | 33.3 | 6 | 25.0 |
| Jabiluka (n = 47) | 44 | 93.6 | 44 | 93.6 | 45 | 95.7 | 40 | 85.1 | 34 | 72.3 | 18 | 38.3 | 27 | 57.4 | 32 | 68.1 | 25 | 53.2 | 20 | 42.6 |
| Mt. Brockman (n = 48) | 42 | 87.5 | 44 | 91.7 | 41 | 85.4 | 41 | 85.4 | 37 | 77.1 | 18 | 37.5 | 33 | 68.7 | 36 | 75.0 | 24 | 50.0 | 20 | 41.7 |
| **Total assemblage (n = 163)** | **142** | **87.1** | **144** | **88.4** | **145** | **89.0** | **134** | **82.2** | **117** | **71.8** | **55** | **33.7** | **89** | **54.6** | **94** | **57.7** | **67** | **41.1** | **51** | **31.3** |

***The presence and absence of particular body parts and completeness of painting***

Macropod body parts reflected a trend across all study areas for higher frequency of certain body parts remaining visible over others. The most frequently depicted body parts are reported in Table 1. The most commonly visible macropod body parts were the Back depicted in 89.0% of motifs (n=145); Face/Snout depicted in 88.4% of motifs (n=144); Ears depicted in 87.1% of motifs (n=142), and macropod Body, depicted in 82.2% (n=134) of instances. The body parts of Arms, Paws, Legs, Tail, Feet and Toes are depicted much less frequently and/or are more subject to both weathering and being covered by more recent paintings (Figure 5, Table 1).

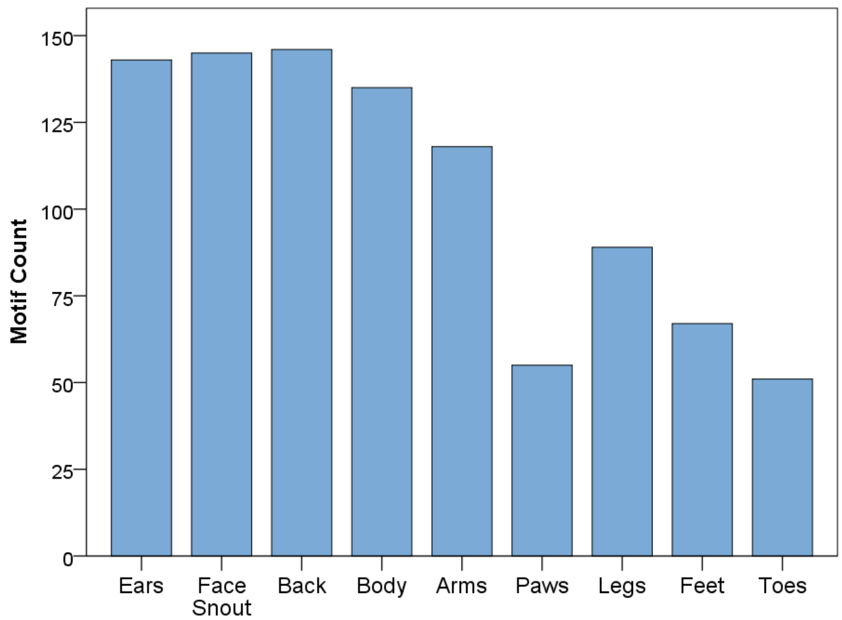


*Figure 6. Graph of frequency of macropod body parts depicted.*

Table 2. Frequency and percentages of feet and toes depicted.

| Study Area and total number of motifs | Number of motifs with feet present | Number of motifs with toes present | Number of toes | | | | |
|---|---|---|---|---|---|---|---|
| | | | 1 toe | 2 toes | 3 toes | Many toes | Ambiguous (foot present digits unclear) |
| Mikinj (n = 44) | 10 | 5 | 2 | 1 | 2 | 0 | 5 |
| Red Lily (n = 24) | 8 | 6 | 0 | 2 | 4 | 0 | 2 |
| Jabiluka (n = 47) | 25 | 20 | 2 | 10 | 7 | 1 | 5 |
| Mt. Brockman (n = 48) | 24 | 20 | 1 | 8 | 11 | 0 | 4 |
| **Totals** | **67** | **51** | **5** | **21** | **24** | **1** | **16** |

While the frequency in the visibility of macropod feet and toes was quite low (41.1% and 31.3% respectively), the number of toes depicted in macropod feet reflected an anatomically correct number for macropod species in all but one instance (Table 2). This phenomena is interesting as it reveals that the manner in which macropods are depicted conforms to the anatomical units of the animal, and thus are indeed realistic in their manner of depiction. The representation of body parts across all four study areas is generally similar except for the representation of tails, feet and toes which are marginally more visible in Jabiluka and Dangurrung.

Table 3. Frequency and percentages of painting completeness.

| Study Area and total number of motifs | Number of complete motifs | |
|---|---|---|
| | n | % |
| Mikinj (n = 44) | 15 | 34.0 |
| Red Lily (n = 24) | 7 | 29.2 |
| Jabiluka (n = 47) | 20 | 42.5 |
| Mt. Brockman (n = 48) | 16 | 33.3 |
| **Totals (n = 163)** | **58** | **35.6** |

In order to explore the nature of visibility of large naturalistic formed macropods the completeness of the paintings was also quantified. The results of painting completeness are reported in Table 3 (Figure 3). Painting completeness ranged between 29.2 to 42.5% across the study areas, with the Jabiluka study area having the most intact assemblage (n=20, 42.5%). In contrast, the Red Lily macropods had lowest painting completeness with only seven macropods remaining completely visible (29.2%). The painting completeness of the overall assemblage was 35.6%, equalling slightly over a third, and is slightly lower than the frequency of most of the body part elements depicted (other than Paws and Toes). These results confirm the original observations made by Chaloupka (1993: 94) that efforts to disentangle the proposed LNS are adversely affected by the lack of painting visibility due to weathering and obscuration from newer art styles.

***Musculature***

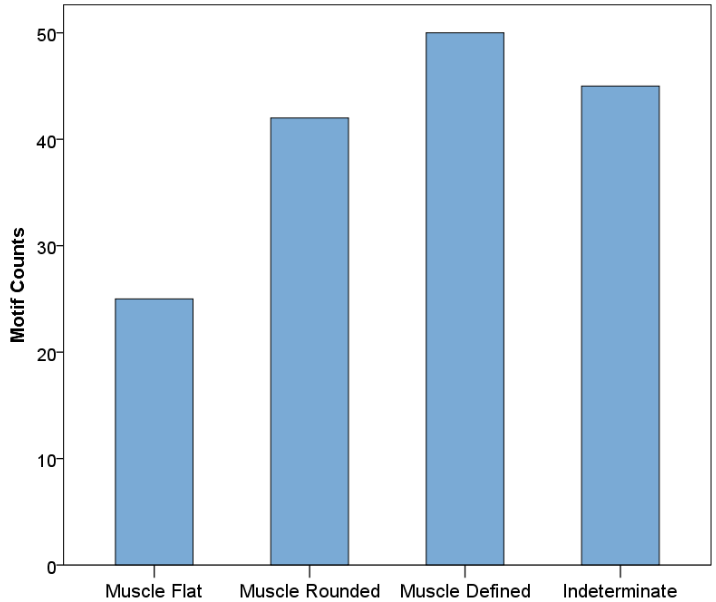


*Figure 7. Graph of muscle type frequency.*

Table 4. Frequency and percentage of muscle types.

| Study Area and total number of motifs | Muscle Flat | | Muscle Rounded | | Muscle Defined | | Muscle Indeterminate | |
|---|---|---|---|---|---|---|---|---|
| | n | % | n | % | n | % | n | % |
| Mikinj (n = 44) | 7 | 15.9 | 12 | 27.3 | 14 | 31.8 | 11 | 25.0 |
| Red Lily (n = 24) | 8 | 33.3 | 2 | 8.3 | 3 | 12.5 | 11 | 45.8 |
| Jabiluka (n = 47) | 5 | 10.6 | 17 | 36.2 | 13 | 27.7 | 12 | 25.5 |
| Mt. Brockman (n = 48) | 5 | 10.4 | 12 | 25.0 | 20 | 41.7 | 11 | 22.9 |
| **Totals (n = 163)** | **25** | **15.3** | **43** | **25.8** | **50** | **30.7** | **45** | **27.6** |

The manner that musculature is depicted in the paintings are reported in Table 4 (Figure 7, Table 4). Defined or Rounded muscles are the dominant manner of depiction with defined muscles being depicted in 30.7% (n=50) of instances and rounded muscles being depicted in 25.8% (n=43) of the total assemblage. Indeterminate muscle types, meaning the manner of muscle representation could not be deciphered, accounted for 27.6% (n=45) of the assemblage. Flat muscle types represented by straight lines, expressing no musculature in the animal at all, accounted for 15.3% (n=25) of the assemblage.

***Infill Types***

We identified seven infill types used in the production of early large naturalistic formed macropods (see Figure 5).

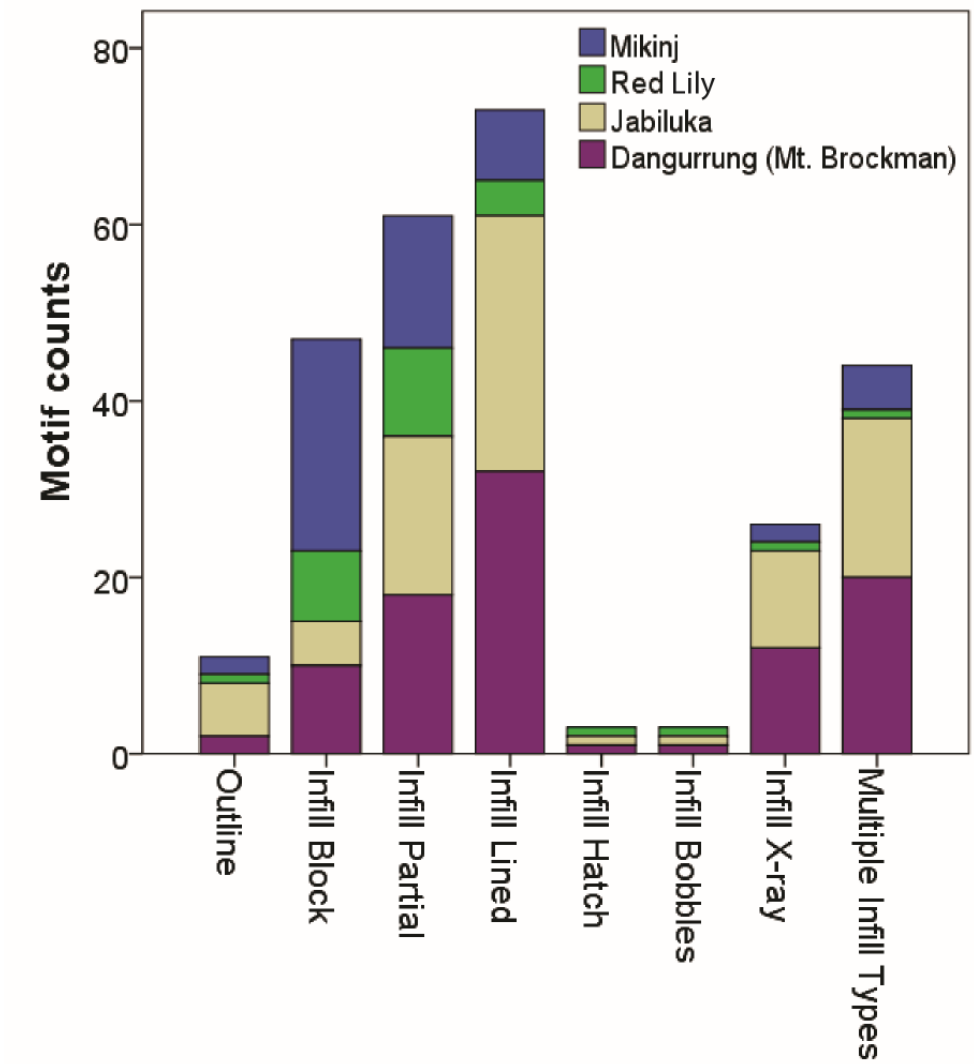


*Figure 8. Graph of frequency of infill types per study areas.*

Table 5. Frequency and percentage of infill types.

| Study Area and total number of motifs | Outline 1 | | Infill Block 2 | | Infill Partial 3 | | Infill Lined 4 | | Infill Dots | | Infill Hatch 5 | | Infill Bobbles 6 | | Infill X-ray 7 | | Number of multiple infill types 8 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | n | % | n | % | n | % | n | % | n | % | n | % | n | % | n | % | N | % |
| Mikinj (n = 44) | 2 | 4.5 | 24 | 54.5 | 15 | 34.1 | 8 | 18.2 | 1 | 2.3 | 0 | 0.0 | 0 | 0.0 | 2 | 4.6 | 5 | 11.4 |
| Red Lily (n = 24) | 1 | 4.2 | 8 | 33.9 | 10 | 41.7 | 4 | 16.7 | 0 | 0.0 | 1 | 4.2 | 1 | 4.2 | 1 | 4.2 | 1 | 4.2 |
| Jabiluka (n = 47) | 6 | 12.8 | 5 | 10.6 | 18 | 38.3 | 29 | 61.7 | 0 | 0.0 | 1 | 2.1 | 1 | 2.1 | 11 | 23.4 | 18 | 38.3 |
| Mt. Brockman (n = 48) | 2 | 4.2 | 10 | 20.8 | 18 | 37.5 | 32 | 66.7 | 1 | 2.0 | 1 | 2.1 | 1 | 2.1 | 12 | 25.0 | 20 | 41.7 |
| **Totals (n = 163)** | **11** | **6.7** | **47** | **28.8** | **61** | **37.4** | **73** | **44.7** | **2** | **1.2** | **3** | **1.8** | **3** | **1.8** | **26** | **15.9** | **44** | **27.0** |

Analysis of outline and infill elements in the rock paintings suggests a high degree of standardisation between study areas in the types of infill used in depicting macropods (Figure 8, Table 5). Four paintings were excluded from infill type analysis due to the ambiguity of infill type caused by poor preservation[2]. Some of these categories are clearly more dominant than others with Lined Infill having the highest individual count (44.7%, n=73) followed by Partial Block Infill (37.4%, n=61), and Block Infill (28.8%, n=47). Outline only large naturalistic formed macropods have a slightly higher incidence in the Jabiluka study area (12.8%, n=6) but are generally not common in all the study areas. A low incidence for Infill Hatch and Infill Bobbles also occurs across all the study areas.

A shifting pattern in the dominance of particular outline or infill elements was identified across the different study areas (Figure 8, Table 5). Infill Block is highest (54.5%, n=24) in the Mikinj study area. In contrast in the Jabiluka and Dangurrung study areas Infill Block has a markedly lower incidence.

Lined Infill is the most dominate infill type in the total assemblage, with Dangurrung (66.7%, n=32) and Jabiluka (61.7%, n=29) study areas having the highest presence of this infill type. Block Infill and Partial Infill have a frequency range of 10.6% – 54.5% and 34.1% – 41.7% respectively across all three study areas. There is greater variability in the presence of Block infill across the three study areas, with Jabiluka having the lowest presence at 10.6% (n=5). The instance of Hatch and Bobble Infills is very low across all the study areas. X-ray infill type was also quite low in the assemblage (15.9%, n=26) with the presence of X-Ray in Dangurrung and Jabiluka exceptionally high (n=12, n= 11 respectively) in comparison to the other two study areas.

Multiple infill types present in a single painting may be significant and informative in clarifying differences in manners of depiction in Early (pre-Dynamic), Middle (post Dynamic through to 6,000 BP) and Late (post 6,000 BP) classes of macropods. There were a significant number of motifs, 27.0% (n=44) of the entire assemblage, that contained more than one infill class (Figure 8, Table 5).

[2] Motifs excluded from infill type analysis included: Jabiluka Motif 7; Dangurrung (Mt. Brockman) Motifs 20 and 23 and Red Lily Motif 24.

Table 6. X-ray Infill type combination frequency and percentage with other decorative infill types.

| | Depicted with Infill Lined | | Depicted with Infill Partial | | Depicted with Infill Hatch | | Depicted with Infill Bobbles | | Infill with more than two variables | | Only X-ray depicted | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | n | % | n | % | n | % | n | % | n | % | n | % |
| Mikinj (n = 44) | 1 | 2.3 | 2 | 4.6 | 0 | 0.0 | 0 | 0.0 | 1 | 2.3 | 0 | 0.0 |
| Red Lily (n = 24) | 0 | 0.0 | 1 | 4.2 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| Jabiluka (n = 47) | 6 | 12.8 | 4 | 8.5 | 1 | 2.1 | 1 | 2.1 | 4 | 8.5 | 3 | 6.4 |
| Mt. Brockman (n = 48) | 9 | 18.8 | 9 | 18.8 | 1 | 2.1 | 0 | 0.0 | 8 | 16.7 | 0 | 0.0 |
| **Totals (n = 163)** | **16** | **9.8** | **15** | **9.2** | **2** | **1.2** | **1** | **0.6** | **13** | **8.0** | **3** | **1.8** |

Table 7. Lined Infill type combination frequency and percentage with other decorative infill types.

| | Depicted with Infill X-ray | | Depicted with Infill Partial | | Depicted with Infill Hatch | | Depicted with Infill Bobbles | | Infill with more than two variables | | Only Lined Infill depicted | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | n | % | n | % | n | % | n | % | N | % | n | % |
| Mikinj (n = 44) | 1 | 2.3 | 5 | 11.4 | 0 | 0.0 | 0 | 0.0 | 1 | 2.3 | 3 | 6.8 |
| Red Lily (n = 24) | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 4 | 16.7 |
| Jabiluka (n = 47) | 6 | 12.8 | 12 | 25.5 | 1 | 2.1 | 1 | 2.1 | 4 | 8.5 | 14 | 29.8 |
| Mt. Brockman (n = 48) | 9 | 18.8 | 13 | 27.1 | 1 | 2.1 | 1 | 2.1 | 8 | 16.7 | 15 | 31.3 |
| **Totals (n = 163)** | **16** | **9.8** | **30** | **18.4** | **2** | **1.2** | **2** | **1.2** | **13** | **8.0** | **33** | **20.3** |

Table 8. Partial Infill type combination frequency and percentage with other decorative infill types.

| | Depicted with Infill X-ray | | Depicted with Infill Lined | | Depicted with Infill Hatch | | Depicted with Infill Bobbles | | Infill with more than two variables | | Only Partial Infill depicted | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | N | % | n | % | n | % | n | % | N | % | n | % |
| Mikinj (n = 44) | 2 | 4.6 | 5 | 11.4 | 0 | 0.0 | 0 | 0.0 | 1 | 2.3 | 9 | 20.5 |
| Red Lily (n = 24) | 1 | 4.2 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 7 | 29.2 |
| Jabiluka (n = 47) | 4 | 8.5 | 12 | 25.5 | 1 | 2.1 | 0 | 0.0 | 3 | 6.4 | 4 | 8.5 |
| Mt. Brockman (n = 48) | 9 | 18.8 | 13 | 27.1 | 0 | 0.0 | 0 | 0.0 | 7 | 14.6 | 3 | 6.3 |
| **Totals (n = 163)** | **16** | **9.8** | **30** | **18.4** | **1** | **0.6** | **0** | **0.0** | **11** | **6.8** | **23** | **14.1** |

The results of the infill type combination frequency and percentage with other infill types are reported in Tables 6, 7, and 8. In order to explore the most dominate combination of infill types the frequency of combinations of all infill types was quantified for the most dominant infill types (X-ray Infill, Lined Infill and Partial Infill). While the frequency of Hatch and Bobble infill types was quantified in combinations, they were not explored as independent infill variables due to their low incidence.

The results show that X-ray Infill is most frequently depicted in combination with Lined Infill (9.8%, n=16) in comparison to the other infill types. The Dangurrung assemblage has the highest frequency of X-ray and Lined Infill combinations (18.8%, n= 9). Jabiluka also has a 12.8% (n=6) incidence of X-ray and Lined Infill combinations, in comparison to the two other study areas which have virtually no incidence of this infill type combination (Mikinj n=1, Red Lily n=0). The second most frequent infill type, X-ray Infill with Partial Infill, is more evenly distributed across all the study areas, except for the Dangurrung assemblage which again has the highest instance of X-ray and Partial Infill type combinations. The frequency of depicting X-ray Infill as a sole infill type almost never occurs in this assemblage (1.8%, n=3).

In contrast, Lined Infill is most commonly represented alone (20.3%, n=33), rather than in combination with other infill types (Table 7). However, when depicted in combinations Lined Infill is most commonly depicted with Partial Infill, followed by X-ray Infill (18.4%, n=30 and 9.8%, n=16 respectively). Partial Infill is also represented as a sole infill type in 12.9% (n=21) of motifs and is most frequently depicted in combination with Lined Infill (18.4%, n=30).

***Superimposition of Anthropomorphic Figures and Material Culture***

The number of anthropomorphic superimpositions present in the entire painting assemblage is very low with only ten positive instances identified, and a further three potentials identified. Of the ten clear anthropomorphic superimpositions only four of the superimpositions were Dynamic Figures over macropods, all in Dangurrung. One of these superimpositions located in Dangurrung is the well-known 'Emu hunter' panel example previously reported by Chippindale and Taçon (1993; our Figures 9 and 10). On the escarpment edge across a small valley from this panel there is a site (R1032) with Dynamic Figures over three large naturalistic macropods with Lined Infill, the largest macropod measuring at least 1.80 metres wide and 1.10 metres tall (but some parts of the body now missing due to weathering and other more recent superimposed paintings). At a site a few kilometres away there are Dynamic Figures over a large naturalistic painting of what appears to be a Thylacine. All of these examples were recorded and verified in the field by co-author Taçon in 2013.

Another possible superimposition of a macropod and Dynamic Figure painting was identified in the Jabiluka study area. Due to weathering the distinction of layers between red pigments could not be substantiated. The macropod depicted on this panel contains both Lined and Partial Infill types.

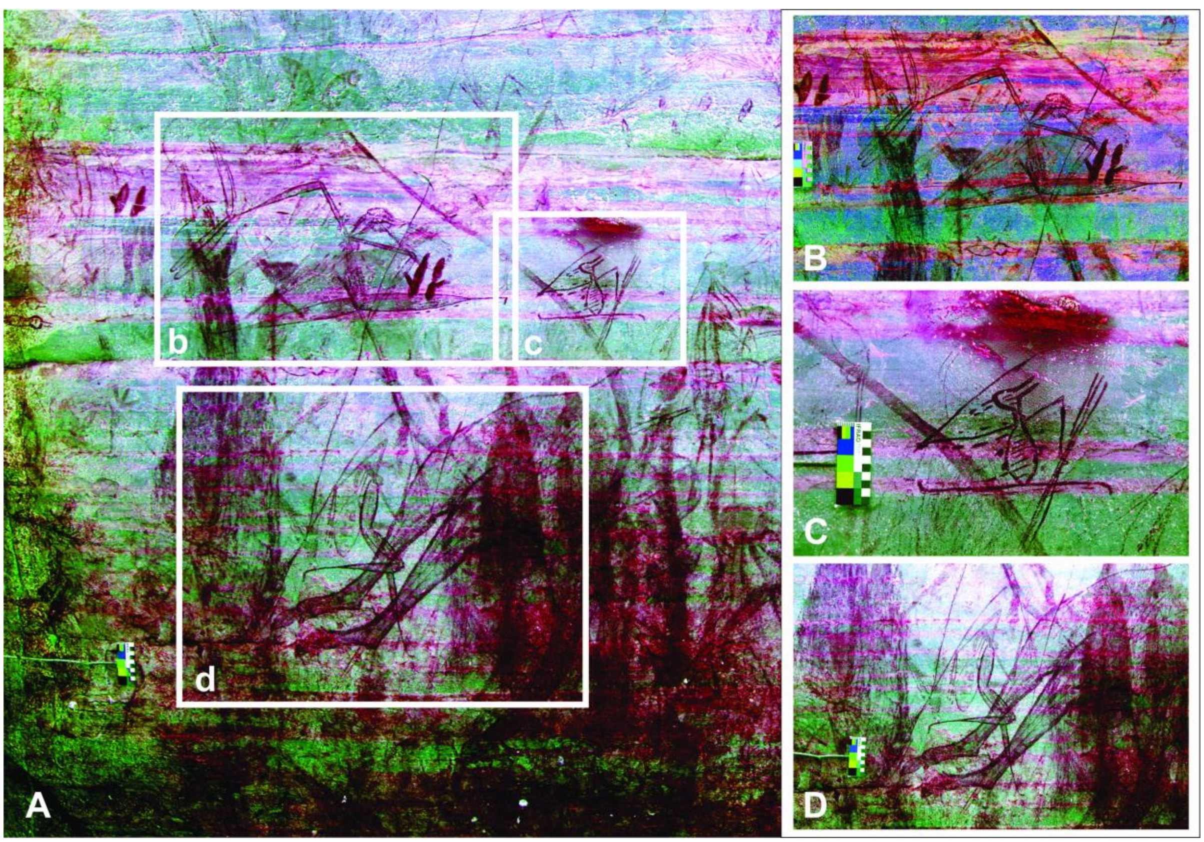


*Figure 9. (a) Dangurrung 'Emu hunter' panel with early macropod depicted in Partial Infill superimposed by Dynamic Figures in three instances (b-d). Photograph by Paul Taçon, enhancement by Daryl Wesley.*


*Figure 10. Sequence of painting of the Dangurrung 'Emu hunter' panel featuring superimposition of macropod underlying Dynamic Figures. Tracing by Meg Walker.*

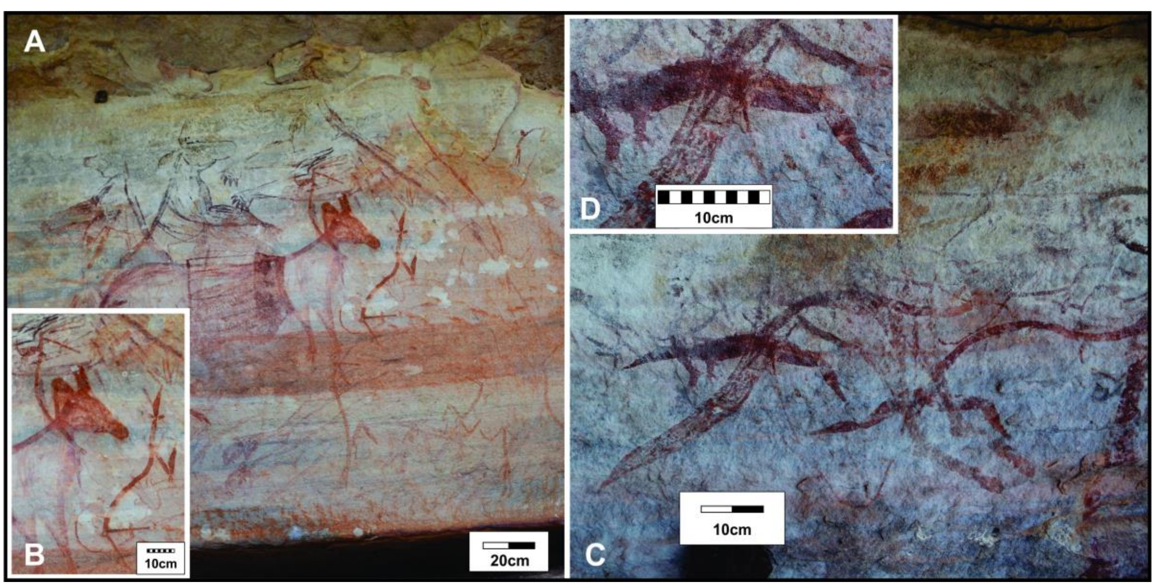


*Figure 11. NRF overlying early large macropods from Red Lily sites 32D and GC 61. (a) and (c) micro-photography detailing direct superimpositions. Photographs by Tristen Jones, enhancement by Daryl Wesley.*


*Figure 12. Sequence of painting at Red Lily 32D featuring macropod and NRF superimpositions (a) first painting layer of four early large naturalistic formed macropods some in Lined Infill, (b) second painting layer featuring a macropod depicted in Partial Infill (c) third painting layer comprised of NRF styled motifs. Tracing by Meg Walker.*

Five superimpositions featured Northern Running Figures (NRF) with the NRFs overlying macropod paintings in all instances. All five NRF superimpositions were from the Red Lily study area from three rock art sites. These superimpositions were verified in person in the field by co-author Tristen Jones, with microphotography (Figure 11, 12) verifying the painting sequence.

The final four instances of superimpositions are anthropomorphic paintings of Simple Figure (or Simple Figures with Boomerangs) styles from a single panel in the Dangurrung study area (Figure 13). The macropod lies underneath the five Simple Figure paintings, and is depicted in Lined Infill. This superimposition was confirmed in the field by co-author Iain Johnston.

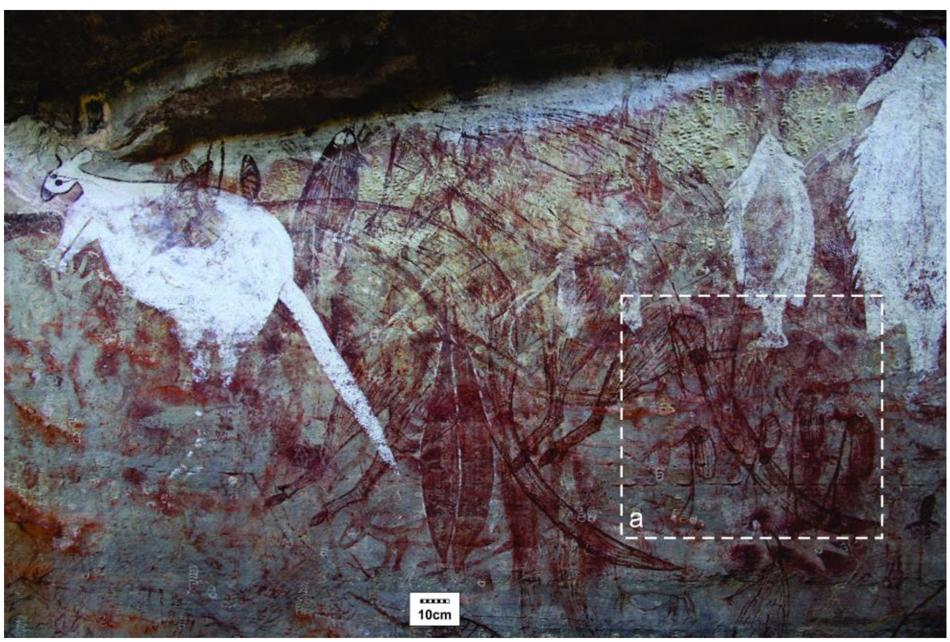


*Figure 13. Five examples of Simple Figures (a) superimposing a macropod depicted in Lined Infill. Photograph by Paul Taçon, enhancement by Daryl Wesley.*

The two remaining possible anthropomorphic superimpositions were of Simple Figure (or Simple Figures with Boomerangs) styled paintings, with the macropods again identified tentatively as occurring underneath. These were located on a single panel from the Mikinj study area. While modest in number these superimpositions are vitally important evidence for the early nature of large naturalistic paintings of macropods and their co-existence with the Dynamic Figure style, also predating the emergence of Northern Running Figures and Simple Figures. There were also four examples of identifiable material culture superimposing large naturalistic macropods. The number of material culture superimpositions identified (external to those items of material culture not associated with an anthropomorphic styled painting such as Dynamic Figures, NRFs or Simple Figures) included three from Dangurrung and one in the Jabiluka study area. Again the number of material culture superimpositions that allow for chronometric anchoring represents a very low percentage of the entire assemblage (2.4%, n=4).

There are two examples of composite barbed spears and sticks from Dangurrung over macropods, one macropod containing Block Infill, the other Lined Infill. Composite spear technology is argued to emerge in Arnhem Land between 6,000 to 4,000 years ago (Hiscock and Maloney 2016). Thus the depiction of this technology could not have been made in rock art before this time. Subsequently, the depiction of this type of material culture would provide a minimum age for the macropods occurring underneath them.

The only instance of a superimposition underlying a macropod in our assemblage was identified at Dangurrung. A large number seven shaped boomerang stencil underlies a large macropod that is depicted in Lined and Partial Infill manners. Boomerangs, together with other material culture types such as hooked sticks and hafted hand axes have been consistently reported to occur in association with the earliest figurative anthropomorphic art styles such as Dynamic Figures, Post Dynamic Figures, Simple Figures (Simple Figures with Boomerangs) and NRFs (Brandl 1973:167, 172-176; Chaloupka 1993:110, 120-123; Lewis 1988:11; Jones and May in press). However, boomerangs were probably used but perhaps not commonly stencilled or painted when the earliest LNS were made and also prior to the first LNS. For instance, co-author Taçon has made field observations of various types of hand and other stencils underneath large naturalistic macropods and other fauna at Dangurrung sites and elsewhere in the region, including under the above mentioned macropods that have Dynamic Figures over them.

The final instance of material culture superimposition is the presence of two three pronged barbed spears that are depicted spearing a Lined Infill macropod (Figure 14). Lewis associates these spears with his Broad Spear thrower period occurring after 6000 BP and after Dynamic Figures and Mountford Figures (1988:58-60, 62-3, 324-5), something that Taçon and Chippindale (2008) also argue using other data.


*Figure 14. Macropods with multiple combinations of infill types with one macropod (a) being speared by two three pronged barbed spears. Photograph by Ines Domingo Sanz, enhanced by Daryl Wesley.*

**Discussion**

When Chaloupka (1993:94) first proposed the LNS he stated that the main issue that impacted on the researcher's ability to detail the stylistic diversity of the LNS style is that it has been adversely affected by weathering (due to antiquity) and that the remaining depictions have largely been painted over due to subsequent rock art production. Our quantitative data supports these original observations. Painting completeness and the frequency of body parts still visible quantify the major impact of weathering and obscuration on early naturalistic animal paintings in western Arnhem Land rock art. Painting completeness in the assemblage remains low. Frequency of body parts depicted reveals that what often remains in the macropod paintings is the upper body depictions with Back, Face/Snout, Ears and Body the most commonly represented elements of the body (Figure 6). It is evident that physical weathering has had a dramatic impact on the archaeological visibility of these early examples of rock art in the Arnhem Land plateau.

This study has also demonstrated that the presence of superimpositions that can act as chronological anchors are very rare. Direct superimpositions that could produce a chronological anchor from anthropomorphic styled paintings and associated material culture types can only be used as a method in a very low number of instances within the entire assemblage and requires caution in our interpretations for the timing of the emergence of the proposed LNS. Of interest, however, are the infill classes that indicate that the painting may have been painted later than the LNS. For example, Early X-ray or Bobbles (which may be an indicator of yam style c.f. Taçon et al 1996) are infill types that have been proposed to occur much later in the relative sequence. If these infill types coexist with other infill types assumed to have a greater antiquity, such as Lined and Block Infill types, there may be a continuation of infill types over a considerable temporal period. Thus crossing chronological boundaries, namely from pre-Dynamic, through the end of the Middle Period c. 6000 cal. BP.

There seems to be a trend of general uniformity in the use of infill types across all the study areas suggesting homogeneity in stylistic design. The most frequent infill types are the same across study areas and include Lined, Block, Partial and X-Ray (in order of frequency, Figure 8, Table 5). The infill types with the lowest frequency are also the same across all the study areas Hatch and Bobbles (in order of frequency, Figure 8, Table 5). However, in the study areas of Jabiluka and Dangurrung there is a much higher frequency of Lined Infill and X-ray Infill as well as a much higher instance of multiple combinations of infill types depicted in their macropod assemblages. These two study areas also have the highest frequency of painting completeness. This discrepancy may be attributed to the geological and localised taphonomic situations provided in the Jabiluka and Dangurrung rock shelters compared to those in the more dissected and exposed sandstones shelters present at Red Lily and Mikinj Valley. Additionally, there may be some expression of stylistic regionalism occurring across differing landscapes that has been identified in the four study areas.

Lined Infill is the most frequently depicted infill type on its own followed by Block Infill. Lined Infill is the most common infill type. After being depicted alone, it is most commonly depicted with Partial Infill and then X-ray. Interestingly, X-ray is most commonly depicted with Lined Infill as is Partial Infill (Table 6). As well, superimpositions of NRFs, Simple Figures, some Dynamic Figures and material culture (three pronged spear) overlie Lined Infill macropods (Figures 11-14). Partial Infill is present in the macropod lying underneath some Dynamic Figures while Line Infill is in others and so these are the oldest known infill types. However, when macropods are depicted with early X-ray they are also represented with Lined Infill in 9.8% of instances and Partial Infill in 9.2% of instances.

It can, therefore, be reliably argued from our results there is a continuation in the use of both Partial and Lined Infill types across large timescales, and that there are changes occurring in the selective choice of artists in how Partial and Lined Infill types are used in the depictions of macropods. It is likely then that Lined Infill was used an infill manner alone in earlier macropods (as demonstrated in the superimpositions) and then continued to be used with the introduction of other infill types such as Partial Infill and Early X-ray. It is probable that the early instances of Lined Infill is the same phenomenon that prompted Chippindale and Taçon (1993) to propose a new style called 'Stroke Infill manner'. A timing for the emergence for Lined Infill is not currently known, but it is clear from our results that this phenomena is Pre Dynamic.

While this study did not set out to establish the existence of the Large Naturalistic Style the evidence presented shows that people are painting large naturalistic macropods and choosing a number of manners of depiction in which to display these animals periodically from the Pre-Dynamic era up to 6000BP.

Chaloupka's assertion that there is a LNS as he described it is not supported with the results produced from the rock art assemblages presented in this study. Certainly, large early macropods appear before Dynamic Figures as shown and described above (Figure 9, 10; Chippindale and Taçon 1993: Figure 9). However, the manner of depictions as described by Chaloupka in his LNS are an over simplification that fail to recognise differences in stylistic variation across space and through time. We suggest that these Pre Dynamic animals be referred to as *'early large naturalistic fauna'* rather than LNS. This study demonstrates that these early naturalistic macropod depictions contain a combination of design elements depicting differing macropod forms and infill types that represent complex relationships to place, that change across large timescales. Naturalistic depictions of macropods (and by proxy other fauna) then illustrate nuanced spatial and temporal changes and do not conform to a homogenous class of art present across all of western Arnhem Land. Lastly, this paper has demonstrated that Lined Infill manner is the most common infill type for large macropods, after Block Infill, and that this manner of depiction continues to be used in the representations of macropods from the Pre Dynamic era up until at least 6000 cal. BP, when Lined Infill begins to be used in combination with early X-ray.

**Conclusion**

In this paper we have presented the results of an analysis of 163 macropod paintings from 861 rock art sites across four study areas in western Arnhem Land in order to explore the frequency, distribution and nature of early naturalistic animal forms that occur throughout the Early and Middle Periods of the regional stylistic rock art sequence. Our results have shown that there is a corpus of early naturalistic macropod forms occurring across western Arnhem Land and that there is generalised standardisation in the assemblage. However, differing macropod forms and infill types do exist and seem to represent complex relationships to place that change across large timescales. Furthermore the original definition of the proposed art style – known as the 'Large Naturalistic Style' (Chaloupka 1977; 1979; 1985; 1993) – and the style's chronological placement in the relative rock art sequence is not supported from the results presented in this study. There is a form of early naturalistic fauna that occur underneath Dynamic Figures but it is not as widespread or diverse as Chaloupka described it. We have, however, revealed that there is a large corpus of Early to Middle Period macropods that are depicted with Lined Infill, originally termed 'Stroke Infill Manner' (Chippindale and Taçon 1993; 2009) that emerges before Dynamic Figures and NRFs (c. 9,400 to 6,000 cal. BP) and continues to depicted with later infill types such as the Early X-ray convention.

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# Chapter 7

**Radiocarbon age determinations for early large naturalistic form macropod motifs from western Arnhem Land**

Authors: Tristen Jones, Vladimir Levchenko and Daryl Wesley.

Publication: Australian Archaeology

Current status: In Review

Tristen Jones: Developed the research question. Undertook field work and recorded the rock art data in the Red Lily study area. Sampled rock art for radiocarbon dating. Formulated the arguments in the manuscript. Drafted the majority of the manuscript, including introduction, site descriptions, methods, results and conclusion.

Signed: 30/3/17

**Tristen Jones**

Vladimir Levchenko: Sampled rock art for radiocarbon dating. Produced table of radiocarbon results. Calibrated radiocarbon data. Signed:

28/03/17

**Vladimir Levchenko**

Daryl Wesley: Participated in field work. Produced figures where acknowledged. Signed:

27/03/2017

**Daryl Wesley**

Short Report

# Radiocarbon age determinations for early large naturalistic form macropod motifs from western Arnhem Land

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## Abstract

In this paper we report the first reliable radiocarbon age determinations for early large naturalistic form macropod motifs with a minimum age of 4882 cal. BP. These dates confirm that this distinctive class of rock art has potential for early antiquity as proposed by the relative stylistic rock art chronologies for western Arnhem Land rock art.

## Introduction

In this study we present radiocarbon age determinations for depictions of two early large macropod motifs from one site located within the Red Lily Lagoon Cultural Precinct (RLLCP). The RLLCP is located within the traditional estate of the Manilakarr clan group of the Erre language group. The RLLCP borders the floodplains of the East Alligator River catchment, and is located approximately five kilometres northeast of Cahills Crossing on the main road into western Arnhem Land. Depictions of animals in large naturalistic forms are reported to be the earliest surviving figurative rock art assemblages in Australia and internationally (Akerman and Willing 2009; Aubert et al. 2014; Clottes 2008; Mulvaney 2013; Pike et al 2012; Taçon et al. 2014; Walsh 1994; Welch 1993). However, while early large naturalistic animals (and humans) are assumed to have great antiquity in western Arnhem Land very little research has focussed on their nature, function and age. Therefore samples were taken from two rock art panels for radiocarbon age determinations to test this proposed model of antiquity (Brandl 1973; Chaloupka 1993; Chippindale and Taçon 1993; 1998; Lewis 1988).

We present minimum ages from two early naturalistic macropod rock art motifs by using radiocarbon techniques to date mineral crusts that overlie the art (c.f. Jones et al. 2017). These dates represent the first chronometric ages for this class of early large naturalistic form of macropods in western Arnhem Land rock art.

**Description of study area and samples**

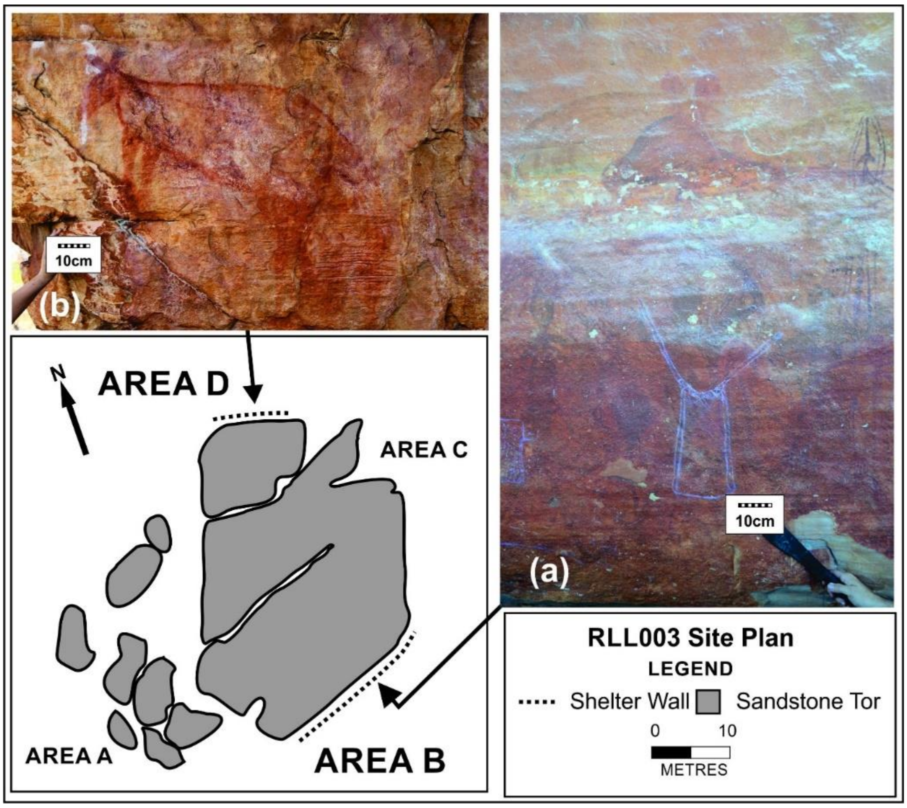


*Figure 1. Site map of Red Lily 3 highlighting Areas B and D and the rock surface locations of sampled motifs (a) and (b). Map by Daryl Wesley.*

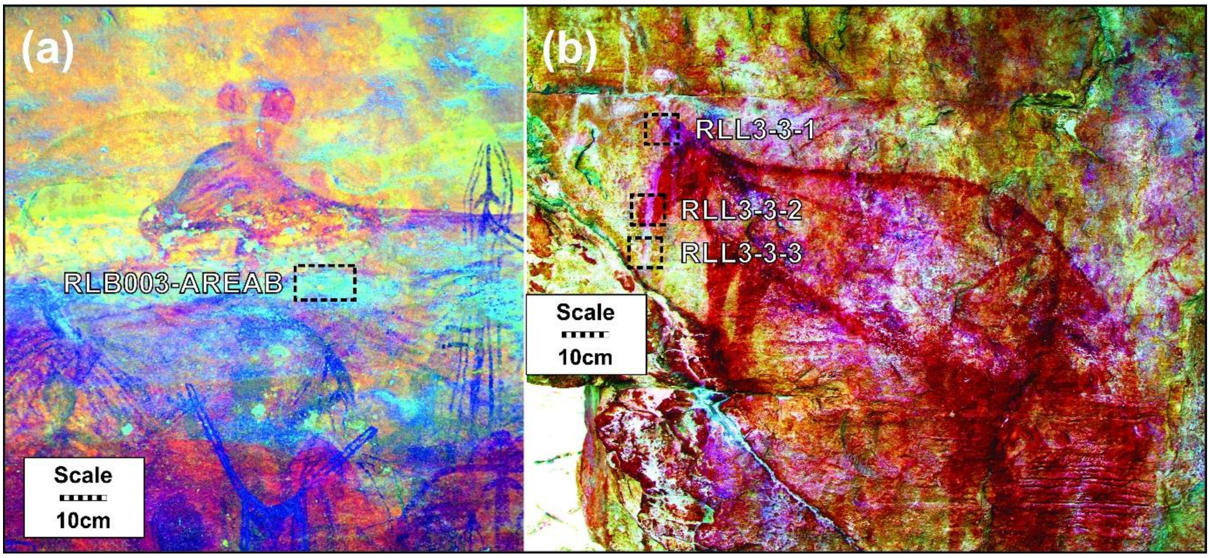


*Figure 2. (a) Macropod motif depicted in Block Infill from Red Lily 3 Area B. Section of motif sampled for radiocarbon dating highlighted. Photograph by Tristen Jones. (b) Macropod motif depicted with Early X-Ray conventions from Red Lily 3 Area D with section of motif sampled for radiocarbon dating highlighted. Photograph by Damien Finch. Enhanced by Daryl Wesley.*

Red Lily 3 is a sandstone rock stack situated on top of the Arnhem Land plateau with an elevation of 70 m Above Sea Level (ASL). There are four rock shelters in total (Shelters A to D) (Figure 1). Combined these four rock shelters contain over 700 rock art images in a range of different art styles. Art styles present span the Early, Middle and Late periods (Chippindale and Taçon 1998:107). A depiction of a large naturalistic styled macropod was identified in Shelter B (Figure 1a). The motif occurs early in the painting sequence on the rock panel and is now mostly obscured due to repainting. Only the head, upper neck / chest, outline of the back and upper back remains visible. This is a common occurrence for this type of rock art (Jones et al. this volume). As the motif is incomplete no measurement of motif dimensions were recorded. The motif is painted in red pigment, applied by brush, and is depicted in Block Infill (see Jones et al. this volume). A white mineral crust tracking across the body cavity of the macropod running parallel to the back outline was identified. A small area of this rock surface was spalling and a flake of the fractured surface containing the white mineral crust was removed and sampled for radiocarbon dating (Figure 2a).

In addition, a depiction of a large macropod containing Early X-ray conventions was identified in Shelter D (Figure 1b). This motif is complete and measures 1.1 metres in length by 0.9 metres in width. The motif is painted in red pigment, applied by brush, with the head, arms and legs depicted in solid infill. A line tracking from the back of the head down the body cavity is interpreted as a spine. This artistic element has previously been catalogued as a common attribute within the Early X-ray style (Taçon 1989:119-133). A white mineral crust was identified running down the rock face across the ears and snout of the macropod. Three samples were removed from the motif for radiocarbon dating (Figure 2b). Samples were removed using a diamond disk Dremel® drill, producing bulk crust removal in powdered form.

Once removed from the field, all samples from Red Lily 3 were taken to the Australian National University's (ANU) Research School of Earth Sciences laboratories to test for the presence of calcium oxalate using Fourier Transform Infrared Spectroscopy (FTIR) and X-ray Diffraction (XRD). Only the mineralogy of sample RLL3-3-1 was analysed. The sample contained quartz, minor phosphates (likely tinsleyite), gypsum, natroalunite, kaolinite, mica and amorphous material. The methods of FTIR and XRD did not detect calcium oxalate in the sample suggesting it may be present in the sample only below the level of detection (estimated to be a few %). The mineralogy of sample RLL3-3-1 is similar to other mineral crusts sampled from the study area for radiocarbon dating (Jones et al. 2017; King et al. 2017). Following mineralogical characterisation the samples were sent to the Australian Nuclear Science and Technology Organisation (ANSTO) research laboratories.

Table 1: Radiocarbon determinations of both the calcium oxalate and inert residue fractions. *The value of δ13C is assumed from determinations of similar samples. A measured value was not available due to the small size of samples. Results have been calibrated using CALIB 7.1 (Stuiver and Reimer 1993) using Southern Hemisphere 2013 calibration curve (SHCal13) (Hogg et al. 2013).

| ANSTO | Sample | Submitter ID | $\delta(^{13}C)$ per mil | | | percent Modern Carbon | | | Conventional $^{14}C$ Age | | | Cal yrs BP |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Code | Type | | $\delta(^{13}C)$ | | 1σ error | pMC | | 1σ error | yrs BP | | 1σ error | 2 σ range |
| OZR992‡ | Mineral crust - residues | RLL3-3-1 - solids | - 25.0* | | | 52.08 | +/- | 1.43 | 5,240 | +/- | 230 | 4436 - 3627 |
| OZR993U1 | Mineral crust- oxalates | RLL3-3-2 - oxalate | - 10.0* | | | 55.62 | +/- | 4.25 | 4,710 | +/- | 620 | 4862 - 1881 |
| OZR993U2 | Mineral crust- residues | RLL3-3-2 - solids | - 25.0* | | | 51.46 | +/- | 3.16 | 5,340 | +/- | 500 | 5311 - 3011 |
| | | | | | | | | | | | | |
| OZP535U1 | Mineral crust - Oxalate | RLB003 - AREA B | - 10.3$ | +/- | 1 | 64.30 | +/- | 0.25 | 3550 | +/- | 35 | 1932 - 1700 |
| OZP535U2 | Mineral crust - residue | RLB003 - AREA B | - 16.7$ | +/- | 1 | 62.95 | +/- | 0.33 | 3720 | +/- | 45 | 2199 - 1930 |

## Radiocarbon method and ages

The radiocarbon age determinations were undertaken using compound-specific dating by separating the calcium oxalate minerals contained with mineral crusts overlying the rock art images. The pre-treatment method and sample processing procedure has been detailed elsewhere (Jones et al. 2017) and has the advantage of separating the calcium oxalate from the other residues in the crust (dust, weathering material, biologic material). Results of blank corrected oxalates samples and inert residue fractions radiocarbon age determinations are reported in Table 1.

**Conclusion**

Sample RLB003 Area B produced a minimum age of 1932-1700 cal. BP for the Block Infill macropod (Figure 2a). Sample RLL3-3-2 produced a minimum age of 4862–1881 cal. BP for the macropod in Area D (Figure 2b) which is depicted with Early X-ray attributes. This minimum age of up to 4882 cal. BP aligns with the radiocarbon age determinations reported for X-ray conventions by Jones et al. (in press) and further supports the proposed minimum age of 8000-6000 BP for the emergence of the X-ray convention in western Arnhem Land rock art (Taçon 1989:119; 1992:203). In particular, this minimum age supports other recent radiocarbon ages for the X-Ray manner of depiction and the assumed antiquity proposed in the relative regional rock art chronology (Chippindale and Taçon 1998:107).

On the other hand while the results do not conform to the proposed greater antiquity for early naturalistic animal forms they do provide important chronometric and geochemical data. Nonetheless, these radiocarbon determinations are the first chronometric minimum age determinations for both motifs and by proxy early large naturalistic animal forms.

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# Chapter 8. Conclusion

The overarching research questions that this thesis has sought to explore concern whether the existing stylistic chronologies of the Early and Middle Periods rock art of western Arnhem Land adequately catalogue the variability of manners of depiction in the rock art record and whether these relative chronologies sufficiently map change in western Arnhem Land rock art assemblages through space and time. The results of this thesis demonstrate that the proposed timings for the emergence of some rock art styles, have been grossly underestimated (Chapter Three). In other examples, the absolute chronometric data has confirmed the work of previous researchers and the proposed antiquity of some artistic conventions (Chapters Five and Seven). Additionally, the results detailing the content, nature and function of some rock art styles (Chapters Four and Six) highlight some of the differing ways that prehistoric Indigenous societies used rock art as social markers in, and during, periods of adaptation and change, resulting in iconographic stylistic breaks in rock art traditions. Yet in other instances (Chapter Six) the research herein has shown how some rock art forms and manners of depiction have continued for millennia, evolving over long timescales integrating both 'old' and 'new' ways of depicting and communicating, through animals, for example.

This chapter synthesises the arguments and discussions outlined in Chapters Two to Seven, presenting a discussion of the implications of the results for our current understanding of rock art styles, the artistic sequence and the antiquity of western Arnhem Land rock art. The chapter concludes with a summary of identified future directions for western Arnhem Land rock art research.

## *8.1 A Revised Chronology for Middle Period Rock Art—Anchoring Rock Art Sequences to Archaeological and Environmental Data Sets*

The age estimates produced from radiocarbon determinations in Chapters Three, Five and Seven provide minimum and maximum ages for different rock art styles that enable the Early to Middle Period rock art of western Arnhem Land to be tentatively anchored to, or placed within, the stylistic sequence. This chronometric data has radically changed the previous chronological estimations for some of the art styles and the rock art sequence more generally. A revised chronological framework for the Early to Middle Period rock art of western Arnhem Land is presented in Table 1.

Table 1: Revised chronology for western Arnhem Land rock art

| **Period** | **Nature** | **Years before Present** |
|---|---|---|
| MIDDLE | Simple Figures + Yam Figures + Early X-ray* + large humans and large fauna | At least 6,000 |
| | \|(?) | |
| | Simple Figures with Boomerangs + large fauna | |
| | \|(?) | |
| | Northern Running Figures*~[?]~Post Dynamic Figures | 10,000 |
| | \|(?) | 12,000 (?) |
| | Dynamic Figures | Unknown (? c. 18,000 – 16,000) |
| | \|(?) | |
| EARLY | Large Lined Infill macropods* plus large animal paintings | Unknown |
| | (formerly Large Naturalistic) plus '3MF' stencils | Unknown |
| | Panaramitee like rock engravings | From |
| | Pigment in shelter deposits | 50,000 continuing |

* Art styles associated with radiocarbon age determinations and direct superimpositions underlined (new data: Jones, T. 2017 Unpublished PhD thesis, ANU).

** Table modified after Chippindale and Taçon 1998:107.

*** Prints and stencils for which there is slight evidence of dates are excluded except for '3MF' hand stencils which in the 1998 table are associated with Dynamic Figures. Recent personal communication with Paul Taçon (16 March 2017) confirmed that numerous newly recorded examples of '3MF' stencils at Mt Brockman occur underneath Dynamic Figure motifs. Thus '3MF' hand stencils have been repositioned to the Early Period in this chronology.

The minimum age for the NRF style is now known to be ca 9,400 cal. BP (see Chapter 3). The NRFs style occurs within the Middle Period of the western Arnhem Land stylistic art sequence (after Chippindale and Taçon 1998), thus providing an anchor with which to link Middle Period rock art to the broader archaeological record.

A large corpus of art styles, particularly depictions of anthropomorphic figures, known as Post Dynamic Figures, Simple Figures with Boomerangs and, potentially, Yam Figures are reported to occur alongside NRFs throughout the Middle Period in western Arnhem Land. Additionally, the first representations of the Rainbow Snake are depicted in Yam-styled imagery (Taçon et al. 1996). While further investigations will be needed to clarify the stratigraphic relationship of art styles such as Post Dynamic Figures, Simple Figures with Boomerangs and Yam-styled art to the NRFs style, our current understanding of the rock art sequence would suggest that these classes of anthropomorphic dominated manners of depiction have a similar antiquity to the NRFs style. The primary question that remains is what is a reasonable upper age limit, or maximum age, for the NRFs and, by association, for other early Middle Period art styles? And what is the evidence to support the hypothesis for a proposed maximum age limit?

My conservative estimation for an upper age limit for Middle Period is 12 ka, and perhaps up to 15 ka. If we have a minimum age of 9,400 cal. BP for the NRFs and other Middle Period art styles, and taking into consideration that:
a) there may be considerable time lag between art production and the growth of mineral crusts (and or other dateable materials such as mud-wasp nests cf. Bednarik 2014b; Ross et al. 2016; Smith et al. 2009), and
b) it is highly improbable statistically that we have dated the earliest instance of NRF art, then it follows that the NRF art style may be significantly older than the NRF minimum age limit. This estimation for an upper age limit for the Middle Period receives some support from other archaeological and environmental data sets.

Numerous studies have outlined the dramatic environmental changes that occurred across the globe throughout the Last Glacial Maximum (LGM), ˜23 ka–18 ka, and over the Pleistocene–Holocene transition (ca 11,700, Walker et al. 2008). The impact in western Arnhem Land was particularly extreme (cf. Allen and Barton 1989; Allen and O'Connell 1995; Hiscock 1999; Kamminga and Allen 1973; Kershaw 1995; Jones 1985; Schrire 1982; Woodroffe et al. 1986, 1987). Sea level was approximately 120 m lower than current levels at the height of the LGM (18 ka), and Australia and New Guinea were connected as one landmass, continental Sahul (Reeves et al. 2013a, 2013b). Temperatures were on average 3.5°C cooler than present day (Gagan et al. 2004; Visser et al. 2003; Weaver et al. 1998). Combined, this resulted in a cooler, drier and more arid environment (Crowley and Baum 1997). From 16.5 ka increases in global temperatures and rapid deglaciation resulted in warmer and wetter conditions and significant marine incursion (Lambeck and Chappell 2001; Lambeck et al. 2002). At 12 ka a major flooding event inundated the Sahul shelf and Arafura plain resulting in a sea level increase of approximately 70 m causing significant landmass loss (Yokoyama et al. 2001). In more understandable terms, the shoreline from the present day township of Gunbalanya at 18 ka was 314.4 km away (-120 m current sea level), at 15 ka the coast was 285.7 km away (-98 m), but by 12 ka Gunbalanya was only 163.5 km (-49 m) (Figure 1). This significant marine transgression across the low-lying flat coastal plains resulted in major land loss. This must have caused significant social disruption both for coastal groups relocating from inundated areas and to those resident groups who occupied the territory besieged by new arrivals.

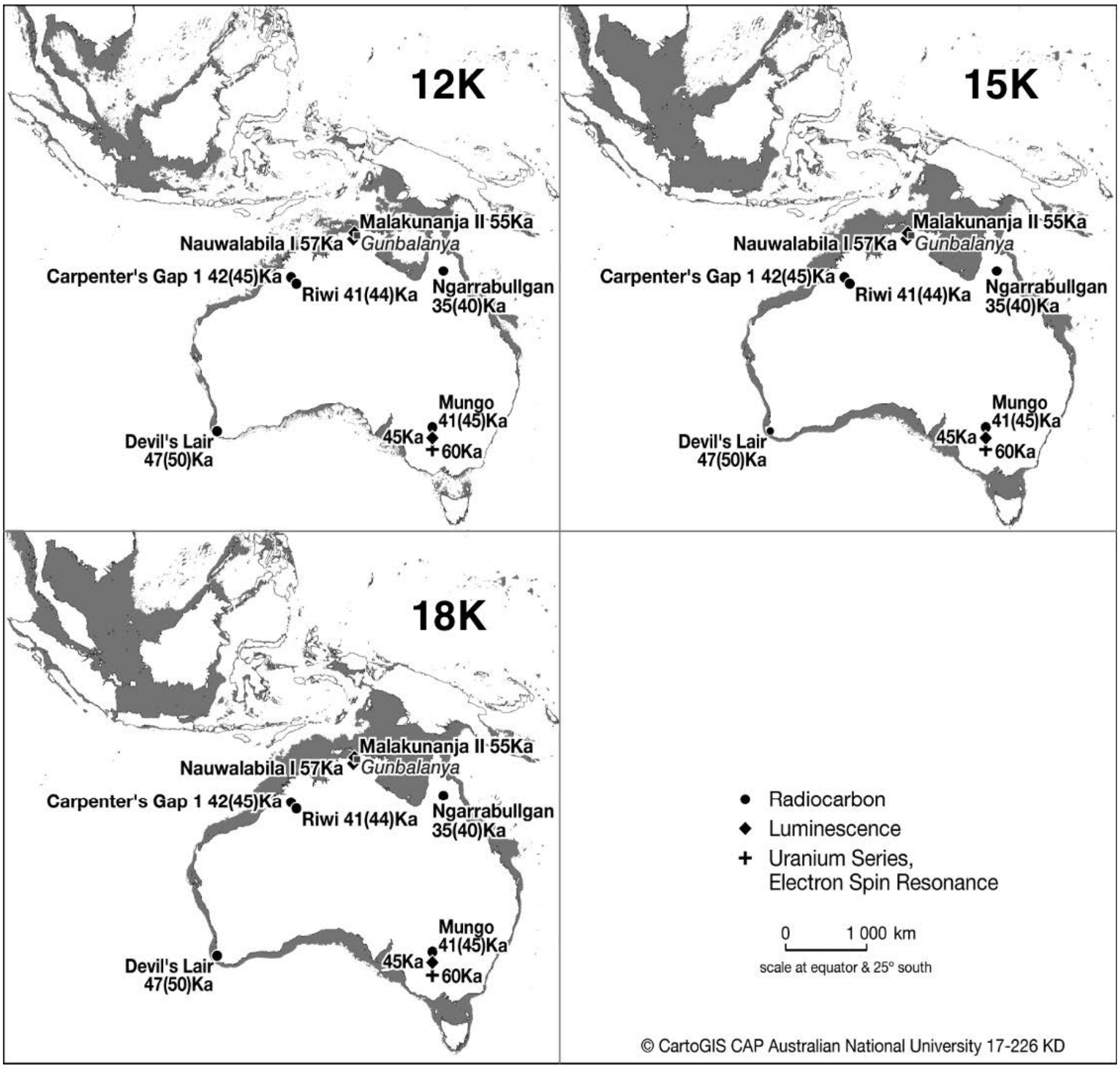


Figure 1. Map of Australian continent depicting changing Pleistocene coastlines and earliest known occupied archaeological sites. Map by ANU CartoGIS.

It has generally been argued that climatic instability throughout the peak of the LGM resulted in a contraction of human occupation in arid and semi-arid zones and decrease in population as Indigenous groups sought respite in zones of refugia (environments supported by permanent water sources) (cf. Smith 2013; Veth 1989, 1993; Veth et al. 2005; Williams 2013). Western Arnhem Land is known to be one such area with archaeological sites, such as Nauwalabila I, Madjedbebe (previously known as Malakunanja II), Malangangerr and Nawamoyn, demonstrating continuous occupation throughout the height of the LGM and into the Pleistocene–Holocene transition (Allen and Barton 1989; Bird et al. 2002; Clarkson et al. 2015; Jones 1985; Kamminga and Allen 1973; Roberts et al. 1990, 1994; Schrire 1982). Of the archaeological sites excavated in Arnhem Land, nine have Pleistocene–Holocene transition occupation, and six have Pleistocene dates extending beyond 18,000 ka (Allen 1989; David et al. 2013a; Shine et al. 2015; Taçon and Brockwell 1995).

Archaeological reviews have postulated that the amelioration of climatic conditions and increased rainfall following the LGM, would have increased carrying capacity for human populations, particularly in regions such as Arnhem Land subject to the reactivation of the northwest monsoon, and that population densities may have risen as a result, in some instances abruptly (Morwood and Hobbs 1995:750). Morwood and Hobbs (1995:750) conclude that in this period, 'the development of social mechanisms, including more complex alliance networks and systems of economic reciprocity, may have led to more efficient use of geographically and seasonally dispersed resource abundances ... '; that evidence of population expansion may include increases in site numbers and use; and that, among other indicators, there would be evidence indicating the implementation of new social mechanisms for territorial bounding. Indeed in a seminal archaeological review for western Arnhem Land by Allen, he suggests that 'there are some indications of an increase in site frequency … also indications of an increase in the intensity of site usage' for the period of 7,000 to 18,000 BP (1989:109). If these hypotheses are correct, increases in abundance and diversity in the production of rock art may illuminate the nature of the changes evidenced in the archaeological record. Following Wobst (1977) and Wiessner (1989, 1990) whereby rock art assemblages can be used by groups as non-verbal communicative tools in social strategies, other regional rock art assemblages have been shown to function as a form of information exchange, enabling resident populations to manage and negotiate alliance networks and access to place through the marking of landscapes, with increases in stylistic heterogeneity and abundance in rock art assemblages associated with increased territoriality and closed social systems (cf. McDonald 2005, 2008, 2016; McDonald and Veth 2006, 2013).

The archaeological evidence for the time period of interest is problematic, however, with minimal high resolution data illustrating increases in site frequency, increases in sedimentation rates in existing occupied sites, and increases in artefact densities for the same stratigraphic units reported in the published literature. Schrire's reporting from her excavations at Paribari, Malangangerr, Nawamoyn and Jimeri (I and II) does not temporally differentiate stratigraphic units or finds between 6000 years ago and the earliest occupation layers, presenting merely a two part cultural sequence: a cultural horizon predating 6,000 BP and one after (Schrire 1982:227–258). Therefore fine-scale changes in artefact and ochre densities, increases in sedimentation, and radiocarbon age determinations signalling potential changes in site occupation frequency and density through the terminal Pleistocene–Holocene transition are not reported or readily discernable from the data (a criticism noted by others, cf. Allen and Barton 1989). On the other hand, her excavations did confirm site occupation from pre-LGM to present at Malangangerr and Nawamoyn, and identified the nature of the early stone tool industries in this region (Schrire 1982:227–258).

Recent excavation results from ongoing research programs led by teams from Monash University, University of Queensland and the Australian National University (ANU) provide evidence that major changes are indeed occurring in the regional archaeological record at this time. Research currently in preparation by Daryl Wesley and ANU colleagues (including myself) will provide further support for major occupation and intensity changes evident in this timeframe, and will resolve the lack of visibility and data resolution of these changes in the archaeological record using the 2009 excavation data from the Bald Rock complex in the Wellington Range. Bald Rock 1 shows an increase in stone artefact density from 12.5 ka to 11 ka, with this period reflecting the second highest artefact density, after the 18 ka to 15 ka period (pers. comm. Wesley, 4 February 2017; Wesley 2013). The site was occupied from at least 25 ka (pers. comm. Daryl Wesley, 4 February 2017; Wesley 2013). The increase in artefact density in this temporal period mirrors changes in artefact densities in the Madjedbebe sequence (Clarkson et al. 2015). At Madjedbebe stone artefact frequency rises sharply at 12 ka (Spit 21), and in other undated stratigraphic units after 17 ka (cf. Clarkson et al. 2015, Figures 5 and 6). The increase in stone artefact frequency in Spit 21 is also matched by increases in haematite/ochres in the same stratigraphic unit (Clarkson et al. 2015, Table 2). The information presented in the Clarkson et al. 2015 paper is a revision of the data and dates from the original excavations in 1973 and 1988. Publication of new data derived from excavations undertaken in Madjedbebe in 2015 is currently ‘in review’ (pers. comm. Christopher Clarkson 7 February 2017). Once published the new Madjedbebe excavation data and dating dates will detail five discrete peaks of occupation, although the site was occupied throughout the entire sequence (pers. comm. Christopher Clarkson 7 February 2017). Of relevance to Middle Period rock art and the art sequence are the two main peaks in cultural material interpreted as reflecting an increase in occupation intensity at Madjedbebe: an early Holocene peak and a pre-LGM to LGM peak. Reportedly in the early Holocene sequence 12 ka through to 8 ka at a depth of between 80 cm and 50 cm there is a great increase in both stone artefacts and ground ochre. In the pre-LGM to LGM peak at 120 cm depth (dated from 22 ka to 18 ka) there is another major peak in lithics, followed stratigraphically by an increase in ochres. At ca 15 ka there is a decline in lithics presumed to reflect decreased occupation of Madjedbebe.

At Nawarla Gabarnmang on the western Arnhem Land plateau a similar broad trend in occupation can be deciphered, with two periods of occupation Period 3 (21,500–15,200 cal. BP) and Period 2 (14,800–8,500 cal. BP) present in Square A, with the site known to have been occupied periodically since 45,180±910 cal. BP (David et al. 2011; Mathews 2013). Occupation periods 2 and 3 are most relevant to timing the emergence of Middle Period rock art. Radiocarbon dates from stratigraphic units from Nawarla Gabarnmang Square E seem not to uniformly conform to the trend reported in Square A, but a dominant occupation phase in the terminal Pleistocene is evident (David et al. 2013a:2497). Decreased occupation intensity and more sporadic site occupation have been reported from 10,000 to 6,000 years ago in Square A, with the same temporal period not visible in the reported radiocarbon dates from Square E (David et al. 2013a:2497; Mathews 2013:23). At Nawarla Gabarnmang, Square A increases in artefact discard are evident from Spit 15 dated to 9,670±34 BP (David et al. 2011, Figure 3; Mathews 2013, Figure 4) steadily increasing to Spit 11 (8,616±34 BP). A full excavation report detailing finds for Nawarla Gabarnmang Square E and the other excavations undertaken at the site is currently not published (though much research is forthcoming and currently in press[1]). This

[1] Senior members of the Nawarla Gabarnmang research team have an edited monograph currently in press: David, Bruno, Paul S.C. Taçon, Jean-Jacques Delannoy and Jean-Michel Geneste (eds) 2017 *The Archaeology of Rock Art in Western Arnhem Land, Northern Australia*. Terra Australis 48, ANU E Press, Canberra.

includes ochre discard rates which are of particular interest. Once published, the results from Nawarla Gabarnmang will greatly inform debate regarding the timing the emergence of both rock art styles and periods in western Arnhem Land rock art chronologies.

Also noteworthy, is that research using time series radiocarbon data suggests a stepwise increase in population at the continental scale from ca 12 ka, resulting in widespread demographic restructuring which have been argued to have resulted in the emergence of complex social and cultural behaviours and traits in Indigenous societies at the time (Williams 2013; Williams et al. 2015a, 2015b). Demography more generally has been shown to be a major determinant in nurturing and sustaining complex modern behaviours (Powell et al. 2009; Shennan 2000, 2001). From both the environmental and archaeological records it seems likely that, following the marine transgression from 16.5 ka to 12 ka and major land losses ~12 ka, the existing populations of western Arnhem Land would have interacted and negotiated over space and resources as new outsider groups moved inland, retreating due to the significant land loss in their coastal territories. It is estimated that sea level rise was so rapid at this time that coastal populations would have lost kilometres of territory during a single generation (Allen and Barton 1989). Thus it is likely that increase of site occupation was occurring in western Arnhem Land during this time as populations relocated and socially restructured. This increase of occupation is reflected archaeologically in increased discard of artefacts and ochres and increases in sedimentation rates in occupied sites.

In addition to the increase in archaeological signatures discussed above, it has been universally noted by rock art researchers that in the postglacial period in western Arnhem Land there seems to be a proliferation in the density and diversity of rock art production (Chaloupka 1993; Chippindale and Taçon 1998; Lewis 1988). There is a reported increase in the stylistic diversity in rock art repertoires—many differing manners of depiction in the representation of anthropomorphic figures plus concomitantly diverse zoomorphic depictions. This is the first period in which regional signatures are evident in the rock art (Chapters Three and Four). As stated above, the role of demography and population increase in the efflorescence of cultural innovation and complexity has been well established elsewhere in the world (Powell et al. 2009; Shennan 2000, 2001). It is logical then to propose that the increase in stylistic diversity and abundance in rock art during this period is one such cultural signature of the demographic and social restructuring suggested by the archaeological assemblages at Madjedbebe, Bald Rock and Nawarla Gabarnmang. The timing of these changes is evident from at least 12 ka, perhaps earlier.

Earlier chronologies (Chaloupka 1993; Chippindale and Taçon 1998; Lewis 1988) estimated the timing of the emergence of the Middle Period rock art styles as coinciding with climatic amelioration and environmental stabilisation in the mid-Holocene (i.e. when sea level came close to its present position). However, the contribution of new data from multiple lines of evidence—demographic studies, archaeological investigations and environmental research, in combination with the absolute chronometric data for Middle Period rock art styles reported in this thesis (Chapter Three), combined with recently published research from the Kimberley region (Veth et al. 2016), provide a compelling argument that the previous estimations of the antiquity of Middle Period rock art antiquity need revision. The minimum age constraints reported here for the NRF art style demonstrate that these previous estimations are too late in time and do not consider the likely significant impact of environmental and demographic changes occurring in the 12,000 years between 18 ka to 6 ka.

### *8.2 Implications of the New Middle Period Art Chronology—the Early Period*

There are art styles that precede the NRF style and other Middle Period art forms (Table 1). Dynamic Figures, Large Lined Infill macropods, plus large animal paintings (formally known as the Large Naturalistic style), Object and Hand Stencils are known to occur earlier in the rock art sequence than NRFs (see Chapter 5; Brandl 1973; Chaloupka 1993; Chippindale and Taçon 1998; Lewis 1988). Subsequently, the minimum age for the NRF art style also produces a minimum age for earlier art styles that occur in the sequence. These results support commonly held assumptions by Australian rock art scholars that the Early Period rock art of western Arnhem Land which underlies the NRF style is of Pleistocene antiquity (Bednarik 2014a; Chaloupka 1993; Chippindale and Taçon 1998; David et al. 2013a, 2013b).

If the proposed sequence for Early Period rock art is correct and Dynamic Figures occur before the early forms of Middle Period art (i.e. NRFs), then a working hypothesis would be that the Dynamic Figure style has a minimum age of at least 12 ka and may possibly be much older, perhaps emerging during the height of the LGM and continuing to be depicted in the periods immediately following. Early Period rock art then would be related to the earlier main occupation period present in the archaeological sites described above at this time. This hypothesis however needs to be supported by radiocarbon or U-Series dates that produce age constraints for the Dynamic art style itself. Verifying the Pleistocene antiquity of this art style is an important chronological research question, which will confirm the early art sequence of western Arnhem Land rock art. A minimum age of 12 ka for Dynamic Figure art aligns with previously proposed assumptions of antiquity for the Dynamic Figure style (Chaloupka 1993; Taçon and Chippindale 1994, 2001). Both argue that Dynamic Figures represent an art style synonymous with a singular cultural bloc/population, in an arid climate, and that depictions of hunting and conflict are in response to social stress faced by resident populations during the harsh climatic conditions of the LGM. Recent research into the nature and function of Dynamic Figures indicates a ritual function (Johnston in press; May et al. in press). It is interesting to note that the nature and function of Dynamic Figure art as described above, would again not be contra to proposed demographic conditions at that time as supported by time series radiocarbon data and geospatial applications (Williams et al. 2013).

Additionally, this minimum age for the Dynamic Figures would not be incompatible with the assumed ages for the production of Gwion Gwion Figures (elsewhere known as Bradshaw Figures) in the neighbouring Kimberley region of Western Australia and would indicate a similar antiquity between the early rock art assemblages of both regions (Mulvaney 2013; Roberts et al. 1997; Ross et al. 2016; Travers 2015; Walsh 1994, 2000; Welch 1993). Stylistic similarities have been noted between the earliest figurative anthropomorphic styles in these regions (cf. Flood 1997:292; Lewis 1997). Indeed, links between the archaeology and art of the eastern Kimberley and the Northern Territory are the subject of current research by Professor Peter Veth (UWA) and colleagues (LP150100490).

### *8.3 How Rock Art Can Inform Our Understanding of the Nature of Social and Cultural Change in the Early Holocene*

This thesis has sought to explicate the chronological span, distribution and detailed content of NRF art in Arnhem Land in order to explore how ancient Arnhem Landers responded socially through their rock art to the disruptions caused by major shifts in climate, environment and demography during the late Pleistocene and into the early Holocene (Chapters Three and Four). How adaptations to social disruption resonate as archaeological signatures in the landscape has not yet been fully explored in the regional archaeological record due to two main factors.

(1) Archaeological excavations in the region have focused on testing and determining the great antiquity of the western Arnhem Land archaeological sequence in order to inform and engage in disciplinary debates regarding the colonisation of Sahul and capacity for founding populations to possess ‘modern cultural complex behaviours’ (cf. (Balme et al. 2009; Brumm and Moore 2005; Franklin and Habgood 2007; Habgood and Franklin 2008; Langley et al. 2011; O’Connell and Allen 2007, 2012), rather than explore and clarify small-scale changes or pulses in the archaeological record that may reflect social, cultural, economic and technological adaptations by populations during terminal Pleistocene–early Holocene transition (16.5 ka to 10 ka).

(2) Researchers have postulated that this paucity of archaeological signatures within excavated deposits dating between 18 ka and 7 ka can be supplemented by the rock art record (Taçon and Brockwell 1995). Yet the attempts to produce dates on figurative art styles for this period until recently have been futile and thus have made attempts linking rock art assemblages to the archaeological record highly conjectural. What is required now is for further analysis into other presumed Middle Period styles, particularly anthropomorphic-dominated styles such as Post Dynamic Figures and Simple Figures with Boomerangs, and potentially also Yam styled Figures, in order to explore their content, function, distribution and chronological relationship to NRF styled art.

Chapter Four details the nature and content of NRF styled art through an analysis of the NRF distribution on both a macro (landscape) and micro (site and panel) scale. The results, combined with an analysis of the NRF motif design elements, suggest that this art style performed a ritual function in past Arnhem Lander culture. Ritual behaviours have been shown to be used as a tool by societies to build social cohesion, utilised in order to adapt, explain and accommodate rapid change and major social and cultural disruptions in human society particularly amongst hunter gatherers (Bell 1992; Hayden 1987; Rappaport 1999; Ross 2004; Ross and Davidson 2006). As Hayden (1987:84) aptly states 'participation in rituals, where religious emotions served to cement bonds between groups, was a powerful agent in maintaining alliance'. This is seen both ethnographically and archaeologically.

For example, in the western Arnhem Land region the explorer Ludwig Leichhardt, on his 1845 journey to the north coast, reported seeing large groups of up to 200 Aboriginal people gathered in December (late dry season) exploiting the rich resources of the South Alligator River freshwater wetlands (Leichhardt 1847). It has been argued that such gatherings may have been sanctioned by ceremonial activity that underpinned a seasonal round of reciprocity and exchange between territorial clan groups living in the region (Brockwell et al. 2001). Chaloupka recorded Nipper Kapirrigi's story of how the Badmardi from the western Arnhem Land escarpment travelled to the wetlands to partake in the late dry season harvest, meanwhile bringing high quality stone from their quarries to exchange for bamboo and reed spears with their South Alligator neighbour (Chaloupka 1981). Likewise, Berndt detailed ceremonial exchange systems in the East Alligator River region where ritual activities played a vital role in maintaining group relationships as well as facilitating trade of goods and resources (Berndt 1951). Archaeologically such seasonal gatherings are suggested by large open sites along the wetlands edges of the South Alligator River that contain hundreds of thousands of stone artefacts, many derived from elsewhere in the region (Brockwell 1996; Meehan et al. 1985). These sites are presumed dry season camps as they are located strategically next to perennial backwater swamps that are flooded in the wet season.

Chaloupka hypothesised that in the rock art sorcery paintings were depicted by artists as a response partly to the widespread and devastating effects of introduced diseases due to contact with Europeans (1993:207–211). The impact of introduced diseases such as smallpox, leprosy, sexually transmitted diseases and influenza on local Indigenous populations is well documented (Keen 1980). Sorcery paintings were often painted in order to explain illness, misfortune and bad luck, or to extract revenge. Chaloupka (1993:207) notes that sorcery paintings appear to dramatically increase after European contact, with very few examples occurring before the contact period, and that these types of paintings are distributed more frequently in the northwestern margin of the plateau—the ‘contact zone’ where interactions with Europeans were more frequent due to buffalo industry land use.

The results from Chapter Four reveal that NRF art depicts ritual behaviours tied to selected places within a selected landscape. Additionally, the likelihood that NRF art is depicted at aggregation sites may be further evidence that the function of NRF art was to communicate broader group cohesion through ritual behaviours during a period of social restructuring. Further circumstantial support for the potential of NRF art to negate social stress in prehistoric western Arnhem Land society is evidenced by the increases in rock art production frequency, abundance and diversity in the Middle Period rock art. Increased heterogeneity in rock art assemblages can be argued to indicate the development of closed social networks (see discussion above), but NRF art may have fulfilled the need for unifying rituals that build broader regional social cohesion and alliances. Examples of rituals, such as the Kunwinjku (Gunwinggu) Wurbu ceremony, have been detailed by Berndt (1951) and have been shown to have played similar social functions where economic and trade alliances are maintained via ceremonial exchange. Yet the iconographic nature of NRF grounded within selected places may have also continued to assert visually concepts of dominance for particular groups (the ritual behaviour owners) over a particular resource abundant place.

### *8.4 From Change to Continuity? Enduring Depictions of Macropods in the Large Naturalistic Style*

While the emergence of NRF art shows ways in which Indigenous communities and their signalling behaviours changed in time, investigations exploring the nature, content and distribution of early large naturalistic depictions of macropods in Chapter Six illustrates an aspect of cultural continuity in ancient artistic practices. The results show that Lined Infill manner is the most common infill type for large macropods in the Early and Middle Period, after Block Infill, and that this manner of depiction continues to be used in the representations of macropods up until at least 6000 cal. BP, when Lined Infill begins to be used in combination with Early X-ray. Superimpositions of Dynamic Figures overlying Lined Infill manner macropods reveals that these types of artistic depictions are of Pleistocene antiquity. The study demonstrates that in general, there seems to be a trend of general uniformity across western Arnhem Land in the way that macropods, and perhaps fauna more generally, are depicted. Furthermore, the results in Chapter Six demonstrate that these early naturalistic macropod depictions contain a combination of design elements depicting differing macropod forms and infill types representing complex relationships to place, which gradually change across large timescales. Naturalistic depictions of macropods (and by proxy other fauna) then illustrate nuanced spatial and temporal changes and do not conform to a homogenous class of art present across all of western Arnhem Land as originally proposed by Chaloupka in his definition of the Large Naturalistic Style (Chaloupka 1977, 1979, 1985, 1993).

### *8.5 Stylistic Transitions at the End of the Middle Period—the Emergence of the X-ray Convention in Western Arnhem Land Rock Art*

The extensive research by Taçon and others (cf. Morphy 1991; Taylor 1996) on X-ray rock art has greatly informed the discipline on the role of rock art within an Indigenous society both in the present and in recent millennia. It also provides an important view of the scale, industry and economy of rock art (i.e. procurement of pigments, time expended in painting, communication of ideology, ritual and kinship). Additionally, due to the fact that the X-ray convention has continuity through into contemporary Indigenous art production, Taçon’s research provides an excellent example of how other supplementary forms of evidence—anthropological investigations, ethnographic and historical accounts, and contemporary art practice—can inform archaeological inquiry. Yet until now no absolute chronometric data for when this artistic practice emerged was available. Chapters Five and Seven provide minimum ages for the X-ray convention; 6,731–5,437 cal. BP and 4,862–1,881 cal. BP respectively. Detailed stylistic and superimposition analysis of motifs containing

X-ray convention design elements by Taçon (1989:119, 1992:203) led him to propose an estimated upper age limit for the emergence of the Early X-ray to between 8,000 and 6,000 BP. This proposed minimum age, utilised in the relative chronology (Chippindale and Taçon 1998:107) is supported by the radiocarbon age determinations reported in this thesis.

This thesis aimed to revaluate and test the validity of the previously proposed stylistic sequences and their assumed antiquity with particular reference to the Early to Middle Periods of western Arnhem Land rock art. It also aimed to anchor the stylistic chronology and our current understanding of western Arnhem Land rock art to the broader regional archaeological record through the production of absolute chronometric age constraints for selected rock art styles. Through a systematic study of identified rock art styles—the Northern Running Figure style, the Large Naturalistic style, and the Early X-ray convention—and through the utilisation of novel radiocarbon dating methods, this thesis produced absolute chronometric information regarding the timings of the emergence and disappearance of key rock art styles. Subsequently a revised chronology for the Early to Middle Periods has been proposed. This revised stylistic chronology for Early to Middle Period rock art enables a combined re-evaluation of both the archaeology and the rock art in the region, thus consolidating our understanding of the social nature, function and cultural context of rock art production in western Arnhem Land throughout the Pleistocene–Holocene transition.

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# Appendix A

# People and fish: Late Holocene rock art at Wulk Lagoon, Arnhem Land

by

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## Introduction

Taçon and Brockwell (1995) made an important contribution to the study of Arnhem Land archaeology by showing that in combining rock art with environmental change, archaeological sequences, and artefact assemblages, a multi-disciplinary synthesis for a regional archaeological narrative could be achieved. A similar approach was taken by David and Lourandos (1998) in an overview of rock art and archaeology in Cape York Peninsula, northern Queensland. This chapter proposes to examine the rock art of the Wulk Lagoon area, northwestern Arnhem Land, by using approaches discussed by Taçon and Brockwell (1995) and David and Lourandos (1998) to analyse rock art, with a methodology that includes reference to environment, ecology and climate change along with local archaeological sequences from excavated rockshelters.

The late Holocene archaeological record of Arnhem Land is abundant owing to high levels of Aboriginal occupation around the extensive wetlands and on the Arnhem Land plateau. Investigations of stone artefact assemblages in Australia have utilised approaches such as manufacturing technologies and proliferation events apparently linked to El Niño/Southern Oscillation (ENSO) and subsequent responses to risk in a context of environmental change (see Attenbrow et al. 2009; Clarkson 2002, 2007; Hiscock 2002, 2008, 2011; Hiscock and Attenbrow 1998, 2005; Lamb and Clarkson 2005; Veth et al. 2011). Residential mobility has also been assessed through characteristics such as the diversity and abundance of cultural materials in archaeological assemblages (see Andrefsky 2005, 2009; Kintigh 1984, 1989; Thomas 1973, 1989). In our case, we here try to understand Aboriginal occupation and behaviour in the Wulk Lagoon area, on the East Alligator River, over the past 1500 years via the distribution of its rock art (Figure 2.1).

Previous archaeological investigations in the region have usually payed minor attention to the rock art (see Allen and Barton 1989; Hiscock 1999, 2008, 2011; Schrire 1982). Hiscock (2008) has repeatedly pointed out that the art encodes valuable information, but identifies current shortcomings for true archaeological interpretation. Nevertheless, valuable advances in rock art research elsewhere have drawn on climate and environmental change (see McDonald 2015; McDonald and Veth 2013), pigment studies (see Huntley 2012; Huntley et al. 2014; Wesley et al. 2014) and 'direct' dating (see McDonald et al. 2014; Smith et al. 2009; Watchman 2000; Watchman and Jones 2002; Watchman et al. 1997, 2010). Each provides valuable information, allowing rock art to be better integrated into discussions of Aboriginal pasts.

– FIGURE 2.1 ABOUT HERE –

At Wulk Lagoon faunal themes are well evident, especially fish. Fish and other animals not only represent food resources, but also reference points for more esoteric aspects of life, as we know from ethnography both here and elsewhere. In the East Alligator River region, fish signal estuarine and freshwater ecologies and the widespread geomorphological changes that took place during the mid- to late Holocene. Wulk Lagoon's rock art also contains many examples of the anthropomorphic 'Energetic Figure' (Taçon 1989a, 1989b), 'Complete Figure', and 'X-ray' styles (see Chippindale and Taçon 1993, 1998) (for descriptions of the various art styles mentioned in this chapter, see Wesley 2015). The emergence of these rock art styles, or manners of depiction, their variation, and their distributions across the landscape are important for understanding late Holocene occupation of the region. We thus ask of Wulk Lagoon's rock art:

- Was it evenly produced across the landscape during the late Holocene?

- To what degree have climate and environment influenced human occupation and mobility, and how can the art aid us in this quest?
- Through time, did the positioning of rock art change across the landscape?
- What were the major subjects expressed in the art, and did these vary across space or change through time?
- Within rockshelters, was the rock art produced during occupation, or were the two largely mutually exclusive?

Significant changes in the environment and ecology of the East Alligator River have previously been noted for the period following sea level stabilization *c*. 6000 years ago (e.g. Chappell 1988; Chappell and Grindrod 1985; Clark and Guppy 1988; Grindrod 1988; Hope et al. 1985; Russell-Smith 1985a, 1985b; Wasson 1992; Woodroffe 1988; Woodroffe et al. 1985a, 1985b, 1986, 1987, 1988). Archaeological research nearby has shown the subsequent dramatic impacts of marine and estuarine change on human occupation and mobility, on the plains and on the plateau generally (Allen and Barton 1989; Bourke et al. 2007; Brockwell 1989, 1996; Hiscock 1999; Hiscock et al. 1992; Jones 1985; Kamminga and Allen 1973; Meehan et al. 1985; Schrire 1982). The last 6000 years saw new economic strategies develop, presumably to deal with these environmental changes, but also in response to social conditions. Excavations at rockshelter sites such as Birriwilk, Ngarradj Warde Djobkeng, Malakunanja II (Madjedbebe), Nawamoyn, Pari-Pari, and Jimeri (Jimede) clearly show the changes that occurred in diet, occupation, and stone tool technologies (see Figure 1.1 for site locations) (Allen and Barton 1989; Hiscock 1999, 2011; Kamminga and Allen 1973; Schrire 1982; Shine et al. 2013). However, these excavations tell us much less about changes in rock art for that same period of time.

Wulk Lagoon's rock art appears to be consistent with Chaloupka's (1977, 1984, 1985, 1993) sequence of major rock art styles that followed post-glacial sea level rise. But there are also limitations to attributing, reducing even, stylistic change to environmental change (see Chippindale and Taçon 1998; Lewis 1988). The late Holocene rock art is diverse and abundant, even within broad stylistic phases (Chaloupka 1977, 1984, 1985, 1993; Chippindale and Taçon 1998; Lewis 1988; Taçon 1989a, 1989b), and preservation has played its part. Nevertheless, it presents a rich opportunity to examine depictive or symbolic aspects of culture and cultural diversity, and in relation to occupation.

## The study area: Wulk Lagoon

To investigate degrees of abundance and diversity in depictive behaviour – how people marked the land – a 3.5 $km^2$ sandstone outcrop next to Wulk Lagoon was surveyed on the western side of the East Alligator River's coastal plain (Figure 2.1). Wulk Lagoon is in the traditional estate of the Manilakarr clan of the Erre language group. It and nearby palaeo-channels form important water features parallel to the northwestern edge of the sandstone plateau. It is in Mamadewerre Sandstone (part of the Kombolgie Sub-Group), a cross-bedded quartzose sandstone with medium to very coarse grain, and siliceous sandstone. Outcropping rock is generally found as sandstone tors, platforms, and escarpment features (Duggan 1994; Needham 1984; Senior and Smart 1976; Sweet et al. 1999). The sandstone outcrop at Wulk Lagoon is bounded by extensive coastal plains of the East Alligator River, rich in alluvial sediments with large lagoons, palaeo-channels, and *Melaleuca* sp., *Eleocharis dulcis* and *Oryza rufipogon*-dominated swamps and sedge-lands.

The Wulk Lagoon area first came to prominence for its rock art during the 1948 American-Australian Scientific Expedition to Arnhem Land through a number of publications by Charles Mountford (1956, 1964, 1965, 1975). The outlying sandstone hills next to Wulk Lagoon were called 'Inagurdurwil' by Mountford (1956). This is a name that is not recognised by Manilakarr Traditional Owners today; Gunn (1992) suggested that it may have been provided by an Aboriginal informant from Gunbalanya rather than by an Erre speaker. Mountford was particularly attracted to the detailed hunting scenes in the art, discussing them in detail along with the greater significance of the rock art seen during the expedition. These scenes and motifs at the Inagurdurwil galleries include images of running figures and men hunting (see Bühler et al. 1965:209). Mountford (1964, 1965, 1975) discussed techniques, materials and pigments used to make rock art in the region, using Inagurdurwil as a primary example. He refers to the rock art of western Arnhem Land as by far the most colourful he had encountered in Australia, again with specific reference Inagurdurwil (Mountford 1964:12).

Fred McCarthy (1965) was also part of that same 1948 expedition; he provided an overview of the archaeology. Some of the material he wrote about includes rock paintings from western Arnhem Land, X-ray and 'spirit' paintings, and painted caves at Red Lily (Wulk) Lagoon and elsewhere on the Manilakarr estate. McCarthy (1965) discusses 'Mormo' and 'Mimi' spirits, and reports X-ray paintings from Inagurdurwil, along with descriptions of the purposes of magic, increase rites, and the education of boys, each a significant feature of cultural knowledge for Manilakarr Traditional Owners. Further research at Wulk Lagoon was later undertaken by Jan Jelinek. Jelinek (1986) incorporated Inagadurwil in his general schema of western Arnhem Land rock art, studying rock art sites Inagurdurwil I to VI in particular. His stylistic identifications, chronological assessments, and interpretations of the archaeological significance of these sites are highly problematic, as they were made without reference to previous research while making highly improbable stylistic chronologies. Later, in 1990, Gunn (1992) undertook a detailed survey of surrounding parts of the Manilakarr estate, recording rock art imagery from numerous sites, including several at Wulk Lagoon. He documented sacred and cultural knowledge relating to Dreaming images and Spirit Beings, such as Birriwilk ('old lady'), Rainbow Snake (Ngalyod), barramundi, malevolent spirits (Namarodo and Marlwah), 'old hairy spirit' (Djidjnguk) and 'scarecrow figure' (Djiworrn Djiworrn).

**Western Arnhem Land during the late Holocene**

Previous archaeological discussions by Allen and Barton (1989), Brockwell (1989, 1996), Hiscock (1999), Hiscock et al. (1992), Jones (1985), Meehan et al. (1985), Schrire (1982) and others all refer to important Holocene environmental transformations for the region. Initial post-glacial sea level rise would have affected Aboriginal economic and, probably, social order, given the vast exposed landscapes that came to be inundated by rising seas. Since then, the past *c*. 6000 years saw two major environmental phases along the Alligator Rivers: a major, 'Big Swamp' phase (*c*. 6000 to 4000 BP), followed by 'Sinuous' and 'Cuspate' phases (4000 BP to present) that in due course came to see a 'Freshwater' period of wetland development (1500 BP to present) (Allen and Barton 1989; Jones 1985; Kamminga and Allen 1973; Schrire 1982). Throughout this time, Aboriginal people continued to occupy the region, as indicated by archaeological deposits in rockshelter sites at and near Wulk Lagoon, including the Birriwilk site a short distance south (Shine et al. 2013). Shine et al. (2013:72) dated the initial use of the Birriwilk shelter *c*. 5065-4865 cal BP, with occupation continuing into the European-contact period.

Archaeological research in late Holocene wetlands of the nearby plains found ecological diversity to be as important as biomass for Aboriginal settlement (Brockwell 1989; Brockwell et al. 2001; Guse 1992; Hiscock et al. 1992; Meehan et al. 1985). Resource biodiversity is usually highest along ecotonal margins between environmental zones. Archaeological studies have demonstrated that ecotones between coastal plains and sandstone plateaux, such as at Wulk Lagoon, provided attractive environments for occupation (Allen and Barton 1989; Hiscock 1999; Jones 1985; Schrire 1982). Such ecotones helped structure resource distributions, and therefore affected the mobility of resident and visiting groups. Areas of higher ecological diversity and resource abundance were targeted, forming sustained subsistence-settlement strategies that made their mark on the archaeological record (Allen and Barton 1989; Brockwell 1989, 1996; Hiscock 1999; Hiscock et al. 1992; Jones 1985; Meehan et al. 1985; Schrire 1982). Archaeological sites located at such ecotones, and in areas of high biodiversity and resource abundance, have thus been found to have substantial archaeological records, including rock art. But whereas these past studies have focused on faunal remains and stone artefacts, here we examine the art on the rocks.

*Environmental change during the late Holocene*

A number of geomorphological studies have investigated landscape history in the greater Alligator Rivers region (see above), but there are currently no palaeo-environmental reconstructions specific to the East Alligator River at Wulk Lagoon. The closest research occurred *c*. 13 km west, at Magela Creek, which focused on the ecological history of this backwater swamp and palaeo-tributary of the East Alligator River (East et al. 1987a, 1987b). Pollen evidence and radiocarbon dates from mangrove muds and shell middens in the Magela floodplain suggest a longer Big Swamp phase for the western East Alligator River region that for the South Alligator River, with *Rhizophora* forest dominating the pollen record from *c*. 8000 to 3000 BP (Clark and Guppy 1988:680-681). The Sinuous phase, which Clark and Guppy (1988:680-681) define as a transitional period from mangrove forest to freshwater wetland, has a later and slightly shorter record in the Magela floodplain than in the main, South Alligator River region, lasting *c*. 1700 years from 3000 to 1300 BP. The increase in sedimentation rates during this period, together with a subsequent phase of levee formation, may also be related to an increase in precipitation and seasonality (Denniston et al. 2013; Lees and Clements 1987). This transitional period, which experienced maximum environmental instability, produced the greatest vegetation diversity and variability of the Holocene (Clark and Guppy 1988:680-681). This has major implications for understanding changing patterns of Aboriginal occupation.

*Climate change during the late Holocene.*

Faulkner (2009, 2011) notes that across northern Australia, Holocene climate change occurred in tandem with sea level rise, and stabilisation strongly influenced coastal ecology. Denniston et al. (2013) show that past activity of the Indonesian-Australian Summer Monsoon (IASM), Inter Tropical Convergence Zone (ITCZ), and El Niño/Southern Oscillation (ENSO) may have driven precipitation variability since at least the mid-Holocene.

In particular, the IASM strengthened during the early Holocene, with enhanced, peak rainfall between 8000 and 4000 years ago, with a possible phase of increasing aridity from 6300 to 4500 years ago. This was followed by a decrease in IASM strength around 4000 years ago, leading to lower rainfall. Denniston et al. (2013) found peak aridity between 2000 and 1000 years ago, followed by a strengthening IASM developing into the pattern we experience today. There is also evidence from Magela Creek and the Daly River indicating a significant dry phase lasting *c*. 160 years from 690 to 530 BP (Wasson et al. 2010:172).

Increasing and decreasing precipitation have major impacts not only on vegetation and faunal communities, but also on rates of sediment accumulation across the landscape, and on the evolution of rivers and coastal systems. In contrast to fluctuating climates, studies of plant species in plateau ravines have revealed that long-lived floristic communities survived all the major climate changes since the Last Glacial Maximum (LGM), a result of the presence of permanent water sources and other factors (Russell-Smith et al. 1997). On this basis, it is likely that fluctuating precipitation driven by ENSO-IASM interactions saw continuity in floristic and faunal communities in dissected sandstone environments, despite a higher overall aridity. Lower precipitation rates can have significant impacts on riverine evolution, with reduced water-flows unable to flush out sediments from the sandstone plateau, leading to the siltation of major river systems, thereby choking mangrove communities and establishing massive floodplains, such as at Wulk Lagoon (Chappell 1993, 1998; Woodroffe et al 1993). These late Holocene fluctuations in IASM precipitation would have aided the proliferation of freshwater swamps and wetlands, significantly influencing shifts in woodland communities.

**Recent rock art research in Arnhem Land**

Archaeological research has shown the great length of Aboriginal occupation across the 'Top End' of the Northern Territory (e.g. Allen and Barton 1989; Bird et al. 2002; Brockwell et al. 2009, 2011; Clarkson et al. 2015; David et al. 2012; Delannoy et al. 2013; Geneste et al. 2010, 2012; Gunn and Whear 2007a, 2007b; Gunn et al. 2010a, 2010b, 2011; Hiscock 1999; Hiscock et al. 1992; Jones 1985; Meehan et al. 1985; Roberts et al. 1990; Schrire 1982; Shine et al. 2013). At Nawarla Gabarnmang, a small piece of quartzite with charcoal lines was retrieved from buried sediments dated to 27,000-28,000 cal BP, one of the oldest dated painted images in Australia (David et al. 2012). Around that time, Aboriginal people were actively modifying the shape of the shelter by knocking down rock pillars to expand the space within (see Chapter 10). Gunn et al. (2012) further document that, during the late

Holocene, rock art at this site included a range of conventions, including what they termed 'Northern', 'Bula' and 'Jawoyn' styles, indicating multiple signalling behaviour at a single site. The Nawarla Gabarnmang research demonstrates how one site or site complex can re-shape our understanding of rock art and Aboriginal occupation of the Arnhem Land region.

At the other end of the time scale, to the north of both Nawarla Gabarnmang and Wulk Lagoon, in the coastal sandstone of the Wellington Range, major archaeological and rock art results have also changed our way of thinking, in this case as it relates to the period of culture contact between Macassans, Europeans, and Aboriginal peoples (Clark and May 2013; May et al. 2010, 2011; Taçon et al. 2010; Theden-Ringl et al. 2011; Wesley 2013; Wesley et al. 2012). Analysis of painted ships and firearms caused us to rethink the involvement of Aboriginal people in maritime and terrestrial industries in northern Australia (Wesley 2013; Wesley et al. 2012).

## Methods

### *Rock art styles as chronologies*

As noted above, there has been a significant amount of research on Arnhem Land's rock art since the 1960s, leading to the identification of a number of major styles and chronologies (e.g. Brandl 1970, 1980; Chaloupka 1984, 1985, 1993; Chippindale and Taçon 1998; Edwards 1979; Jelinek 1986; Lewis 1988; Taçon 1989a, 1989b). These regional style chronologies have not made much use of absolute, chronometric dates, except in the case of beeswax figures (e.g. Taçon et al. 2004). Although Rosenfeld and Smith (1997:407) note that using 'style' can be problematic for the definition of chronologies, they also emphasise its value when rigorously applied.

Here we rely largely on Chippindale and Taçon's (1993, 1998) revised style chronology for western Arnhem Land. In a study such as ours at Wulk Lagoon, we need to be clear as to how style, and age, are given to the art, for we are working without absolute dates. Chaloupka (1993), Chippindale and Taçon (1998), Lewis (1988) and Taçon's (1988) identifications of late Holocene art styles, for example, have significantly affected how most, and perhaps all, researchers think of the sequence of stylistic conventions for this broad period of time (see the chronological table in Chippindale and Taçon 1998:107). As Chippindale and Taçon (1998) note, the Arnhem Land sequence has been developed mostly by seriating superimposed classes of painted motifs (*cf*. Lyman and O'Brien 2006). This includes both the presence and absence of fauna known, or thought, to have been associated with particular environmental conditions (Chaloupka 1993), and weaponry (Lewis 1988). These were perhaps the most viable approaches available to researchers since critical analysis of Arnhem Land rock art began in the early 1970s. Formal analyses of Rainbow Serpents, ‘Yam’ figures, and X-ray motifs have added to this schema, with links to climate and environmental change (Chaloupka 1993; Chippindale and Taçon 1998; Taçon 1994; Taçon and Brockwell 1995; Taçon et al. 1996).

Although each chronological model has its problems and limitations (see Bednarik 2012, 2014a, 2014b), the Arnhem Land style chronologies proposed by the above authors largely converge towards a broadly acceptable temporal schema (Figure 2.2), with all researchers also recognising that absolute dates are required to better understand the ‘real’ age of each style.

– FIGURE 2.2 ABOUT HERE –

*Survey strategy*

Wulk Lagoon provides an important lens for the archaeology of art at the interface of the stone country and the extensive coastal plains. This is a varied landscape, where questions of taphonomy are important for understanding the frequency of art, and of art styles and conventions. To deal with such questions, a small sample area was intensively surveyed at Wulk Lagoon, as a way of assessing how the larger rock art galleries that preferentially feature in the archaeology, and focal research areas in the escarpment base, compare to the whole. Also to be considered is the three-dimensional nature of the rock escarpment. Rock art occupies a complex space in this landscape, where elevated areas erode and valleys tend to accumulate rocks and finer sediments (see Chapter 1), so we divide the study area into three major zones: the escarpment base, the steeply eroded sides, and the rocky hilltops. This enables us to provide samples from different geomorphological, and erosional/depositional, zones. Of particular interest is whether the late Holocene saw all these zones used for rock art production and occupation. By stratifying the survey area in this way, we could also test for preservation and occupation bias in the resulting patterns.

*Assessing mobility*

A number of analytical techniques have been developed to model mobility and intensities of site use (e.g. Andrefsky 2005; Baxter 2001; Kaufmann 1998; Kintigh 1984, 1989; Thomas 1973, 1989). Many make use of measures of resource diversity and/or richness in the environment, or as evident in the archaeological record. Two properties are usually considered: the number of distinct *classes* present; and their degree of *evenness* or uniformity (Kintigh 1989:26). Thomas (1989:86) proposes that the overall relationship between the number of archaeological classes and the number of individual items is influenced by ecological, technological, informational (i.e. 'traditional ecological knowledge'), and scheduling factors. He describes three types of sites, distinguished (and measurable) by their archaeological richness: single use/activity-specific sites; short-term occupation sites; and long-term occupation sites. Frequently occupied sites are identified by technologically and typologically diverse stone tool assemblages that might have been used for many purposes, and over long periods of time. Less frequently occupied sites were usually used for more ephemeral, more specific, even single tasks; they have less diverse stone tool assemblages than the more frequently occupied sites. Infrequently occupied sites were even more task-specific, and here stone tool assemblages are the least diverse and least abundant (Thomas 1989:86).

Does this kind of diversity and richness modelling also apply to rock art, and to the rock art sites of Wulk Lagoon? To explore this we apply Thomas's (1989) principles of *frequency* and *abundance* of stone artefacts to the art. The production of rock art involves the use of materials, and it takes time and energy, much like the production and use of stone tools does. We would thus expect the greatest diversity and frequency of rock art styles, motifs, and elements to occur also at the most frequented places (Thomas 1989:86). The archaeological classes we use are the rock art styles, anthropomorphic motif types and elements, and zoomorphic motif types. Places where rock art was frequently produced are predicted to be rich and diverse in their art styles, motifs, and elements; less frequented sites to have intermediate levels of diversity and abundance; and rarely visited places, low diversity and low abundance. Applying these principles of diversity and abundance to rock art may provide a new way of investigating patterns of visitation and engagement, including aspects of occupational intensity not previously considered in Australian rock art research.

### *Taphonomy*

All archaeological assemblages in Arnhem Land possess taphonomic limitations. Owing to high rainfall levels associated with the IASM, and the predominantly sandy soils, faunal remains and other organic materials are usually poorly preserved (see Jones 1985; Schrire 1982). Highly seasonal climates see annual cycles of drying and wetting, burrowing animals, and high levels of soil mobility and/or soil acidity, all poor conditions for the preservation of organics (see Bourke 2000; Brockwell 2009; Gregory 1998; Guse 2006; Mowat 1994, 1995), and the potential for long-term preservation of both on-wall art and buried pigments requires systematic assessment.

At Wulk Lagoon a number of pigment types have been found, some in reasonable quantities, during excavations: ferrous oxides and haematite (reds, orange), kaolinite (white), whelwellite (white), kaolinitic claystone (white, red, yellow, orange) (Chaloupka 1993; Taçon 1989a, 1989b; Wesley et al. 2014). Claystone, whelwellite, and kaolinite pigments are thought not to preserve well, in part because they are soluble in water. This has often led researchers to assume that paintings (and motif types) made with such pigments date to the mid- to late Holocene, but not earlier, for surely they would have disintegrated since then. Climatic regimes with annual wet tropical monsoons will have quickened the dissolution of these soluble pigments, and the strengthening of the IASM through the mid to late Holocene with increased seasonal rainfall would have impacted on the art. The presence of white pigment in Arnhem Land rock art may not mean a late antiquity, but in more exposed conditions it more likely does, and thus helps in assigning a time-frame.

**Results**

In 2011, a total of 77 rock art sites were recorded within the 3.5 km$^2$ Wulk Lagoon study area, providing a mean density of 33.4 sites per km$^2$ (Figure 2.3). In this region, we estimate there are 13,000 rock art motifs painted on approximately 460 sandstone panels. Eight rock art sites face the coastal plain, with the remainder 70 sites on the sandstone outlier itself. The majority of sites were found on the escarpment base, hillside, hilltop, or on independent tor outcrops (Table 2.1). Of the 77 rock art sites, 44 are ‘rock art panels’ (rock art on one to three panels with no other archaeological features), and 33 are ‘rockshelters’; this differentiation was made to assess the location of the art relative to the size and nature of its site context. Documented archaeological features include grinding hollows and surfaces, buried cultural deposits, stone arrangements, hearths, stone artefacts, stone quarries, faunal remains, human burials, ‘contact’ materials, and wooden artefacts. Figure 2.4 shows their distribution at Wulk Lagoon. Table 2.2 indicates that, on average, only two archaeological features are present per site. An archaeological excavation was undertaken at Minjnymirnjdawabu 5 (MN05); in conjunction with the survey, it added valuable information regarding the timing of occupation and geomorphological processes at Wulk Lagoon.

– TABLE 2.1 ABOUT HERE –

– FIGURE 2.3 ABOUT HERE –

– FIGURE 2.4 ABOUT HERE –

Table 2.2 provides descriptive statistics for the art. There are, on average, 4.5 rock art styles per site (median = 3; maximum = 19). Zoomorphs and anthropomorphs are evenly represented (in 84.4% vs. 83.1% of sites, respectively, averaging 4.5 vs. 5.1 per site). Eighteen sites have 100 or more images, the largest being RLB032 with *c*. 3000 (Figure 2.5). The median of 15 motifs per site is more indicative of the trend, as a high standard deviation of 485.3 shows considerable variation in numbers, which range from one to *c*. 3000. The average number of panels per site is skewed by a few sites with high numbers.

– FIGURE 2.5 ABOUT HERE –

A broad range of rock art styles is found at Wulk Lagoon (Figure 2.6). Large Fauna, Large Human, Simple Figures and Complete Figure Complex paintings predominate, followed by X-ray, Early X-ray and Early Decorative Infill. Energetic Figure and X-ray motifs are most common in the major site complexes. Energetic Figures are especially common at the base of the rock outcrops, whereas X-ray and Complex Decorative figures are most common at the two major art complexes on top of the plateau. These three rock art styles clearly superimpose most others, indicating that they are amongst the most recent. Many rock art panels have multiple layers of superimposition.

– FIGURE 2.6 ABOUT HERE –

*Zoomorphs*

Zoomorphs include: dingo, marsupial, echidna, flying fox, macropod, reptile, goanna, frill-neck lizard, crocodile (freshwater and saltwater), snake, python, long neck turtle, short neck turtle, fish, thylacine, and bird. Fish motifs are the most abundant; they are discussed at greater length below. Macropods, reptiles, birds, goannas, and snakes are each present in more than 20% of sites (Figure 2.7).

– FIGURE 2.7 ABOUT HERE –

Paintings of fish occur in 43 sites. Taçon (1988:5) noted that 43 different native fish species are known from the Alligator Rivers region, with a dozen being consistently depicted in the rock art. He further found that most X-ray depictions are of barramundi, saratoga, fork-tail catfish, eel-tail catfish and mullet. Other depicted species include the freshwater longtom, archer fish, black bream, boney bream, and terapon perches or grunters (Tacon 1988:5).

Here we analyse 385 fish motifs from the art at Wulk Lagoon. Species include: barramundi (*Lates calcarifer*), saratoga (*Scleropages jardini*), fork-tail catfish (a.k.a. 'boofhead' catfish) (*Hexanematichthys leptaspis*), eel-tail catfish (*Neosilurus hyrtlii*), mullet (*Liza alata*), freshwater longtom (*Strongylura kreffti*), archer fish (*Toxotes chatareus*), toothless catfish (*Anodontiglanis dahli*), and black catfish (a.k.a. narrow-fronted tandan) (*Neosilurus ater*) (Figure 2.8). Additional to these, many fish depictions could not be identified to species.

– FIGURE 2.8 ABOUT HERE –

Figure 2.9 indicates the manner in which the fish were painted. The study found 54.5% of the fish paintings were in a Late Phase style. Estuarine species are more frequent than freshwater-only species. Fork-tail catfish, and catfish in general, are the most common. Their habitats can vary from brackish estuaries to only freshwater: for example, *Hexanematichthys leptaspis* inhabits both estuarine and freshwater habitats, whereas *Neosilurus hyrtlii* and *Neosilurus ater* only live in freshwater, be it still or flowing in streams, billabongs or pools.

The painted fish at Wulk Lagoon are associated with types of waterways that evolved locally only after post-glacial sea level rise *c*. 8500-8000 BP (Woodroffe et al. 1985a, 1985b, 1986, 1988). Between 8000 and 3000 BP, the Wulk Lagoon sandstone headland became surrounded by wetlands, swamps, and paleo-channels of the former East Alligator River (Hope et al. 1985:239). Large, backwater swamps and billabongs are thought to have increased in numbers in the Alligator River region after 3000 BP (Clark and Guppy 1988:680-681; Hope et al. 1985:240).

Figure 2.9 also shows the distribution of fish paintings by geographic zone at Wulk Lagoon. There is a preference for sandstone hillsides and hilltops.

– FIGURE 2.9 ABOUT HERE –

*Anthropomorphs*

At Wulk Lagoon, anthropomorphs include a range of shapes and associated items of material culture (see Figure 2.10). Human or human-like figures occur in over 80% of art sites. The majority are males with spears. Many have headdresses and spear-throwers, and a range of spear types is depicted. There is greater diversity in types of weapons than there is in armlets, neckbands, aprons, fans and bags. There are also high numbers of scenes where human figures are engaged in what appear to be ceremony (10.3%), fighting (11.6%), and hunting (23.3%); most of these are in what are thought to be late Holocene styles. Some scenes are in the Northern Running Figure style.

– FIGURE 2.10 ABOUT HERE –

**The Minjnymirnjdawabu sites: MN01, MN05, and MN12**

A detailed study was undertaken of 65 rock art panels at three of the Minjnymirnjdawabu sites (MN01, MN05 and MN12). Here the art is again mainly in late Holocene styles. Pigment colours are diverse, many consisting of hues of red, white, orange, or yellow (Figure 2.11). Many paintings are in two or more colours, and much pigment was used. Anthropomorphs and fish motifs are again common. Fish were painted in three distinctive patterns: solid infill, outline, and X-ray (Figure 2.12).

The size of art panels appears to have largely been affected by local geology, although there is a continuum in the area of the wall surface selected for painting (Figure 2.13). Figure 2.14 indicates moderate levels of damage on the 65 art panels.

– FIGURE 2.11 ABOUT HERE –
– FIGURE 2.12 ABOUT HERE –
– FIGURE 2.13 ABOUT HERE –
– FIGURE 2.14 ABOUT HERE –

*Archaeological excavation: MN05*

MN05 was selected for excavation because it appeared to have the best potential for datable occupational deposits (Figure 2.15). This is a rockshelter with a large overhang, 8 m long, 5 m wide, with an average height of 2.75 m from floor to ceiling. The ceiling and walls have a number of panels with multiple layers of art, including an impressive array of X-ray paintings of local freshwater fish. The site also contains the famous ‘blue’ contact painting of a sailing ship. Grinding hollows and surfaces are abundant, attesting to much occupation.

Three 1 × 1 m test pits were excavated, one against the wall (Test Pit B), one just outside the dripline (Test Pit A), and one outside the overhang to test the depth of sediment drop-off

(Test Pit C). Test Pit A quickly bottomed out on a slab of sandstone. Test Pits B and C were deeper, providing information on occupation beginning shortly after 1000 cal BP (Table 2.3).

– TABLE 2.3 ABOUT HERE –
– FIGURE 2.15 ABOUT HERE –

The deposits contain post-contact objects such as glass flakes and fragments, ceramic sherds, buttons, bullets, metal fragments, and glass beads. Stone artefacts are mostly quartz flakes and quartzite. There are many red, yellow, orange, and white ‘ochre’ fragments. A number of these are haematite crayons with striations clearly evident. Five beeswax fragments and a nodule of Reckitt’s Blue were recovered from Test Pit B. Faunal remains include barramundi (*Lates calcarifer*) and catfish (*Arius leptaspis*) otoliths, freshwater turtle bone fragments, varanid (monitor lizard) teeth, and freshwater bivalve shells (*Mytilus* sp.); highly fragmented, non-diagnostic burnt bone is abundant. There is evidence of bioturbation of sediments by macropods, introduced feral animals, and human hearth-building.

Excavation and ground penetrating radar (GPR) surveys indicate significant build-up of sands at the base of the Wulk Lagoon sandstone escarpment. Nott (2003) provides estimates of up to 6 m of accumulated sands from the plateau onto the coastal plains, dating back from Pleistocene times. In Test Pit C outside the MN05 shelter, 1 m of sand has accumulated in 1000 years. Excavations at MN05 and nearby Birriwilk (Shine et al. 2013; see Figure 1.1) show that cultural deposits have limited depth confined to the last 5000 years at the edge of the Wulk Lagoon sandstone outlier. Here any evidence of early Holocene or Pleistocene occupation would be buried under several metres of aggraded sand and flood deposits.

**Discussion**

Figure 2.16 shows two things for Wulk Lagoon’s rock art by temporal phase: 1) the proportion of total number of rock art styles; and 2) the proportion of total number of motifs (of any style) (see Figure 2.2 for details of each phase). There are few sites with Early Phase styles (those that are thought to be older than *c*. 8000 BP), and few motifs within those sites that do have them. Many (58%) of the sites have Middle Phase styles (*c*. 8000 to 3000 BP), but these contain a moderate proportion of motifs (only 25% of the overall rock art assemblage). There are a moderate number (33%) of sites with Late Phase (*c*. 3000 BP to present) styles, but these contain the majority of motifs (accounting for 70% of the total assemblage). Most of the art in the 18 sites with more than 100 images (which together account for 90% of Wulk Lagoon's rock art) are in late Holocene styles. At Wulk Lagoon, therefore, during the late Holocene rock art becomes very abundant in a moderate number of focal sites; it is less evenly distributed across the landscape than previously.

– FIGURE 2.16 ABOUT HERE –

Paintings of fish are fairly evenly distributed between the Middle and Late Phases: 45.5% are in styles of the Middle Phase, 54.5% in those of the Late Phase. This is consistent with a heightened importance of fish following risen sea levels, coastal infill and the development of swamps and waterways on the floodplains after *c*. 6000 BP. At sites MN01, MN05 and MN12, most paintings are of fish (55.5%) and anthropomorphs (31.5%), and of these most are in Late Phase (i.e. late Holocene) styles; 71% of rock art scenes at Wulk Lagoon (i.e. ceremony, fighting, and hunting) are also in Late Phase styles (all others are of the Middle Phase). Here there is clearly a proliferation of rock art in the Middle and Late Phases when fish, anthropomorphs, and scene depictions predominate.

Macropods occur in 36.3% of Wulk Lagoon sites, often in Large Naturalistic or Large Fauna styles. An $R^2$ value of 0.4846 indicates no preferential co-occurrence of zoomorphs with anthropomorphs. This suggests that in many cases sites were selected to paint zoomorphs, or anthropomorphs, but not both.

Much of Wulk Lagoon's rock art is found at the top of the sandstone outlier, with fewer sites along the base of the escarpment (Figure 2.17). Figures 2.18 and 2.19 show the number of rock art sites and art styles that occur, by geographic zone for each phase (see caption to Figure 2.19 for further description on calculation of number of art styles represented). During the Early and Middle Phases, the art is most abundant on the hillsides. But during the Late Phase, it is fairly evenly distributed across all three zones.

– FIGURE 2.17 ABOUT HERE –
– FIGURE 2.18 ABOUT HERE –
– FIGURE 2.19 ABOUT HERE –

These results suggest that during the late Holocene, pretty much all topographic zones of the Wulk Lagoon sandstone outlier were inscribed with rock art. Taçon and Chippindale (1994), Taçon and Brockwell (1995), and Hiscock (1999) have argued that the late Holocene saw rich resource supplies on the floodplains, resulting in population growth and increasing regionalism of clan estates: social organisation and land tenure systems shifted as clan estates with geographically-based totemic associations changed. This is consistent with the shifting distributions, and peak densities of rock art seen during the late Holocene at Wulk Lagoon. Here small clan estates with focalised occupation used sites intensively into the ethnographic period, as evident by the diverse and abundant rock art of the late Holocene. We suggest that this is evidence for lower levels of residential mobility and greater rock art production than previously. This happened at a time of increasing precipitation and strengthening of the IASM *c*. 1000 years ago, when the East Alligator floodplain developed deep lagoons, shallow lakes, and productive *Eleocharis* and *Melaleuca* swamps. Across much of Arnhem Land, X-ray art and the Complete Figure Complex flourished at this time, and there was a notable increase in the movement of exotic raw materials for the production of stone artefacts (e.g. Shine et al. 2013). The rock art and buried archaeological deposits of that time both seem to signal the onset of the kinds of cultural practices encountered at the time of European contact.

In support of this interpretation, Wulk Lagoon boasts a wide variety of rock paintings we might consider as scenes (n = 35) (Taçon 1994). May and Domingo Sanz (2010:41) discuss the significance of rock art scenes as modes of encoding socio-cultural practices. At Wulk Lagoon, late Holocene scenes have long been a focus of research (e.g. Chaloupka 1993; Jelinek 1986; Mountford 1956; Moyle 1981), especially those depicting the playing of didjeridus, prominent in at least eight scenes. The didjeridu is considered by Moyle (1981) to be a late Holocene musical development in Arnhem Land, because of the rock art styles it is associated with.

Although scenes are also found during earlier phases, their proliferation and increased variability during the late Holocene may be a reflection of the increasing density of local populations in the Alligator Rivers region (May and Domingo Sanz 2010). In contrast to the early battle scenes reported by Taçon and Chippindale (1994), at Wulk Lagoon those of the late Holocene generally involve fewer personages. Scenes depicting groups of >10 males engaged in either actual or ritual combat, or hunting, express individual engagements in social events (see Figure 2.20).

– FIGURE 2.20 ABOUT HERE –

That people and fish predominate in the rock art of the late Holocene might be linked to a number of factors. The emergence of freshwater wetlands *c*. 1500 years ago provisioned people with an enormous diversity and abundance of resources, driving population numbers and densities (see Hiscock 1999; Jones 1985). An intensifying IASM after *c*. 1000 years ago saw greater precipitation and major flooding events that would have significantly impacted on the development of freshwater systems in the Wulk Lagoon area (Denniston et al. 2013; Sandercock and Wywroll 2005; Wasson et al. 2010). Whether regional population densities were a result of actual population growth or a reorganization of existing groups from the broader region, mid- to Late Holocene rock art production signal increasing occupation intensities in the vicinity of Wulk Lagoon. With a greater population exploiting newly developed wetland resources, came greater levels of rock art production, increased rates of deposition of food refuse within sites, and increased stone artefact production (see also Allen and Barton 1989; Jones 1985; Schrire 1982; Shine et al. 2013).

In Arnhem Land, the proliferation of rock art during the late Holocene has been noted in a number of previous studies (e.g. Chaloupka 1993; Taçon 1989a, 1989b). However, its significance is often ignored or sidelined in narratives of the past (Hiscock 1999). Alongside the development of new stone tool technologies, perhaps to manage risks or exploit emerging environments, the proliferation of late Holocene rock art at Wulk Lagoon is an integral expression of the reorganisation of human populations in the Alligator Rivers region.

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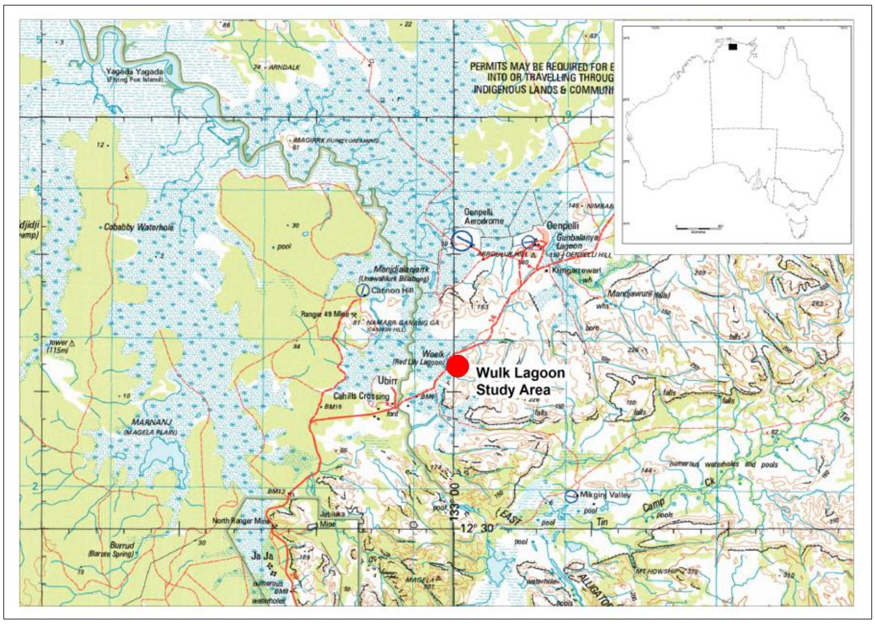


**Figure 2.1**. Location of Wulk Lagoon study area, western Arnhem Land, Northern Territory (base map after SD-5301 Geosciences Australia).


**Figure 2.2**. Composite rock art phases, after Chippindale and Taçon (1998:107), with amendments after David et al. (2012) and Gunn et al. (2012).

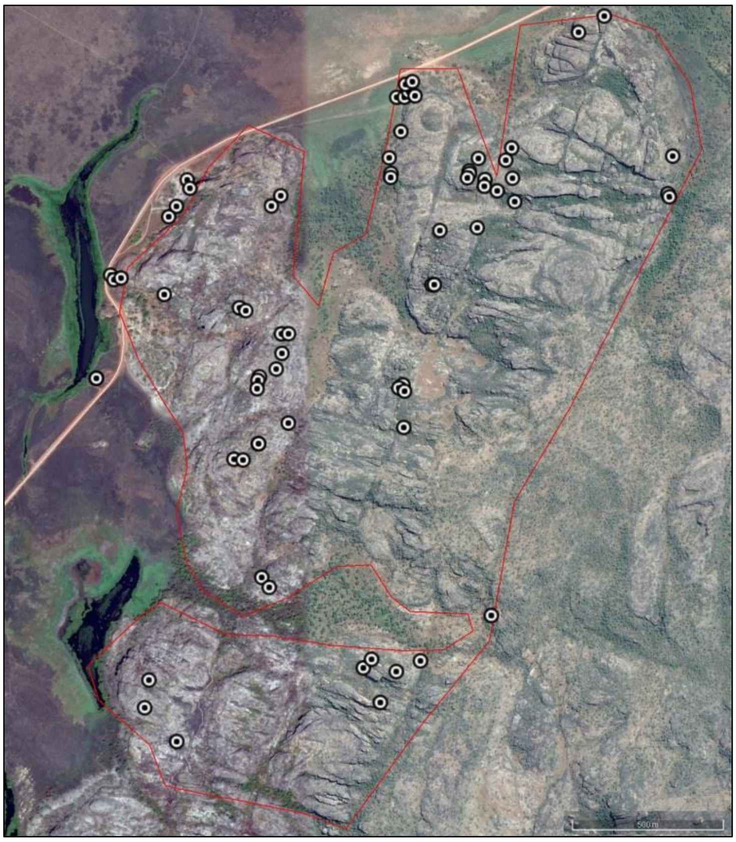

**Figure 2.3**. Survey area showing location of rock art sites (© Google Earth 2014).

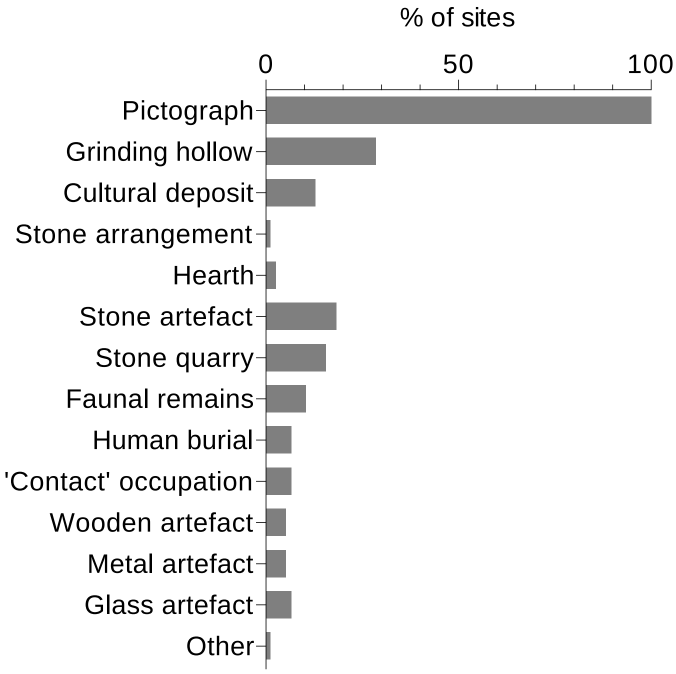


**Figure 2.4**. Types of archaeological materials present at rock art sites (n = 77 sites).

Source?

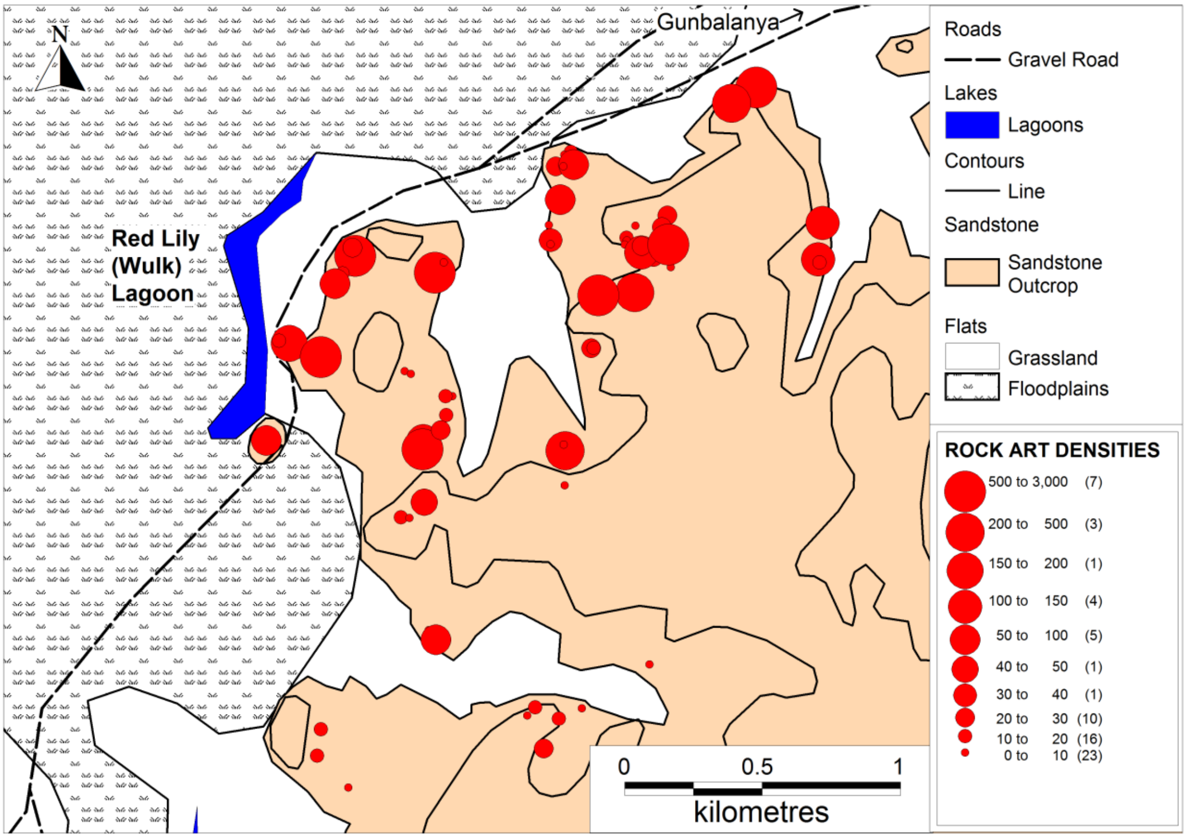


**Figure 2.5**. Distribution of rock art sites, showing number of artworks in each site.

source?

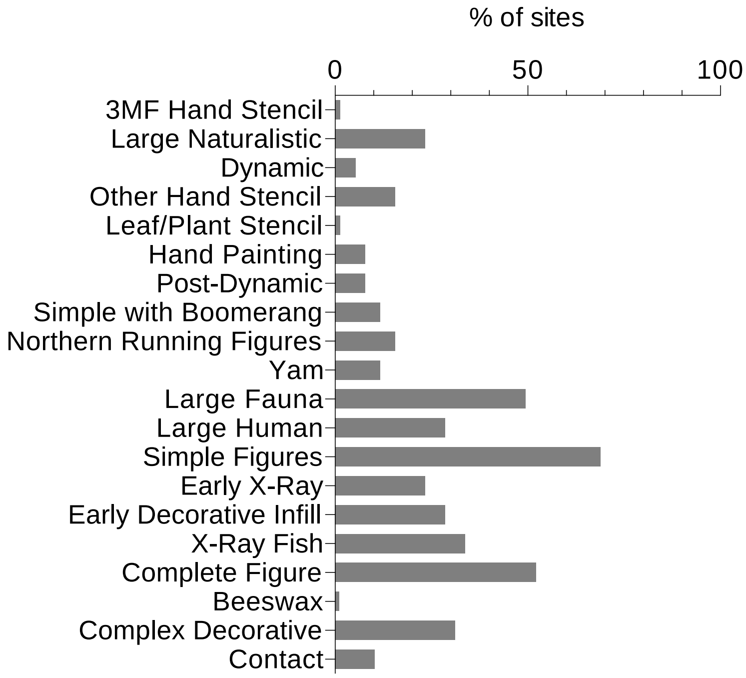


**Figure 2.6**. Proportion of sites with each rock art style (n = 77 sites).

Source?

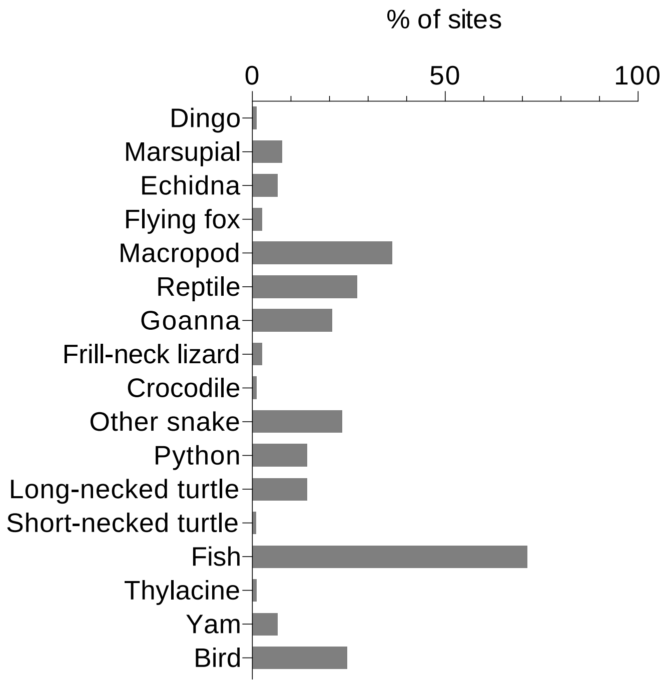


**Figure 2. 7**. Proportion of sites with each type of zoomorph (n = 77 sites).

Source?

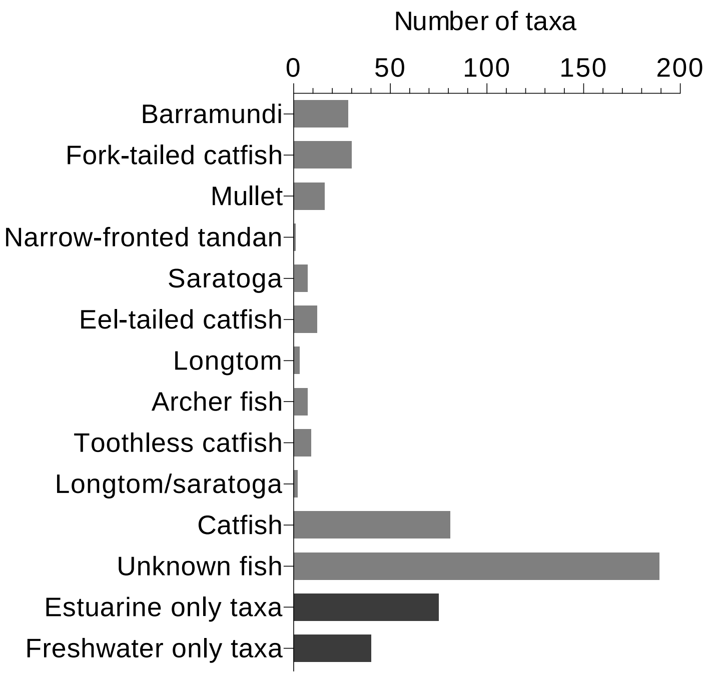


**Figure 2.8**. Number of paintings by fish taxa.

Source?

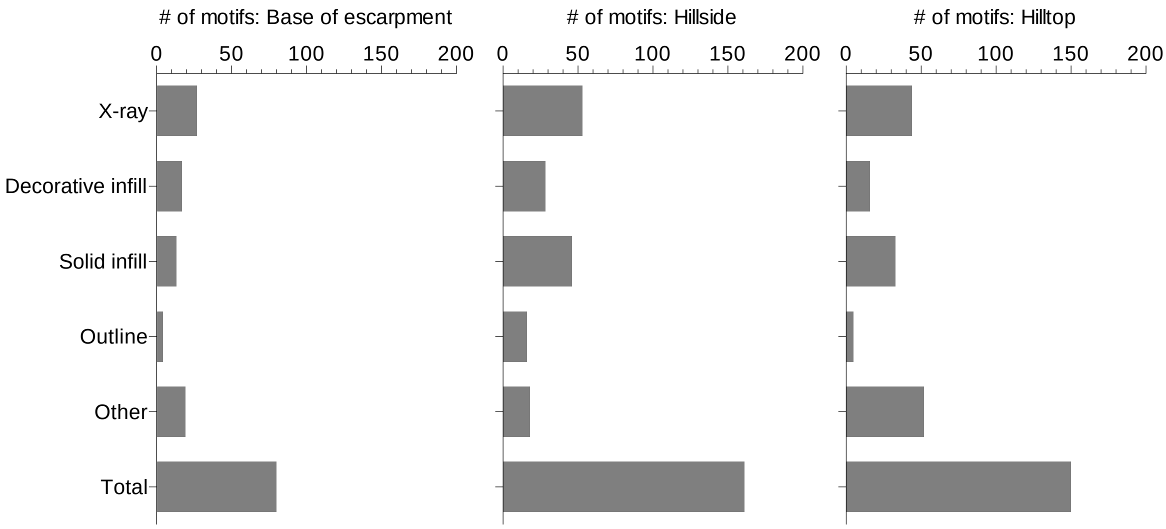


**Figure 2.9**. Painting manner for fish, by topographic zone. Source?

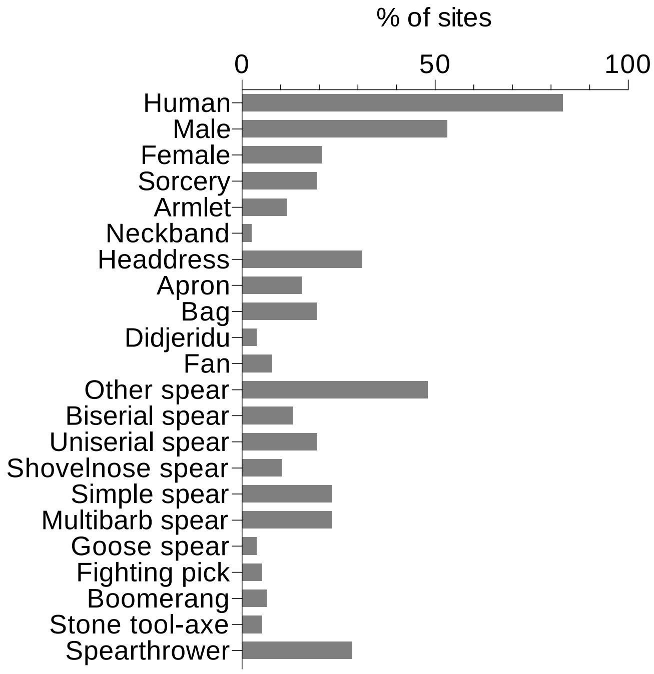


**Figure 2.10**. Proportion of sites with paintings of anthropomorphs and items of material culture (n = 77 sites).

Source?

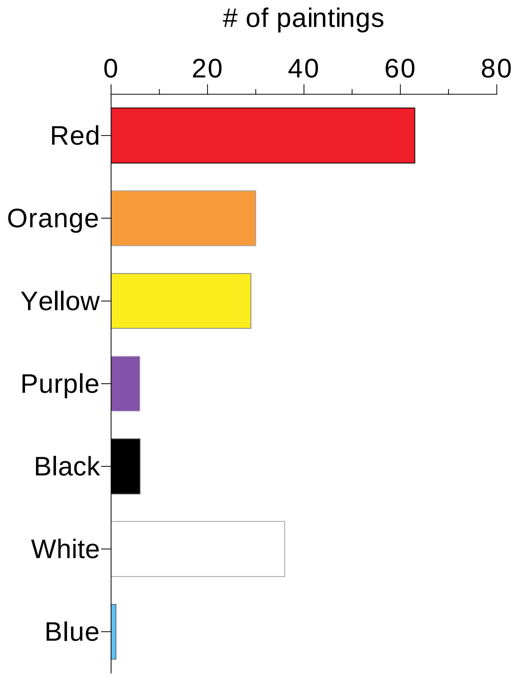


**Figure 2.11**. Number of paintings by colour, sites MN01, MN05 and MN12.

Source?

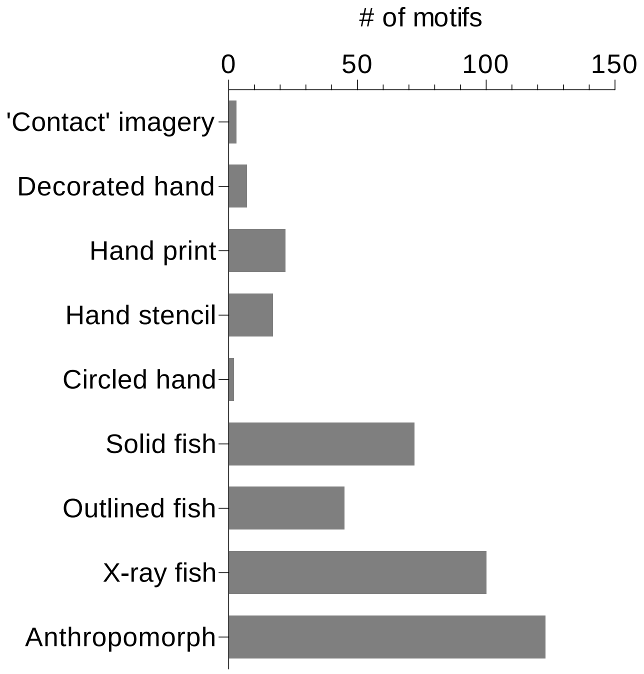


**Figure 2.12**. Number of artworks by motif type, sites MN01, MN05 and MN12.

Source?

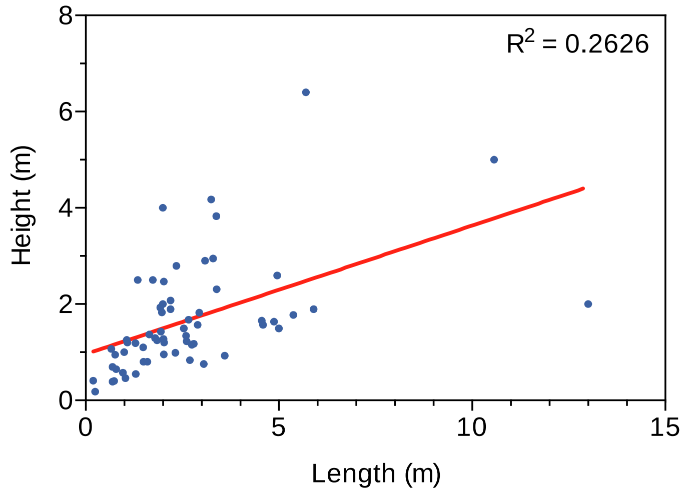


**Figure 2.13**. Distribution of panel sizes, sites MN01, MN05 and MN12 (n = 65 panels).

Source?

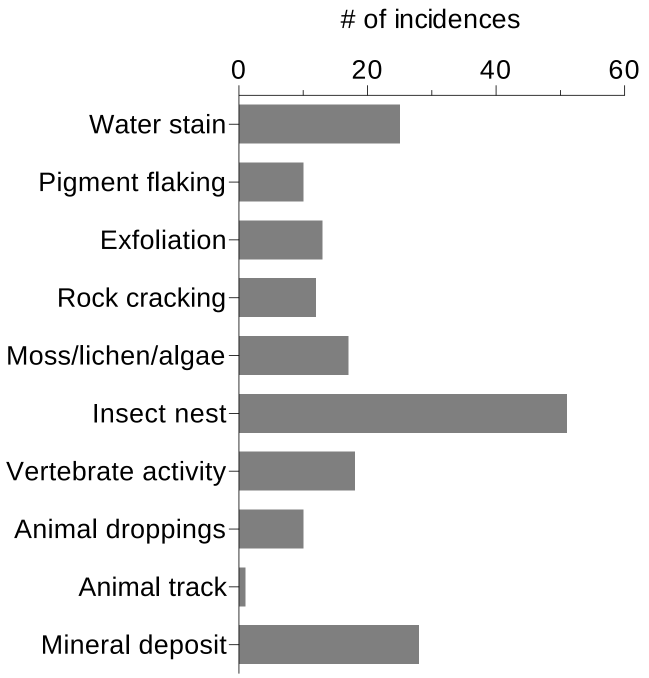


**Figure 2.14**. Frequency of impacts on rock art across 65 rock art panels, sites MN01, MN05 and MN12.

Source?

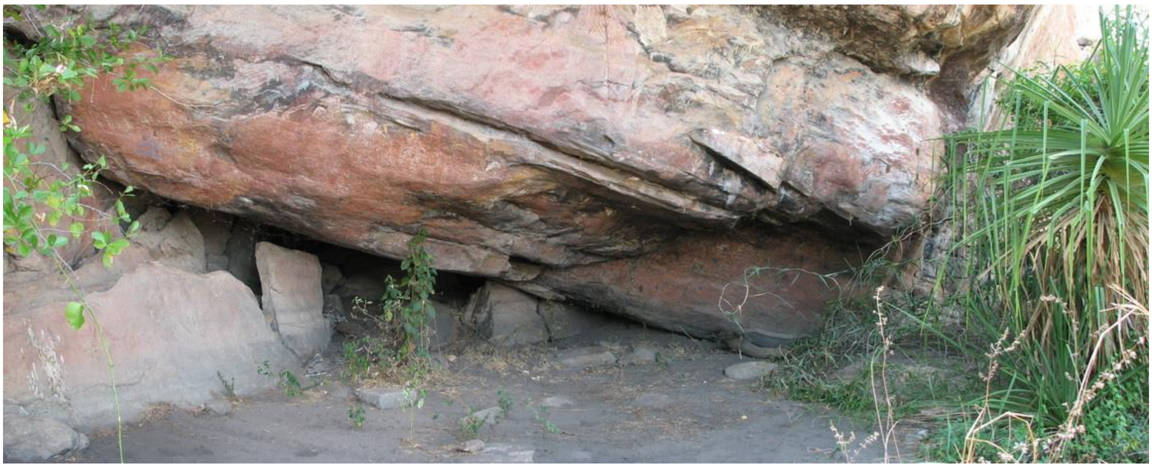

**Figure 2.15**. Site MN05 (photograph: Daryl Wesley). Source?

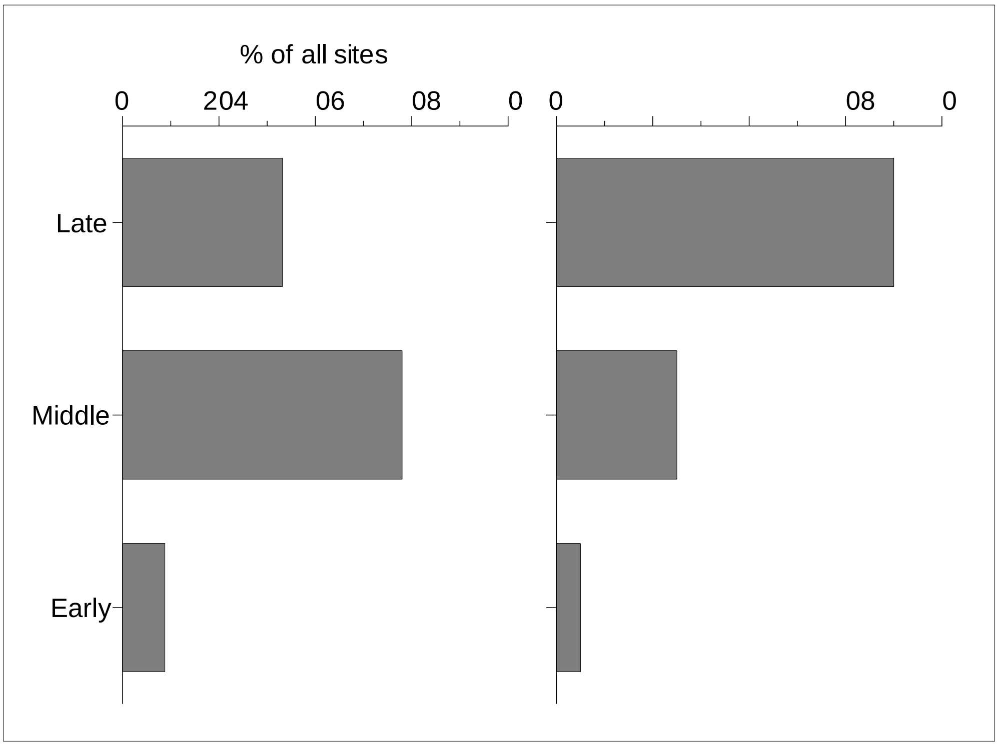


**Figure 2.16**. Relative frequency of rock art styles? and motifs by temporal phase (number of sites = 77; estimated number of motifs = 13,000)

Source?

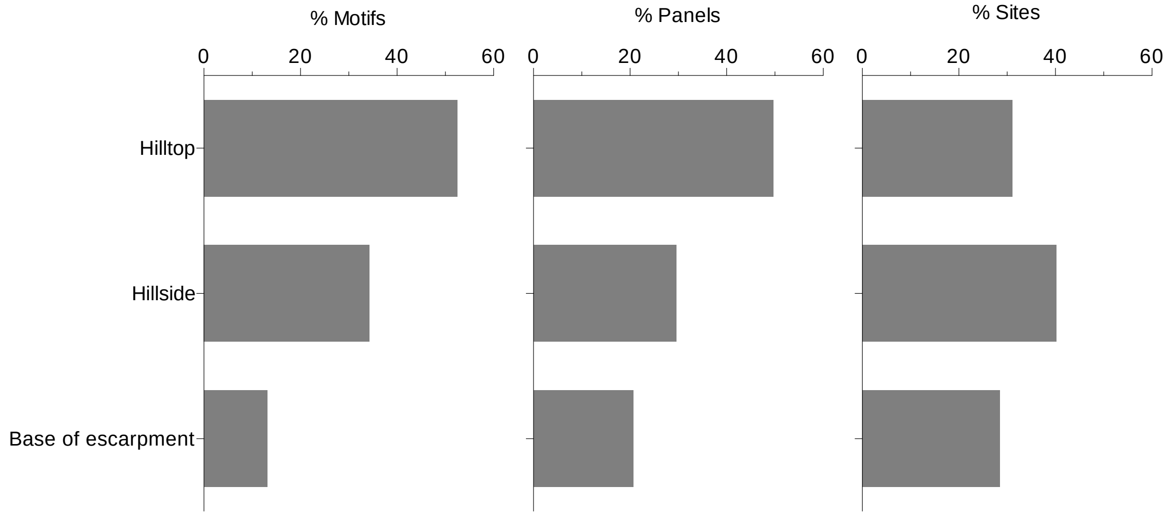


**Figure 2.17**. Proportion of motifs, panels and sites by topographic zone (number of motifs = 13,000; number of panels = 459; number of sites = 77).

Source?

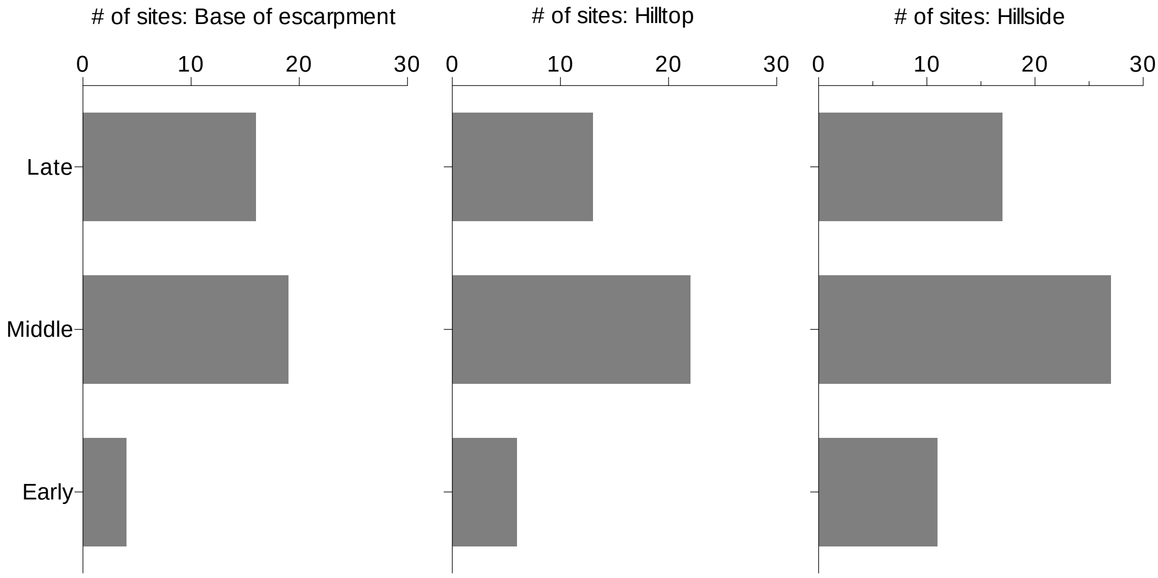


**Figure 2.18**. Number of rock art sites by phase and topographic zone.

Source?

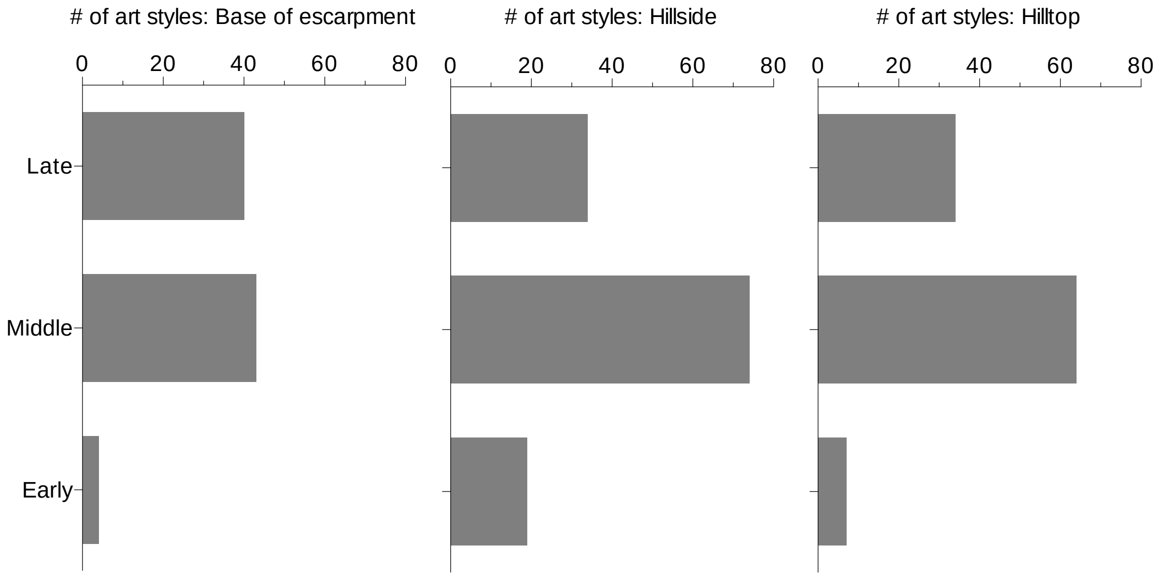


**Figure 2.19**. Sum of the number of different art styles represented per site, by phase and topographic zone (e.g. if there are two Late Phase sites on a Hillside, one site with five paintings of one style and the other with three paintings of another style, then that site will have two different art styles represented for that phase; to work out how many art styles are represented in the Hillside environment, all such Late Phase site values are summed). Source?

**Figure 2.20**. Example of complex late Holocene art scene, Wulk Lagoon site RLL004 (photograph: Paul Brugman).

**Table 2.1**. Geomorphological context of rock art sites.

| **Context** | **# of sites** |
|---|---|
| Bluff face | 2 |
| Boulder | 3 |
| Escarpment base | 18 |
| Hillside | 24 |
| Hilltop | 16 |
| Tor | 14 |

**Table 2.2**. Descriptive statistics for the 77 surveyed rock art sites at Wulk Lagoon.

| | **# of archaeological features/site** | **# of styles/site** | **# of zoomorphic classes/site** | **# of anthropomorphic classes and elements/site** | **# of motifs/site** | **# of rock art panels/site** |
|---|---|---|---|---|---|---|
| Mean | 2.4 | 4.5 | 4.5 | 5.1 | 167.7 | 6.0 |
| Standard deviation (SD) | 2.3 | 3.9 | 4.4 | 5.8 | 485.3 | 13.2 |
| Standard error of mean (SEM) | 0.264 | 0.449 | 0.503 | 0.665 | 55.308 | 1.502 |
| Lower 95% confidence limit | 1.85 | 3.58 | 3.46 | 3.75 | 57.38 | 2.96 |
| Upper 95% confidence limit | 2.90 | 5.37 | 5.47 | 6.40 | 278.02 | 8.95 |
| Minimum | 1 | 1 | 0 | 0 | 1 | 1 |
| Median | 2 | 3 | 3 | 3 | 15 | 2 |
| Maximum | 12 | 19 | 19 | 24 | 3000 | 100 |

**Table 2.3**. Radiocarbon dates on charcoal from Test Pits B and C, MN05.

| Laboratory code | Test Pit | Excavation Unit | Depth (cm) | $^{13}C$ per mil | % modern carbon | Radiocarbon date (BP) | Calibrated age (95.4% probability) (cal BP) |
|---|---|---|---|---|---|---|---|
| D-AMS 007849 | B | 21 | 47 | -24.2 | 97.95 ± 0.25 | 166 ± 21 | 165-225 |
| D-AMS 007850 | C | 23 | 95 | -24.5 | 88.97 ± 0.24 | 939 ± 22 | 795-950 |

*OxCal v4.2.3 Bronk Ramsey (2009); IntCal13 atmospheric curve (Reimer et al. 2013).

# Appendix B

Data in Brief 10 (2017) 537–543

Contents lists available at ScienceDirect

Data in Brief

journal homepage: www.elsevier.com/locate/dib

Data Article

# Characterization of mineral coatings associated with a Pleistocene-Holocene rock art style: The Northern Running Figures of the East Alligator River region, western Arnhem Land, Australia

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A B S T R A C T

This data article contains mineralogic and chemical data from mineral coatings associated with rock art from the East Alligator River region. The coatings were collected adjacent to a rock art style known as the "Northern Running Figures" for the purposes of radiocarbon dating (http://dx.doi.org/10.1016/j.jasrep.2016.11.016; (T. Jones, V. Levchenko, P.L. King, U. Troitzsch, D. Wesley, 2017) [1]). This contribution includes raw and processed powder X-ray Diffraction data, Scanning Electron Microscopy energy dispersive spectroscopy data, and Fourier Transform infrared spectral data.

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**Specifications Table**

| | |
|---|---|
| Subject area | Archeology |
| More specific subject area | Rock art |
| Type of data | Tables and Figures |
| How data was acquired | 1. Powder X-ray diffraction (XRD) analysis (PANalytical Empyrean powder X-ray diffractometer, Research School of Chemistry, Australian National University)<br>2. Scanning Electron Microscope energy dispersive spectral (SEM-EDS) analysis (Hitachi 4300SE/N field emission scanning electron microscope equipped with an Oxford INCA Energy 350 EDS system at the Centre for Advanced Microscopy, Australian National University)<br>3. Fourier Transform Infrared (FTIR) spectroscopic analysis – mid-infrared spectral range (Bruker Tensor 27, Research School of Earth Sciences, Australian National University) |
| Data format | Raw and analysed |
| Experimental factors | Characterization of mineralogy and chemistry of mineral coatings associated with rock art |
| Experimental features | Analysis of minerals, their quantities and their chemical composition |
| Data source location | Eastern Alligator River, western Arnhem Land, Australia |
| Data accessibility | The data is available with this article. |

**Value of the data**

- Data presented here will be useful to other researchers as a benchmark for Powder X-ray Diffraction and Fourier Transform Infrared spectra of natural oxalate-bearing mineral coatings.
- The raw XRD data may be reanalyzed with a different set of phosphate, sulfate and oxalate standards, which may help constrain the uncertainty in the Rietveld refinement values.
- The raw FTIR data may be deconvolved using other appropriate mineral databases and the results compared with the XRD Rietveld refinement values.

## 1. Data

### 1.1. Data from X-ray diffraction with Rietveld refinement fits

The oxalate mineral, whewellite, is found in all mineral crusts sampled (13–26.4 wt.%), except RLL3-1-1 where it is not detected (Table 1, Supplementary Figs. 1 and 2, Supplementary Table 1). Samples RLL32-B-S1 to RLL32-B-S4, RLL3-1-2 and RLL3-1-3 have the same mineral assemblage: whewellite and tinsleyite, with lesser taranakite, quartz and gypsum (Table 1). Sample RLL32-B-2011 is dominated by quartz and whewellite, with a little gypsum, a 10 Å-mica and a 7.1 Å-clay. Sr-crandallite or goyazite may be present at low levels (Table 1).

### 1.2. Data from Scanning Electron Microscope analysis

Backscattered electron (BSE) imaging data (Fig. 8a and 8d in [1]) indicates that the mineral crust contains at least four intimately mixed minerals ($<1$ μm to $\sim 3$ μm). As shown in Table 2, SEM-EDS data from the mineral crust indicates whewellite, and Ca–Al–(Sr)–phosphate(s) –crandallite, Sr–crandallite, or crandallite mixed with apatite.

**Table 1**
Quantitative data for minerals in the crusts based on Rietveld refinement fits of X-ray diffraction data.

| **Sample** | **RLL032-B-2011** | **RLL032-B-S1** | **RLL032-B-S2** | **RLL032-B-S3** | **RLL032-B-S4** | **RLL3-1-1** | **RLL3-1-2** | **RLL3-1-3** |
|---|---|---|---|---|---|---|---|---|
| **Scan No.** | A24950 | A25292 | A25302 | A25301 | A25290 | A24950 | A25292 | A25302 |
| $R_{wp}$[a] | 4.53 | 4.63 | 3.28 | 3.40 | 3.70 | 4.75 | 4.09 | 4.30 |
| ***Mineral- wt.% (sd)***[b] | | | | | | | | |
| Amorphous material | 70.5 (5.0) | 53.8 (5.0) | 52.3 (5.0) | 65.9 (5.0) | 69.5 (5.0) | 28.3 (3.0) | 14.9 (3.0) | 40.6 (5.0) |
| Quartz $SiO_2$ | 9.3 (0.7) | 2.5 (0.1) | 3.1 (0.1) | 2.9 (0.2) | 1.7 (0.2) | 32.7 (0.6) | 5.6 (0.3) | 3.2 (0.2) |
| Gypsum $CaSO_4.2H_2O$ | 1.1 (0.2) | 3.7 (0.3) | 3.0 (0.3) | 0.8 (0.2) | 1.7 (0.2) | 1.8 (0.1) | 3.1 (0.2) | 2.0 (0.1) |
| Whewellite $CaC_2O_4.H_2O$ | 13.0 (0.9) | 20.3 (0.8) | 20.1 (0.7) | 17.4 (0.8) | 15.1 (0.9) | | 26.4 (0.6) | 17.4 (0.6) |
| Tinsleyite $KAl_2(PO_4)_2(OH).2H_2O$ | | 17.7 (1.0) | 18.2 (0.8) | 12.9 (0.8) | 11.9 (0.9) | 21.5 (0.5) | 48.3 (0.8) | 35.2 (0.9) |
| Taranakite $K_3Al_5(HPO_4)_6(PO_4)_2.18H_2O$ | | 2.1 (0.1) | 3.4 (0.3) | 0.1 (0.2) | 0.2 (0.2) | 0.3 (0.1) | 1.8 (0.2) | 1.6 (0.3) |
| Goyazite $SrAl_3P_2O_7(OH)_7$ | 1.5 (0.4) | | | | | | | |
| 7.1 Å-clay[c] | 0.8 (0.4) | | | | | | | |
| 10 Å-mica[c] | 3.8 (0.6) | | | | | | | |
| Variscite $AlPO_4.2H_2O$ | | | | | | 15.4 (0.4) | | |
| **Total** | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |

[a] Goodness-of-fit indicator $R_{wp}$ for the weighted profile: $R_{wp}= [(\Sigma w_i(y_{io}-y_{ic})^2)/(\Sigma w_i y_{io}^2)]^{1/2}$, where $y_{io}$ is the observed intensity, $y_{ic}$ the calculated intensity, and $w_i$ the weight assigned to each observation based on counting statistics.
[b] Refined variables included zero correction, scale factors, unit cell parameters of major phases and up to four peak shape parameters per mineral.
[c] 7.1 Å-clay is likely kaolinite and 10 Å-mica is likely illite or muscovite.

### 1.3. Data from Fourier Transform Infrared spectroscopy

Fourier Transform Infrared spectra provide constraints for the presence of oxalates, sulfates, phosphates and clay minerals in the crusts (Fig. 1a and b). Infrared bands associated with the calcium oxalate (whewellite) are evident in the spectra at 1315–1320 and 780 ($C_2O_4$) and 670 cm$^{-1}$ (water libration) and possible bands include 1430 cm$^{-1}$ ($C_2O_4$), 3420 cm$^{-1}$ (OH), and 1625 cm$^{-1}$ (HOH). Phosphate minerals (crandallite, Sr-crandallite/goyazite and apatite) have bands at 1383, ~1110 and 890 cm$^{-1}$ and 1020 cm$^{-1}$ related to $PO_4$ vibrations and 3486 cm$^{-1}$ related to OH. Bands due to silicate minerals are found at 3246 cm$^{-1}$ ($Al_2$-OH, clay) and 1020 cm$^{-1}$ ($SiO_4$). The FTIR data does not rule out sulfate (Supplementary Table 2). Bands at 3344 and 3062 cm$^{-1}$ are assigned to OH groups in minerals.

The six FTIR spectra obtained from the RLL032B-B site ([1], Fig. 1a) are consistent with one another with only slight differences observed in the topmost sample (RLL032-B-2011). The latter shows slightly less defined OH bands at 3490–3420 cm$^{-1}$ and a doublet in the area near 670 cm$^{-1}$. The FTIR data is consistent with the XRD that shows that RLL032-B-2011 differs from the rest of the samples (Fig. 1a).

RLL3-1-2 and RLL3-1-3 both contain strong oxalate bands, phosphate bands and H–O molecular species (Fig. 1b). RL3-1-1 does not show detectable oxalate, but instead contains bands between 1000–1100 cm$^{-1}$ and 1800–2100 cm$^{-1}$ (Fig. 1b) due to Al–O and Si–O vibrations (e.g, varsicite and quartz; Table 1, Supplementary Table 2).

**Table 2**
SEM-EDS analyses of the phases and mixed phases in RL32-B-2011.

| **Mineral** | Whewellite | | Crandallite | Sr crandallite | Crandallite |
|---|---|---|---|---|---|
| **SEM analysis of** | > 1 phase | > 1 phase | 1 phase | 1 phase | > 1 phase |
| **Analysis #** | #15 | #7 | #1 | #26 | #13 |
| **wt% (norm C free)** | | | | | |
| **$SiO_2$** | 6.5 | 5.22 | 0 | 0.2 | 2.42 |
| **$Al_2O_3$** | 5.15 | 7.09 | 42.83 | 37.73 | 8.17 |
| **FeO** | 1.29 | | 1.08 | 0.27 | |
| **MgO** | 0 | 0 | 0.01 | 0 | 0 |
| **CaO** | 79.36 | 68.48 | 9.87 | 11.23 | 43.65 |
| **SrO** | | | | 11.14 | |
| **$Na_2O$** | 0.74 | 1.13 | 0.57 | 0 | 1.23 |
| **$K_2O$** | 1.25 | 3.9 | 1.41 | 0.19 | 2.62 |
| **$P_2O_5$** | 5.37 | 11.06 | 37.56 | 29.64 | 39.51 |
| **$SO_3$** | 0 | 2.5 | 6.35 | 9.52 | 1.11 |
| **Cl** | 0.35 | 0.62 | 0.32 | 0.08 | 1.29 |
| **Atomic formula unit, based on:** | **4 O + 2 C** | **4 O + 2 C** | **13 O** | **13 O** | **11 O** |
| **Si** | 0.21 | 0.17 | 0 | 0.02 | 0.17 |
| **Al** | 0.2 | 0.27 | 3.84 | 3.8 | 0.69 |
| **Fe total** | 0.04 | 0 | 0.07 | 0.02 | 0 |
| **Mg** | 0 | 0 | 0 | 0 | 0 |
| **Ca** | 1.40* | 1.18* | 0.8 | 1.03 | 3.34 |
| **Sr** | | | | 0.55 | |
| **Na** | 0.05 | 0.07 | 0.08 | 0 | 0.17 |
| **K** | 0.05 | 0.16 | 0.14 | 0.02 | 0.24 |
| **P** | 0.15 | 0.3 | 2.42 | 2.14 | 2.39 |
| **Cl** | 0.02 | 0.03 | 0.04 | 0.01 | 0.16 |
| **TOTAL** | 1.95 | 1.84 | 4.82 | 5.23 | 4.59 |
| **Ideal Formula** | $CaC_2O_4.H_2O$ | | $CaAl_3(PO_4)_2(OH)_5.H_2O$ | $(Ca,Sr)Al_3(PO_4)_2(OH)_5.H_2O$ | $Ca_3Al(PO_4)_2(OH)_3.H_2O$ |
| **Measured Formula** | | | $Ca_{0.8}Al_{3.84}(PO_4)_{2.42}(OH)_5.H_2O$ | $(Ca,Sr)_{1.58}Al_{3.8}(PO_4)_{2.14}(OH)_5.H_2O$ | |

## 2. Experimental design, materials and methods

### 2.1. Study area description

Mineral coatings were collected from rock walls adjacent to art described in detail by [1]. The locations are given in Table 3.

### 2.2. X-ray diffraction (XRD) methods

Samples were prepared as powders, mounted on a silicon low-background sample holder, and analyzed from 4 to 70° 2? at a spacing of 0.02626° (Supplementary Table 1). Data was collected using Bragg Brentano geometry, fixed divergence slits with *Cu Kα* radiation and a PIXcel 1D detector (active length = 3.3473°, 255 channels, 542 s per step). Minerals were identified using the SIEMENS software package Diffrac*plus* Eva 10 [2] (Supplementary Fig. 1) and quantified using Rietveld refinement [3,4] with the program Rietica [5] (Table 1, Supplementary Fig. 2). The background was fixed manually. The weight fraction of the amorphous material $W_{AMORPH}$ was determined for each corundum-spiked

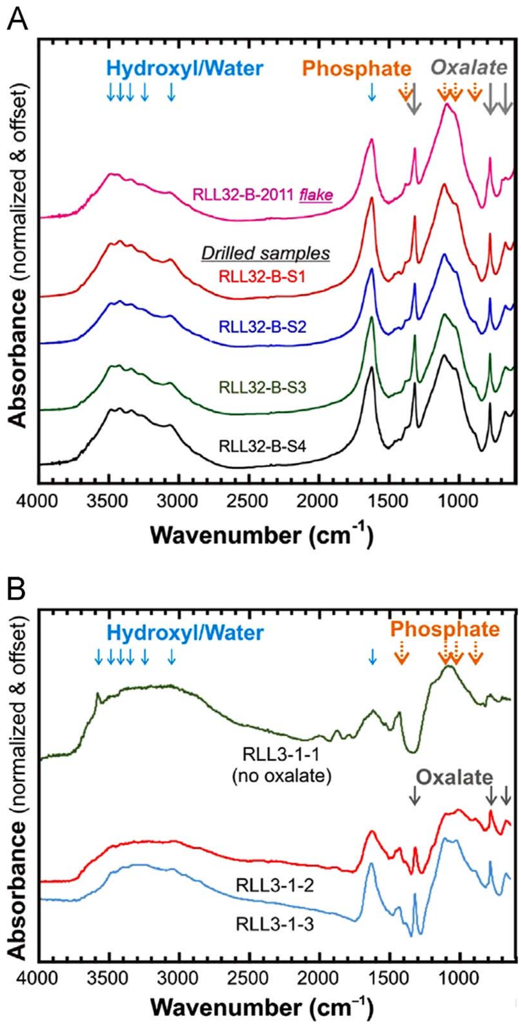


**Fig. 1.** FTIR spectra of bulk samples from the mineral crusts. The positions of the bands identified in Supplementary Table 2 are indicated. (A) RLL032-B powders. (B) RLL3-1 powders. RLL3-1-1 does not contain detectable oxalate.

**Table 3**
Sample identification and location.

| Sample | Latitude | Longitude |
|---|---|---|
| RLL032-B-2011 | 12°23'49.55"S | 133° 0'26.81"E |
| RLL032-B-S1 | 12°23'49.55"S | 133° 0'26.81"E |
| RLL032-B-S2 | 12°23'49.55"S | 133° 0'26.81"E |
| RLL032-B-S3 | 12°23'49.55"S | 133° 0'26.81"E |
| RLL032-B-S4 | 12°23'49.55"S | 133° 0'26.81"E |
| RLL3-1-1 | 12°24'7.59"S | 133° 0'5.51"E |
| RLL3-1-2 | 12°24'7.59"S | 133° 0'5.51"E |
| RLL3-1-3 | 12°24'7.59"S | 133° 0'5.51"E |

sample according to equation $W_{AMORPH} = 1 - y/x$, where $y = \%$ corundum, and $x$ is the calculated % corundum given by the program Rietica [6]. Amorphous, poorly crystallized and/or very finely grained material is identified in all samples by elevated or undulating backgrounds.

### 2.3. Scanning electron microscopy – energy dispersive spectrometry (SEM-EDS) methods

Sample RLL032-B-2011 was mounted in epoxy perpendicular to the mineral crust surface and polished to a ¼ μm diamond grit finish using kerosene, not water. SEM analysis was undertaken using a 15 kV accelerating voltage and 1 nA beam current with an approximately 2 μm beam diameter that overlapped multiple mineral phases.

### 2.4. Fourier Transform Infrared (FTIR) spectroscopy methods

Samples were ground, dried at ~100 °C, and mixed with KBr (sample:KBr = 0.6:1) and pressed into a 3 mm diameter disc held in a paper holder. Spectra were collected using a Bruker Tensor 27 with a Globar source, KBr beamsplitter and DTGS detector in transmission mode under a dry air purge from 400 to at least 4000 $cm^{-1}$, with 4 $cm^{-1}$ resolution and 100 scans. (Supplementary Table 3). FTIR bands were located using the OPUS software (v8.0) provided by Bruker and identified using data from the literature (Supplementary Table 2, [7–10]).

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## Transparency document. Supporting information

Transparency data associated with this article can be found in the online version at http://dx.doi.org/10.1016/j.dib.2016.12.024.

## Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at http://dx.doi.org/10.1016/j.dib.2016.12.024.

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# Appendix C

# Pigment geochemistry as chronological marker:

## The case of lead pigment in rock art in the Urrmarning 'Red Lily Lagoon' rock art precinct, western Arnhem Land

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***Abstract***

*This paper presents selected results of an experimental study using portable x-ray fluorescence (pXRF) for the non-destructive analysis of rock art pigments in northern Australia. During two weeks of fieldwork in the dry season of 2011 at the Red Lily Lagoon area in western Arnhem Land, 32 rock art motifs in four rockshelter sites were analysed. A total of 640 analyses were undertaken, including of white, red, black, yellow and blue pigments from both early and contact art motifs. This paper discusses the geochemical analysis of one particular motif painted with black pigment. It was determined that processed metal lead was the most likely pigment base. Contrary to previous stylistic analysis that suggested the motif had an old age, our analysis suggests that the motif was painted within the last 200–300 years.*

### Introduction

Direct dating of most rock art is often unresolved because pigments are inorganic and not suitable for radiocarbon dating and/or because the geology, such as the Kombolgie Sandstone Formation in western Arnhem Land, does not facilitate the use of other direct dating techniques (see Aubert et al. 2007). Establishing age determinations can assist with dating sequences of Aboriginal rock art. Rock art age determinations in Arnhem Land have traditionally been assisted by methods such as superimposition, typology or the archaeological context of inhabited sites.

The earliest evidence for rock art in northern Australia, dated to 28,000 cal. BP, was established through radiometric dating of stratigraphic layers that contained a painted fragment of sandstone from an excavated deposit on the Arnhem Land plateau (David et al. 2012). The current chronology and sequence of rock art in Arnhem Land, however, has been proposed mainly without the aid of direct dating techniques (Brandl 1970; Chaloupka 1984, 1993:89; Chippindale and Taçon 1998:107; Jelinek 1978, 1989; Lewis 1988).

The Red Lily Lagoon area (Urrmarning) in western Arnhem Land of the Northern Territory (NT), has long been recognised as one of the most significant complexes of rock art in the Gunbalanya region (Edwards 1974:136, 1979:51) (Figure 1). Red Lily Lagoon lies on the edge of the extensive freshwater wetlands and plains to the east of the East Alligator River and falls within the Gagudju/Erre/Mangereridji language group zone. Taçon (1993:116) found that Freshwater Period motifs in this zone consisted of an extensive selection of fish (most commonly painted in x-ray and solid/stroke infill), painted hand or hand-and-arm stencils, beeswax compositions, stick figures and energetic style stick figures. This complex of rock art motifs

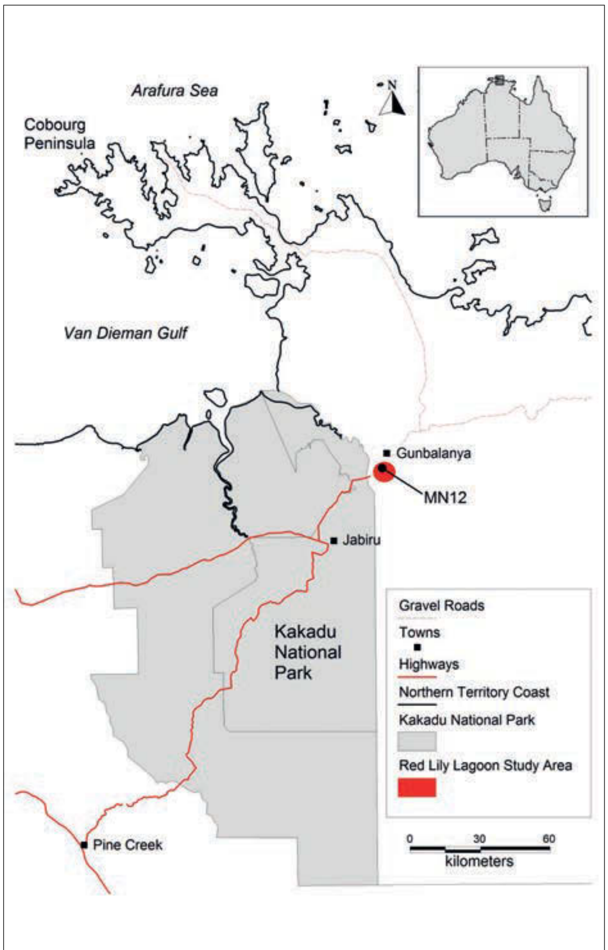


**Figure 1** Location of Minjnyimirnjdawabu (MN12) within the context of Kakadu National Park and Arnhem Land.

as described by Taçon (1993) was found in abundance in the Urrmarning rock art precinct.

Despite documentation of rock art in the Urrmarning precinct, no geochemical studies of rock art pigments in this study area had previously been conducted (Chaloupka 1993; Gunn 1992; Jelinek 1989; Mountford 1956). Geochemical studies of rock art pigments in general are only infrequently conducted, as they involve controlled destruction of small parts of motifs that are then subject to laboratory analyses (Huntley et al. 2011; Jercher et al. 1998). The application of the non-destructive portable x-ray fluorescence (pXRF) technique in the field remedies this situation, although this approach has significant constraints on precision and accuracy of the geochemical results (Huntley 2012).

In this paper we present data from an experimental pXRF study of the pigments comprising one particular motif, and discuss how low resolution geochemical data can be used to infer meaningful archaeological interpretation if the pigment raw material indicates a non-Indigenous provenance (cf. Cole and Watchman 1993). Our study is part of an ongoing project to develop practical conservation strategies to assist Indigenous rangers and traditional owners in monitoring disturbances to places of cultural significance. The results cast some doubt on previous age determinations by stylistic typology and give evidence for the potential of pXRF to provide important data for the understanding of the chronological sequence of rock art in western Arnhem Land.

## Minjnyimirnjdawabu Rockshelter

Our particular focus is the Minjnyimirnjdawabu rockshelter (MN12, previously recorded by Gunn [1992] as MN15), located approximately 40 m above the sandy plain on the edge of the sandstone escarpment which is part of the Kombolgie Formation (Plumb and Roberts 1992) (Figure 2). This site is notable for the presence of a 'contact' painting of a sailing ship and several decorative infill hand and forearm paintings, along with a diverse array of painted and beeswax motifs. This particular panel of the sailing ship and painted hand is amongst the most widely publicised examples of this style of rock art.

These paintings have particularly high social significance to the Manilakarr traditional owners owing to personal connection with the painter of these motifs. According to senior traditional owner, Jacob Nayinggul (dec.) (pers. comm. 2011), the ship and a decorative hand painting to its right were of recent antiquity, having being painted by his adopted father in the early twentieth century. A substantial silty, charcoal rich, cultural deposit with numerous stone artefacts and faunal remains is present on the shelter floor, while grinding hollows and ground surfaces attest to the likely processing of local seeds, plants, fibres and ochre (Jones and Johnson 1985; Meehan et al. 1985).

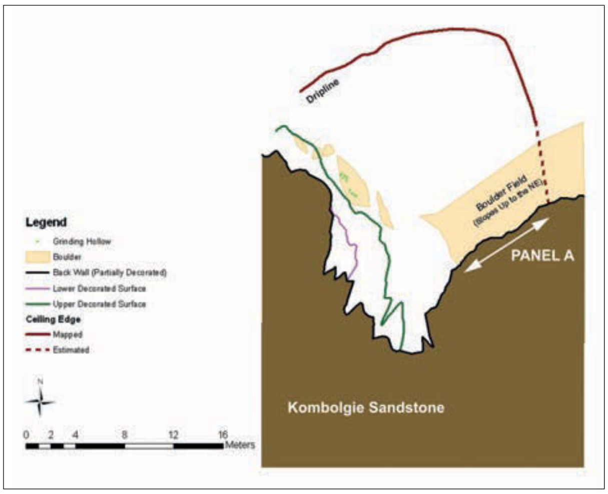


**Figure 2** Plan view of Minjnyimirnjdawabu (MN12) rockshelter indicating the location of Panel A.

Panel A in MN12 is on a vertical sandstone face orientated to the northeast and measures approximately 40 m². It consists of 30 clearly identifiable motifs, with evidence for many others obscured by weathering (Figure 3). The subject matter of motifs includes anthropomorphic figures, weapons, x-ray fish, solid infill fish and macropods executed in red, yellow, white and black pigments. Mountford (1956:153) described the anthropomorphic figures as 'supposed to be self-portraits of the Mimi people'.

A sample of these figures was selected for pXRF analysis based on motif pigment colour, thickness and colour diversity, including:

- Motif 1 – a large red male anthropomorphic figure (Figure 3.1);
- Motif 2 – a scene of four or five red anthropomorphic figures (Figure 3.2); and,
- Motif 3 – a large black female anthropomorphic figure (Figure 3.3).

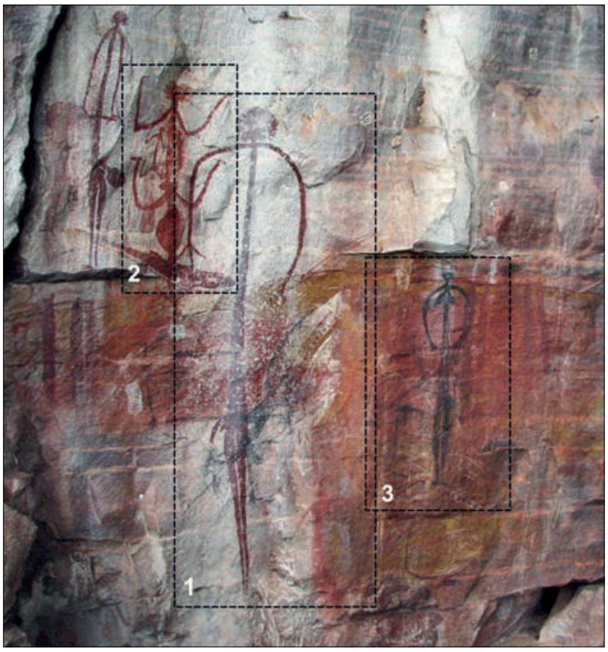


**Figure 3** MN12 Panel A with Motifs 1, 2 and 3. Motif 3 is shown in more detail in Figure 4 (Jelinek 1989:173; Mountford 1956:154, Figure 41).

Motif 1 is a vertical figurative depiction of a male individual (displaying genitalia) painted with red pigment in an outline and solid infill method in frontal view. It is depicted with short spears with large rounded ends, a spear thrower and possible 'goose spears' (Chaloupka 1993:148). The motif is uncommonly large, measuring 190 by 120 cm.

Motif 2 consists of a scene composed of line and solid infill human figures. The scene is centred on two human figures that are joined vertically, with another shown upside down.

The figures are painted in a characteristic manner common to human figures: static and frontal with outstretched bent arms and legs. The uppermost figure appears to have two smaller human figures around, or attached to, the torso area. All figures are painted in red pigment and have been executed over faded indistinguishable motifs. The motif measures 90 by 40 cm.

Motif 3 is a large anthropomorphic female human figure rendered in a black pigment in a line and solid infill form. Figure 4 reveals further details showing the complexity of painted elements of Motif 3 revealed through D-Stretch filter YBK. This motif is surrounded by other black pigment motifs, however it cannot be ascertained whether these constitute a scene with this motif. This motif is an atypical depiction of a female because there are at least three types of spears painted across the figure from right to left, with one spear painted across the figure from left to right giving the impression the female figure is being 'speared'. This is atypical within the general corpus of Arnhem Land rock art, as male figures have a higher representation of such depictions of 'spearing'. The uppermost spear appears to be a composite 'shovel-nosed' type, with a solid stone or flat wooden point (Chaloupka 1993). That painted across the figure's torso is typical of a uniserial barbed spear (Chaloupka 1984; Lewis 1988). A further three lines are painted diagonally across the torso that resemble a composite three pronged spear, or are perhaps three separate simple spears. A fourth spear is painted diagonally from left to right across the thigh portions of the figure. An oval shape with small lines protruding from the outer edge of the shape is painted over the right thigh. Unlike Jelinek (1989:173), Mountford (1956:153–154) did not make any reference to the multiple spears that seem to be associated with this figure, nor that it was painted in a black pigment.

**Antiquity of Motifs According to Taphonomic Indicators and Stylistic Analysis**

Classification of anthropomorphic motifs according to form, or 'style', is exceedingly problematic, mainly owing to the appearance of such figures throughout the entire painting sequence (Bednarik 2002:1214). Motifs with non-diagnostic features, such as those lacking individualising forms, methods or stylistic conventions, depicted without material culture, are difficult to allocate to a temporal phase. It is only through mobilising multiple lines of evidence—'cabling', as discussed by Chippindale and Taçon (1998:93)—that assumptions about the antiquity of motifs can be made. Most researchers continue to utilise the revised chronological stylistic sequence for western Arnhem Land presented by Chippendale and Taçon (1998:107), with the basis of art styles originating from Chaloupka (1993). Yet major issues with the chronology remain. Research undertaken in the early 1990s to test the stylistic sequence, for example, recorded the superimposition of all motifs within the Kungurral and Brockman sites in Kakadu National Park (Chippindale and Taçon 1993). The results illustrated that the majority of art within the sample could not be allocated to a Chaloupka style. Other researchers, such as Lewis (1988) and Haskovec (1992), have suggested major changes are required to the sequence owing to major disagreements over particular stylistic sequences.

Mountford (1956) argued that the motifs at Minjnyimirnjdawabu could be assumed to have considerable age owing to the use of the term 'Mimi'. This term was used by Indigenous informants to denote art work which was produced by earlier peoples (Chippindale and Taçon 1998:94), though they also painted Mimi figures themselves. Jelinek (1989:173, Figures 188a and 190a) recorded similar motifs within his Gallery 1 at Inanagurduwil I–III, describing them, 'whether white or red, [as belonging] to the same (Late Archaic) style and probably [coming] from the same period' (see also Jelinek 1989:179). Although he did not specifically refer to black pigment, Jelinek (1989) included these motifs within his general assessment of the panel and it is highly likely he attributed the black pigment motifs to this period as well. Under his chronology, the Late Archaic style was attributed to a period spanning from the Pleistocene to 5000 BP (Jelinek 1989:479–480).

Yet there are several indicators suggesting that the motifs may be much younger. Motif 3 is amongst the last painting events in the sequence of superimposition on the panel. Motif 3 superimposes a number of now significantly weathered motifs, with the weathered non-distinct imagery being polychromatic (yellow, red and white). White and orange pigments are known to have the least permanency, as they do not bond to the rock substrate like pure red pigment and thus are highly susceptible to weathering (Chippindale and Taçon 1998:103). As such, paintings containing white, orange and yellow pigments have been generally assumed by archaeologists to be of a younger age, especially in poor preservation contexts such as MN12.

Motif 1 is a static, full bodied simple figure and, as such, could be diagnostic of numerous styles from the Intermediate (10–6 K) or New Phase (6 K to present), as depictions of large human figures are found throughout these phases (Chippindale and Taçon 1998; Taçon and Chippindale 1994). Assessing the material culture associated with the motif in this case assists in chronological identification (after Lewis 1988). The spears depicted in Motif 1 are typical of ethnographic examples of goose hunting spears (Spencer 1914). This type of technology is commonly associated with the 'Freshwater Period', when magpie geese colonies flourished in the expansive freshwater wetlands (Finlayson et al. 1998; Whitehead et al. 1990).

The non-distinct classification of human motifs also impacts on the stylistic classification of Motifs 2 and 3. The depiction of upwards bent arms and legs in a static and frontal position, as depicted in Motif 2, can be commonly found in anthropomorphic motifs throughout the entire sequence of Arnhem Land art, though it is most common in the late Holocene period (Chaloupka 1993). The material culture in Motif 3 indicates that the motif might be of a younger age. While simple, uniserial and pronged spear types are known to have been utilised throughout the Holocene, shovel-nosed spears or leilira blades are known only to occur in the late Holocene or contact period (Allen 1989; Taçon 1991). It is presumed that the production of shovel-nosed spears was bounded in different social circumstances than the more common smaller projectile points, and indeed, ethnographically, shovel-nosed spears were recorded as part of tribal ritual exchange around Gunbalanya in the 1940s (Allen 1989; Berndt and Berndt 1988).

## Methods

The rock art motifs selected were analysed by pXRF in three stages for a wide variety of chemical elements in situ in the field. For pXRF analyses a Bruker Tracer III-V pXRF was employed, equipped with a rhodium tube, peltier-cooled

Si-PIN detector at a resolution of approximately 170 eV (electron Volt) FWHM at the Mn K peak (5.9 keV [kilo electron Volt] at 1000 counts per second) and a 1024 channel configuration multichannel analyser. Initially, instrument parameters for this case study were 40 keV, 15 µA, using 0.1524 mm Cu [copper], 0.0254 mm Ti [titanium] and 0.3048 mm Al [aluminium] filters in the x-ray path, and a 100 second live-time count at 185 FWHM setting. This is the manufacturer recommended setting for higher Z elements (>Fe [iron]) for silicate rocks. Additional analyses were conducted for light elements (Si [silicate], S [sulphur], P [phosphorus], K [potassium], Ca [calcium], Ti, Mn [manganese]) with 15 keV, 15 µA without filter for 100 seconds in a vacuum and finally in 'lab-rat mode' with 40 keV, 1.1 µA for 180 seconds, also in a vacuum. Interferences from air were minimised by placing the instrument as close as possible to a flat surface of the sample. Net values of the samples were calculated with the Bruker ARTAX Spectra 7.1 package. Nine correction cycles were run for background stripping and peak deconvolution. Presence of elements in the pigment were assessed by subtracting mean net values of three bedrock analyses in close vicinity of the motif[1] and mean net values of four red pigment analyses of underlying rock art motifs. For this study, we refrained from calibrating the net values to actual elemental composition, as the argument is based on qualitative presence/absence of important signature elements for common lead ores in Australia (S [sulphur], Zn [zinc], Ag [silver]).

The difficulties of in situ analysis of rock art pigments have recently been discussed by Forster et al. (2011) and Huntley (2012). The main methodological obstacle is the surface structure of the analysis spot and the critical penetration depth of the x-ray beam[2] (Potts et al. 1997a, 1997b). As the penetration depth of the beam is an equation of the density of the penetrated surface, the energy input for analysed elements and the mass attenuation coefficient, it is assumed here that for heavier elements only a maximum of ~50% of the count rate is related to the pigment itself (Markowicz 2011). On the other hand, light element geochemistry is particularly difficult to assess in non-laboratory conditions, as the penetration depth of the beam is only a few hundred microns, making it exceedingly susceptible to surface morphology (Forster et al. 2011; Liangquan et al. 1998; Potts et al. 1997a, 1997b). Considering these limitations, it is necessary to analyse not only the pigment itself, but also the underlying bedrock and, in the case of superimposition, the geochemical composition of underlying earlier paintings.

## Results

As shown in Table 1, we report analysis of selected light and heavy elements (Si, P, S, K, Ca, Ti, Mn, Fe, Ni [nickel], Cu, Zn, As [arsenic], Sr [strontium], Zr [zircon], Ag, Sn [tin], Sb [antimony] and Pb [lead]).

### Bedrock

The bedrock of the area is described as quartz sandstones, conglomerates and dolostones intersected with hematitic and brown ferrugious sandstones of the Katherine River Group in the Kombolgie Formation (Ahmad and Scrimgeour 2006; Mitchell et al. 1983; Plumb and Roberts 1992; Smart et al. 1980). As such, it consists mainly of quartz ($SiO_2$), dolomites, ($CaMg[CO_3]_2$), feldspars ($[K,Na,Ca]AlSi_3O_8$) and iron-oxides ($Fe_2O_3$). The pXRF analysis detected Si, K, P, S, Ca and Ti in significant amounts in the bedrock. Bearing in mind the limitations of geochemical analysis in non-laboratory conditions, it is suggested that all analyses of elements lighter than Fe, such as Si, P, S, K and Ca (Forster et al. 2011), are quantitatively unreliable. In reference to the possible natural origin of the pigment, Cu, Zn and Ag were detected in the bedrock.

1 Analysis spots were selected after assessment of the area with D-Stretch (Harman 2010).

2 Equation to calculate penetration depth of x-ray beam: t = -Ln(I/I0) / ((µ/*p*)**p*) [-Ln(I/I0 = 4.61], where *p* equals the density of the analysed compound.

**Figure 4** MN12 Motif 3 shown with D-Stretch filter YBK for black pigment enhancement.

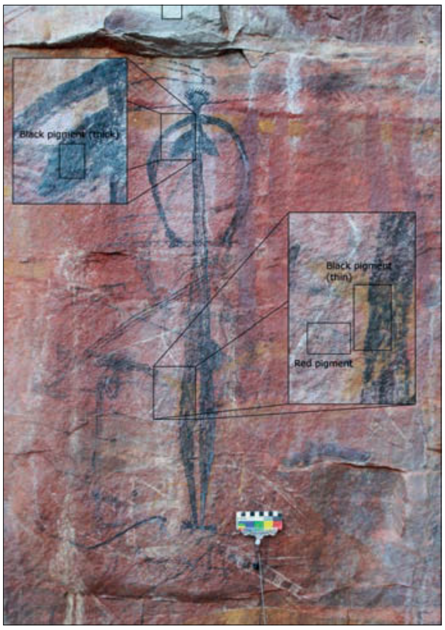


**Figure 5** MN12 Motif 3 illustrating the locations sampled for pXRF.

### Motif 3

The art panel studied contains multiple painting episodes, with the black Motif 3 underlain by red pigment motifs. Figure 5 illustrates the locations from which pXRF samples were taken on Motif 3. The geochemical composition and its colour suggest that iron-oxide (e.g. hematite) is the main constituent of the underlying red pigment. Comparatively high counts of iron and sulphur were detected in Motif 3. Some amount of lead was also identified in the analysis (Table 1); however, it is unclear whether this originates from weathering of the black pigment.

Initially, it was assumed that the black pigment consisted of charcoal or a manganese-oxide, as these materials have been previously reported for western Arnhem Land rock art and elsewhere (Chaloupka 1993; Huntley et al. 2011). Manganese, however, was not detected in amounts exceeding the background readings. Elements identified with significant higher counts than underlying bedrock or red pigment are Si, As[3] and Pb (Table 1). As discussed before, net values of Si are dismissed as either machine-induced or as a weathering product of the underlying sandstone. The main constituent of the black pigment is Pb, although without significant amounts of S and Zn, elements commonly associated in Australian natural lead mineralisation, suggesting processed metal lead as the most likely source of the raw material (Geoscience Australia 2004). The identification of lead in the pigment is supported by analysis of several spots with less black pigment cover (Figures 6A and 6B), reducing significantly the amount of lead detected (Table 1).

3 The detection of As in the presence of high Pb with pXRF has been problematic in the past, as the Kα peak of As at 10.5 keV and the Lα peak of Pb at 10.6 keV overlap to produce a strong interference and result in a significant increase of the detection limits for arsenic.

## Discussion

### Naturally Occurring Lead Sources

Natural occurring near-surface lead deposits have been reported across Australia. The most common lead mineral with a dark grey streak is galena (PbS). In Australia, surface deposits of galena are usually metamorphic formations, though galena can occur in limestones, sandstones and calc-silicate rocks. Weathering of galena results in carbonated lead minerals, such as cerussites ($PbCO_3$), or lead sulphites, such as anglesites ($PbSO_4$); however, these minerals can be excluded as a possible source of the pigment, as their streak is white (Deer et al. 1992). In the NT, particularly in the 'Top End', lead ores are usually associated with uranium deposits, the closest to MN12 being the Cahill Formation in the Pine Creek Inlier, which is now mined at the Ranger Uranium Mine (approximately 30 km southwest of Urrmarning) where small amounts of lead-zinc ores are

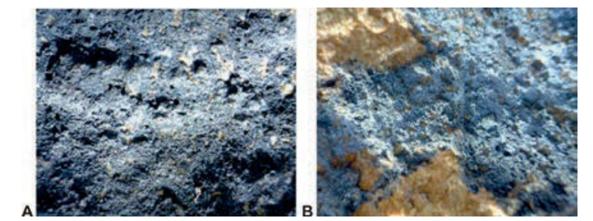


**Figure 6** Microphotograph of black pigment showing (A) thick and (B) thin cover.

| | Bedrock | | Underlying Red Pigment | | White Erosion Crust | | Black Pigment (Thin) | | Black Pigment (Thick) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Average (n=4) | SD | Average (n=4) | SD | Average (n=4) | SD | Average (n=3) | SD | Average (n=3) | SD |
| Si K12 | 4517 | 672 | 3763 | 495 | 16,843 | 8836 | 6588 | 2682 | 20,415 | 2635 |
| P K12 | 7768 | 5440 | 2245 | 2509 | --- | --- | 122 | 155 | 2 | 1 |
| S K12 | 1676 | 1290 | 5050 | 1182 | 949 | 28 | 4147 | 1780 | 2175 | 391 |
| K K12 | 5867 | 4018 | 5744 | 176 | 2538 | 49 | 5569 | 1324 | 3017 | 93 |
| Ca K12 | 1662 | 1517 | 1955 | 749 | 615 | 172 | 1114 | 528 | 2318 | 211 |
| Ti K12 | 1122 | 654 | 2170 | 484 | 269 | 85 | 1563 | 267 | 1198 | 850 |
| Mn K12 | 879 | 431 | 880 | 165 | 578 | 154 | 462 | 132 | 770 | 114 |
| Fe K12 | 18,883 | 9714 | 81,916 | 13,351 | 3271 | 1954 | 64,046 | 9737 | 61,873 | 26,413 |
| Ni K12 | 245 | 30 | 116 | 18 | 133 | 4 | 133 | 8 | 239 | 36 |
| Cu K12 | 110 | 7 | 55 | 8 | 59 | 14 | 63 | 26 | 77 | 15 |
| Zn K12 | 255 | 100 | 103 | 4 | 112 | 5 | 111 | 28 | 318 | 23 |
| As K12 | 42 | 4 | 55 | 4 | 9 | 2 | 70 | 28 | 452 | 136 |
| Sr K12 | 3797 | 3224 | 626 | 74 | 1589 | 403 | 760 | 70 | 4281 | 355 |
| Zr K12 | 2834 | 124 | 411 | 90 | 499 | 318 | 368 | 80 | 1682 | 265 |
| Ag K12 | 1715 | 66 | 335 | 34 | 396 | 139 | 439 | 80 | 2145 | 371 |
| Sn K12 | 694 | 130 | 495 | 95 | 447 | 165 | 555 | 53 | 608 | 259 |
| Sb K12 | 892 | 27 | 537 | 168 | 27 | 21 | 687 | 109 | 760 | 204 |
| Pb L1 | 129 | 64 | 666 | 104 | 19 | 6 | 991 | 192 | 10,122 | 2768 |

**Table 1** Summary statistics of net values of MN12 pXRF analysis of bedrock, white erosion crust, hematite and lead pigment; the thicker the black pigment the higher lead counts, indicating that the black pigment indeed is metal lead. The white erosion crust was also measured to assess possible contamination through leaching of lead from the bedrock; no lead was found in the erosion crust.

associated with uranium-oxide mineralisation (Needham 1988). Galena, as well as other common lead mineralisations, can be excluded as potential sources for the pigment, as the pXRF analysis only showed traces of Zn and S comparable with the background amounts, indicating they were associated with the underlying bedrock rather than the pigment.

**Processed Metal Lead**

The lack of elements usually associated with natural lead mineralisation indicates that the lead used for painting motifs is more likely to derive from processed metal. It is suggested that procurement of lead pigment most likely resulted from interaction and/or exchange with Macassan, Dutch or other European settlers. Initial contact between Aboriginal groups and Macassans and Dutch explorers is known to have occurred from the 1700s (Allen 2008; Clark and May 2013; Hiscock 2008). Settlement of the Arnhem Land region by British colonists is documented as beginning ca 1839. Indigenous and British interactions in the area intensified with the development of the buffalo hunting industry in the 1890s and is known to have involved the bartering and exchange of high value items, such as metals and tobacco (Powell 1996). Lead was a very common multipurpose metal in colonial times, used variously for minting coins, water pipes, lead-based paints, sheeting, sheathing for hulls, anchor stocks, seals, stamps, tablets, musket balls and shot cartridges (Tripati et al. 2003; van Duivenvoorde et al. 2013). The largest amounts of lead transported, however, were most likely ship ballast.

It has been well established that there was pre-European evidence of trading with Macassan fishermen and that metals were part of the items exchanged (Clarke 1994; Hiscock 2008; Lamilami 1974; MacKnight 1969, 1986; Mitchell 1994, 1996). Macknight (1969:223) reported finding a lead ball (possibly a musket ball) at the Anuru Bay Macassan trepang processing site on the northwest Arnhem Land coast. Fredericksen (2003) reported miscellaneous finds of lead musket balls from the colonial Fort Dundas (occupied from 1824–1828) on Melville Island. Evidence of metal in general, mostly tin and iron, has been recovered from excavations and observed on the surfaces of many rockshelters in western Arnhem Land (Chaloupka 1993; Clarke 1994; Guse 1998; Guse and Woolfe 2006; Mitchell 1994; Schrire 1982). Although there have been no reports of lead in these studies, Macassan contact with European traders in the Indonesian archipelago reaches back into the sixteenth century (Knapp and Sutherland 2004).

Apart from minor exploratory incursions, the Red Lily Lagoon area experienced regular European settlement only after 1891. The large Asian water buffalo herds of the East Alligator River were a potentially lucrative enterprise for European settlers in the NT and in 1891 Paddy Cahill became one of the first shooters to move into the area. Aboriginal labour was soon incorporated into buffalo enterprises, and Indigenous people were attracted to Cahill's settlement, where tobacco and meat could be readily obtained (Forrest 1985:87). The incorporation of Aboriginal labour into the buffalo industry starts to be widely reported in the local newspapers during the 1890s (*Northern Territory Times and Gazette*) (Figure 7). By 1897, rifles, shotguns and lead ammunition started to enter into Indigenous ownership in Arnhem Land in large quantities (Wesley 2013). Aboriginal men were typically armed with less expensive, older Martini Henry rifles and shotguns to assist the horse-mounted white shooters to follow up and dispatch the wounded buffalo (Wesley 2013).

We cannot be certain of the exact source of the pigment used in Motif 3 in MN12. We can infer, however, that the lead in the pigment most likely derived from pulverised shotgun ammunition. In Australia and abroad, evidence of trading in shotgun bullets between Indigenous groups and European settlers is scarce. Lead bullets from Martini Henry rifles occasionally occur in archaeological sites, including Leija on the Barkly Tablelands (Ken Mulvaney pers. comm. 2013) and in the Urkuk Village sites in the Duke of York islands (Ian Lilley and Sally Brockwell pers. comm. 2013). Surface artefact assemblages elsewhere at Red Lily Lagoon include flaked glass implements, iron wire, clay pipes, beads and wooden implements worked by metal, all of which demonstrate that European materials were purposely adapted for local use. Excavations on the wider Arnhem Plateau, such as at Malarrak rockshelter in the Wellington Range, recovered large amounts of tin, iron and glass. Roberts and Parker (2003:26) documented a cache of material culture at 'Artefact Cave' near Mt Borradaile (Awunbarna), some 40 km to the northeast of Urrmarning, including a Bell and Black matchbox tin (1870), a Macassan adze, a domino piece, a tobacco pipe, a bag of shot (Figure 8), and hand-forged nails and screws.

This research has illustrated the difficulty of placing rock art motifs within a chronological framework regardless of the style in which the motif has been painted. The importance of applying pXRF to this study has allowed us to identify the introduction of a foreign raw material into the material culture of Indigenous society in Arnhem Land, which can be considered as an important chronological 'event marker'. Event markers, along with proliferation events, are significant in the identification of the introduction of new cultural materials (see Hiscock 2008). The growing body of research on Arnhem Land culture contact points to seventeenth century origins for foreign materials entering Arnhem Land (Clarke 1994; MacKnight 1969; Mitchell 1994; Taçon et al. 2010; Theden-Ringl et al. 2010). The use of an introduced material to paint motifs that are irrefutably Indigenous subjects rather than introduced imagery (i.e. ships, guns, Europeans) attests to the difficulty in assigning chronology based solely on style. Without knowledge of the use of lead in the pigment, and based on current assumptions on the introduction of Arnhem Land rock art styles, the age of the black motif could be grossly over-estimated. Estimating motif age is inarguably one of the most difficult areas of rock art research in general. Given the evidence presented above, the most likely period for painting Motif 3 coincides with the escalation of English settlement in Arnhem Land from the mid- to late nineteenth century, owing to the introduction of much larger quantities of foreign materials into Indigenous society.

## Conclusion

The application of pXRF to the study of rock art is a relatively recent development in Australian archaeology and is still in its experimental phase (Huntley 2012). However, this study has demonstrated that the use of pXRF can make a meaningful contribution to the study and conservation of rock art. The application of pXRF analysis to one such motif has demonstrated that it, at least, comprises lead rather than some other black substance, such as charcoal or manganese. This discovery has expanded our knowledge of pigment diversity and contributed significantly to a greater chronological understanding of the rock art sequence at Minjnyimirnjdawabu, and indicated that at least some of

**Figure 7** Buffalo shooters (NT Library; Kathryn Brown Collection. Photo Number PH0413/0041).

**Figure 8** Cache of contact materials at a rockshelter near Awunbarna to the north of the study area containing a 'bag of lead shot' (photo sourced from <http://www.flickr.com/photos/winam/3734029464/>).

these motifs, previously assessed as being of substantial antiquity, are clearly younger than a seventeenth century origin. Importantly, it demonstrates that assumptions about chronology based on style alone may be seriously flawed and direct dating is required for the Arnhem Land artistic sequence.

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# Appendix D

# Thesis by Compilation

## Purpose

There is an increasing expectation in many disciplines, that PhD students should publish journal articles during and shortly after their degrees. A thesis by compilation allows a student to focus their writing on publishable journal articles and book chapters.

## Preamble

Because of disciplinary variability, the guidelines are not prescriptive in details such as number of papers required. Overall, the quantity and quality of the material presented for examination needs to equate to that which would otherwise be presented in the traditional thesis format. The guidelines assume a vital role for Colleges, Schools and supervisory panels thus aiming to embrace sensible disciplinary differences while ensuring an ANU PhD remains of the highest quality.

## Procedure

1. Submission of a thesis by compilation requires approval by the Delegated Authority. The approval process ensures that the student has received important, discipline*specific guidance on the appropriate quantity and quality of papers for submission as a thesis. Only in exceptional circumstances will approval be given to a candidate for a Master of Philosophy or Professional Doctorate to submit a thesis by publishable papers.
2. The papers must have been researched and written during the course of the candidature, except in the case of students admitted to a program under the ANU staff provisions (Research Award Rules 2.3(3) and 2.3(4)). A thesis by compilation may include video recordings, film or other works of visual or sonic arts, computer software, digital material or other non*written material for which approval has been given for submission in alternative format.

### Approval

3. The option to submit a thesis by compilation will require the support of the supervisory panel and the approval of the Delegated Authority well in advance of the submission. Typically, students should commit to this form of submission and seek approval at least 12 months from completion, no less than 6 months out, although in some disciplines a commitment to thesis by compilation would be appropriate much earlier. Supervisors should discuss the option early in the student's candidature and offer practical guidance about realistic peer*review and publication timeframes in their discipline.

### Number and status of papers

4. The thesis will be based on a number of papers published in, accepted by, under review at, or in preparation for high*quality, peer*reviewed journals. In some disciplines (e.g. mathematics) a single long monograph may be acceptable; in others the discipline expectation might be 4-5 peer* reviewed papers. Normally it would be expected that the majority of papers were published, or accepted for publication. Those papers that have not been accepted for publication will be

examined in the same manner as traditional thesis chapters. Colleges, Schools and supervisory panels should provide sound disciplinary advice on appropriate number and publication status.

### Authorship

5. Students who are undertaking a thesis by compilation should seek advice before signing publisher's agreements to ensure each agreement does not preclude the inclusion of the published work in their thesis.
6. Whether or not the candidate is sole author of all, some or any of the papers will vary by discipline and Colleges, Schools and supervisory panels should provide advice on what is most appropriate within particular disciplines. Where the candidate is not the sole author of a paper, they must demonstrate that they have made appropriately significant contributions to the paper.

### Construction of the thesis

7. A number of distinct papers are expected, and while some overlap between related papers is acceptable, they should nevertheless be substantially different in focus or content. A thesis constructed of chapters/papers/manuscripts must be presented in a logical and coherent way and will require the addition of linking text to establish the relationship between one chapter and the next. This could, for example, be achieved by the inclusion of a foreword to each chapter.
8. An extended context statement demonstrating the relationship between all aspects of the research is also required as part of the thesis. This will include an introduction to the field of study and the hypothesis or research questions, how these are addressed through the ensuing chapters, and a general account of the theory and methodological components of the research where these components may be distributed across separate papers/chapters. The context statement should be in the order of 10,000 words in length. The outcomes of the project and the author's conclusions will either be summarised in the context statement, or covered in a concluding chapter.
9. The thesis may also include relevant appendices containing raw data, programs, questionnaires and other material that would normally appear in a standard PhD thesis.
10. A thesis by compilation must include a signed declaration that specifies:
    - Title, authorship and publication outlet of each paper.
    - The current status of each paper (In press, Accepted, Under Review, In preparation).
    - The extent of the contribution of the candidate to the research and the authorship of each paper.
    - For each paper where the candidate is not the sole author, the collaborating authors must also sign the declaration.

11. The entire thesis, including the published papers, must be formatted in an acceptable PhD thesis style, although journal formatting can be preserved. The papers and supplementary material should be on A4 paper (or similar), bound together in a single volume.

### Examination

12. Following submission of the thesis the standard ANU examination procedures will apply.