

ROCK ART IN ARID LANDSCAPES: Pilbara and Western Desert petroglyphs

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Abstract

This paper develops a testable model for understanding rock art within archaeological phases of the arid northwest Pilbara and Western Desert bioregions. It also presents the first multivariate analysis of foundational recording work undertaken almost 50 years ago, and deploys more recently recorded assemblages from the Burrup Peninsula (Murujuga) and the Western Desert. It establishes a framework for testable hypotheses about how art production in these adjacent bioregions through deep-time reflects information systems, emergent territoriality, group identity and signalling behaviour against a backdrop of climatic oscillations, including the LGM (23–18 ka), Antarctic Cold Reversal (14.5–12.5 ka) and intensification of ENSO (3.8–2 ka). The Pilbara piedmont has clearly defined gorges with major water sources; the Western Desert has uncoordinated drainage punctuated by well-watered but subdued ranges. We argue that rock art has been used to negotiate social identity in

both contexts since each was first colonised. The role that art may have played in the formation of social networks in these different landscapes through time is the key focus of this paper. We hypothesise that the episodic use of art as signalling behaviour in the Australian arid zone can be linked to behavioural correlates and major archaeological phases with discrete signatures that can be tested from myriad sites.

Introduction

The Pilbara–Western Desert nexus involves contrasting landscapes which, in the recent past, had disparate language groups and different territorial arrangements. There is a dynamic contrast in the social relations within and between these two fundamentally arid environments. The rock art in these landscapes provides us with insights into the nature of these social dynamics through time. We describe an engraved (petroglyph) art province from the Western Desert and compare this with a number of Pilbara petroglyph style provinces (following Wright 1968) (Figure 1).



Figure 1 Map of the Pilbara and adjacent Western Desert showing major drainage lines, language distribution (after Tindale 1974) and art assemblages analysed in this paper.

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The aim of this paper is to develop a detailed and testable model for how rock art systems have operated in the arid zone through time, and how the different landscape characteristics of the Pilbara and Western Desert can provide an explanation for the changing use of graphic systems.

Two Distinct Arid Landscapes

The Pilbara is a mountain and piedmont desert with well-defined river systems draining into the Indian Ocean. It contains numerous gorges, many of which retain abundant and year-round supplies of water, which form habitable corridors throughout a desert uplands landscape. These habitable corridors have provided a territorial basis for the social organisation of their inhabitants. It is likely the deep pools in these gorges and wetlands, such as the Fortescue Marsh, have provided a focus for people since the initial settlement of the Pilbara.

The Western Desert lies inland and east of the Pilbara Uplands. This vast lowland comprises a series of sandy and stony deserts, with internal and uncoordinated drainage. Amongst the extensive dunefields are numerous subdued ranges—many of which contain permanent water. As described by Tindale (1974), desert people classify the different types of waters found across these regions, graphic representations of which often appear in rock art and contemporary acrylic paintings (Figure 2):

- Soak waters—trapped in deep sands;
- Claypan waters—where shallow supplies form after rain;
- Rock holes (both permanent and semi-permanent);
- Permanent waters (*jila*)—often springs—sometimes located in these isolated ranges; and,
- Creek and river pools.

Knowledge about waterholes is curated as social geography through Dreamtime narratives and this knowledge has allowed for seasonal and ritual use, the planning of journeys, and, in times of drought, retreat. Veth (1993, 2005; Veth et al. in press; and see Smith 2013 for a recent recasting of this same model) has identified that throughout the Western Desert the more permanent and reliable water sources, and their associated biota, would have functioned as refugia, and has modeled human settlement behaviour during fluctuating climatic conditions. We have previously suggested how Western Desert rock art can be modeled as part of this settlement behaviour (McDonald and Veth 2006, 2010). In this paper we build on recent developments in understanding Pilbara settlement patterns to present a model with art correlates for occupation across these two adjacent but different arid landscapes. We provide an initial analysis of several Pilbara style provinces, following Wright (1968), and examine how Mulvaney's (2010) chronology developed for the Dampier Archipelago fits into this broader model of the arid Pilbara piedmont.

Ethnography and Linguistics

Ethnographic and linguistic information help illustrate how people were arranged across these landscapes, and the nature of their social interaction in the recent past. In the Pilbara, 21 socio-linguistic groups were recorded at contact (Tindale 1974). The area of particular interest to our analysis has been defined linguistically as the Ngayarda subgroup of the Pama

Nyungan family (McConvell 1996, pers. comm. 2007; O'Grady 1966; O'Grady and Laughren 1997). At least 15 of Tindale's 21 socio-linguistic groups fall into this classification, and notably these are surrounded on all sides by distinctly different language subgroups. Linguistic stratigraphy suggests that the distinctive Ngayarda subgroup is at least 4000 years old (McConvell 1996). The Pilbara language groups had well-defined territories, with boundaries being the relatively waterless watersheds of river catchments (Peterson 1976; see Figure 1). Territorial ranges varied in size from 500 square kilometres for the Yaburara on the coast (Dampier Archipelago [Muruguja]), up to 42,400 square kilometres for the Nyamal, whose territory included the Coongan and Shaw Rivers, and the headwaters of the Yule and Turner Rivers. Tindale (1974) noted significant movement between groups just prior to contact and suggested that Western Desert lores and customs were highly influential in the period just before European contact. Social influences at this time were moving from east to west—from the arid lowlands to the arid piedmont.

In this paper we focus on a small portion of the Western Desert: 200,000 square kilometres at the western interface between the Pilbara and the Little Sandy Desert. Tindale recorded six dialects of the Wati language here, covering territorial ranges of between 16,000 square kilometres for the Wiridinja (Warwula; Horton 1994) and 78,000 square kilometres for Kartujarra/Putijarra (Martu; Horton 1994). Territorial ranges were large and included a series of ranges, waterholes and other water sources of varying permanency. Territorial boundaries were based on dialect rather than language boundaries, and these were not necessarily

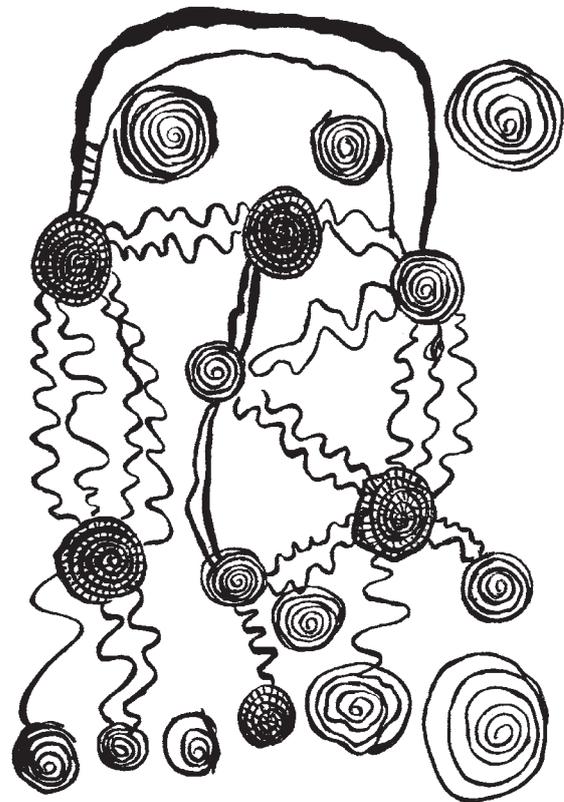


Figure 2 Map of the *Natatjara* group's storage wells, pools and sand soaks, also showing tracks made between the various water sources. Drawn by Katabulka, an old *Natatjara* man (from Tindale 1974:Figure 23).

based on clearly identifiable geographical features. Given that population sizes for the defined groups in both the Pilbara and Western Desert were ca 300 people, population densities were all extremely low, but varied markedly across these two landscapes: on the Pilbara coast, in Ngarluma territory, population density was 1 person/29 square kilometres; in Panjima territory, in the Pilbara piedmont, the population density was 1 person/57 square kilometres; and in the Western Desert, in Putjarra territory, the population density was 1 person/173 square kilometres.

In summary, the Pilbara represents a dissected arid landscape centred on well-watered gorges, with relatively smaller territories, distinctive languages and comparatively higher population sizes. Western Desert territoriality is more loosely arranged across a wider area, with reliable but more amorphous water sources often shared by neighbouring groups speaking different dialects of the same language.

Information Exchange in the Desert

Information exchange theory (IET) has been mobilised into rock art analyses through the notion of style as social strategy. Following Wobst (1977), this has been used to correlate stylistic information with the nature of prehistoric social networks and broad environmental parameters. Where social networks are closed and kinship, language and territoriality are relatively rigid, stylistic information will demonstrate distinctive group identifying behaviour (and rock art styles will be perceived as being stylistically heterogeneous); where social networks are open (with language, kinship and territoriality being shared), rock art will be stylistically homogeneous and function to provide broad scale intergroup cohesion.

We have written previously on this fertile/arid dichotomy, arguing that aggregation behaviour can explain the high levels of stylistic heterogeneity which are sometimes encountered in the desert (McDonald and Veth 2006, 2010, 2012). What we are interested in here is the fact that arid zone rock art appears to demonstrate changing levels of stylistic heterogeneity across the Pilbara-Western Desert interface, and that these levels of heterogeneity change through time. We suggest this can best be explained by contextualising rock art production into a broader suite of behavioural correlates which can be understood against the canvas of changing environmental conditions through time.

Rock Art and Mythology

Across the Pilbara it is believed that petroglyphs were not created by people but by Marga (Ancestral Beings) who lived in the Dreamtime (Juluwarlu Aboriginal Corporation 2008; Palmer 1975:155). Petroglyphs are seen as mnemonic devices to recall songs and invocations learned during initiation or for use in hunting (Palmer 1975:157). Mythological narratives link features in the landscape and rock art provinces, e.g. Ganya (near Gregorys Gorge), Depuch Island and the Port Hedland petroglyph sites. These are linked by Ancestral Beings, including Kangaroo (marlu), Two Men (Wati Kutjarra) and Seven Sisters (Minyiburu) (Palmer 1977). Where mythology has been ascribed to particular glyphs, as part of the regional narrative of Ancestral Beings, the sites are usually incorporated into larger geographic features (e.g. Depuch Island). Specific motifs on Depuch Island were identified as representing these beings:

... the petroglyphs were thought not only to have been made by the Dreaming ancestors, the marlu or the Minjiburu, but also were regarded as symbols of the deeper meaning and reality of their mythology. And so they are seen as representations of the myth and ritual adornments through which the body of traditional belief is expressed (Palmer 1977:45).

The Western Desert petroglyphs are similarly perceived. The Martu distinguish between pictographs—created by humans and depicting both every day and sacred themes—and petroglyphs, which were created in the Dreamtime and left behind by creator-beings (McDonald and Veth 2008, in press; see Gould 1969; Tonkinson 1974). The creator-beings are said to have had great magical power, which included the ability to assume animal forms at will.

Pilbara Petroglyphs

The Pilbara region possesses a 'dazzling array of Complex Figurative styles' (Maynard 1979:107 following Dix 1977; Petri and Schultz 1951; Worms 1954; Wright 1964, 1968, 1977). Various distinct style regions have been described, including Port Hedland (Franklin 2004; McCarthy 1962), the Upper Yule River (Woodstock-Abydos, Figure 3), Cooya Pooya (including the Fortescue River, Figure 4), and the eastern Hamersley Gorges and Ophthalmia Ranges (Figure 5). The art of Depuch Island (Berndt 1964; Crawford 1964; McCarthy 1961), extending up the Sherlock River, is another style province—as is the spectacular Dampier Archipelago (Murujuga) (Figure 6; and see Bednarik 2002a; Green 1982; JMCHM 2005, 2006, 2009; Lorblanchet 1992; McDonald and Veth 2009; Mulvaney 2009, 2010, 2013; Turner 1981; Vinnicombe 1987, 2002). It has been noted that the art provinces in the Pilbara piedmont are 'separate styles (which) seem to be quite distinctive and there does not seem to be any evidence of the gradual evolution of these figures' (Wright 1977:115–116). The examples given here show the stylistic heterogeneity demonstrated by anthropomorphic depictions in a few of these style provinces.

We have no absolute or relative dates for the regional engraving provinces of the Pilbara, except for suggestions through the micro-erosion technique (Bednarik 2002b:Figure 9) and, more recently, through erosion rates calculated from cosmogenic nuclide measurements (Pillans and Fifield 2013:105), that the slow weathering rates mean that they could be between 27,000–65,000 years old. While some have argued that the development of regional styles may be a Holocene and perhaps even more recent phenomenon (Ross 2013, following Rosenfeld 1993), others suggest that regionalism can be demonstrated much earlier in the occupation of Australia (e.g. Balme et al. 2009; McDonald and Veth 2010; Mulvaney 2013). Indeed, Maynard's (1979) tri-partite sequence recognised (following the earlier work of many, e.g. Edwards 1968) that the pan-continental Panaramitee¹ likely started in the Pleistocene. The complex Pilbara engraving styles were interpreted by Maynard (1979:100) as more recent manifestations than the Panaramitee and Simple Figurative styles. The problem with Maynard's model was that this generally saw art evolving from simple to more complex: an assumption which has been found to

¹ While recognising the problems and connotations which derive from this name, we still consider that this is a pan-continental style which represents the earliest art form in most regions (cf. Mulvaney 2013). We are referring to the (primarily) geometric and track assemblages that have the archaic face as a late phase addition focused across the arid zone (Edwards 1968; McDonald 2005; Mulvaney 2010)



Figure 3 Upper Yule petroglyphs (from Wright 1968:Figures 16–20).

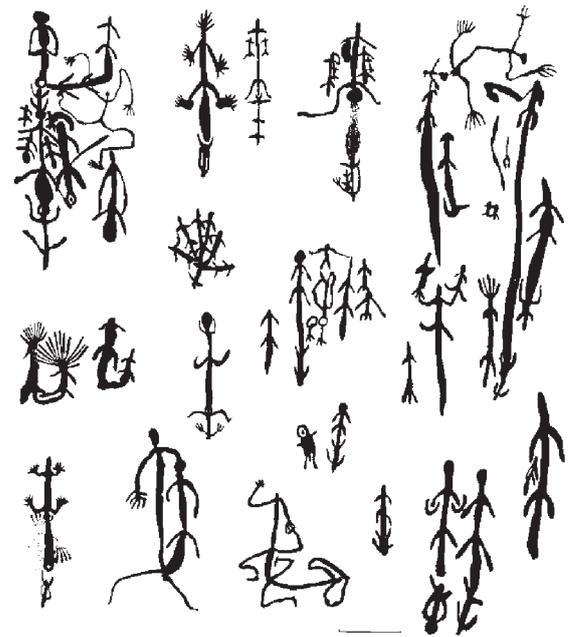


Figure 4 Cooya Pooya petroglyphs (from Wright 1968:Figure 745).



Figure 5 Juna Downs petroglyphs, from the east Pilbara (from Wright 1968:Figure 558).

be incorrect. Detailed Pilbara recording work identified multiple engraving phases at many sites, although an overall directional diachronic change eluded Wright (1968:66–68). Mulvaney (2010) recently proposed a five-phase sequence for the Dampier Archipelago (Murujuga) based on the patterns of superimposition and contrast-state, in combination with stylistic attributes of form,

technique and subject. He placed the earliest phase well within the Pleistocene, but, interestingly, did not classify a track and geometric phase (the Panaramitee) as earliest. Diachronic change across and within the style provinces of this region requires significantly more detailed analysis and is beyond the scope of this paper. What we are interested in here is the likely impetus for changing styles through

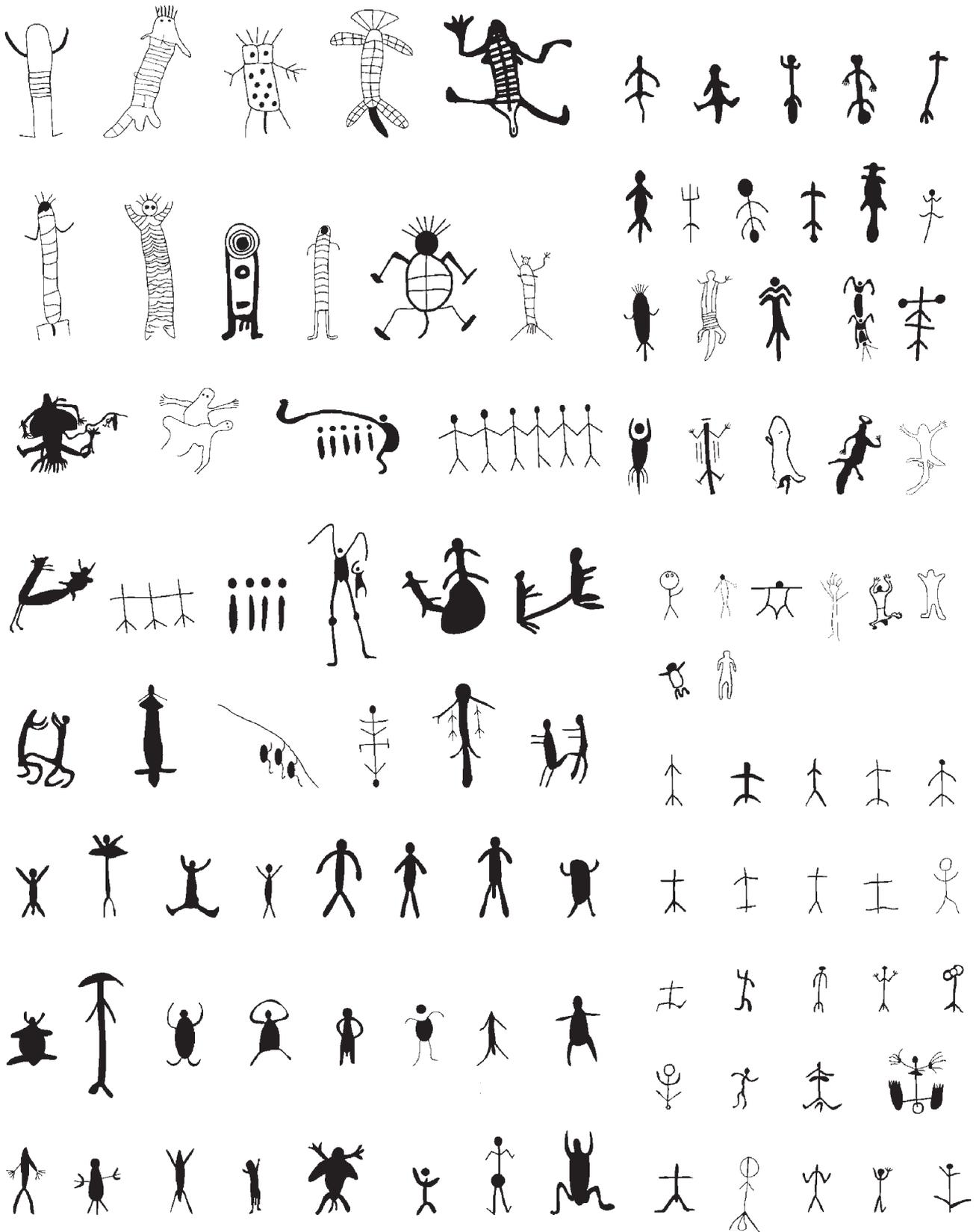


Figure 6 Example of some of the anthropomorphic variability recorded across the Dampier Archipelago (*Murujuga*) from JMCHM (2006).

time and the spatial variation of the definable style provinces. While it is likely that Wright's published assemblage data includes multiple diachronic elements in the various style provinces discussed here, it is apparent that the earlier style elements represent relatively small proportions of the overall assemblage data.

Western Desert Petroglyphs

Western Desert petroglyphs have only recently been investigated (e.g. McDonald 2001, 2005). Research along the Canning Stock Route (e.g. McDonald and Veth 2006, 2012) has revealed the widespread distribution of petroglyphs and systematic recording

is revealing stylistic patterning across this vast landscape. For this paper we utilise the art of a single Western Desert art province: that of the Calvert Ranges (Kaalpi), where 32 individual petroglyph sites in two major valley systems have been recorded in detail.

The petroglyphs represent only 20% of the rock art in this province: most of the art is produced with pigment. The petroglyphs here are incredibly diverse in terms of style and subject matter, with the following general categories recorded:

- Cupules;
- Intaglio bird and kangaroo tracks, with circles and small pecked dots (interpreted as animal scats; Clegg 1987) art: classic Panaramitee style;
- Archaic Faces, as recorded elsewhere in the arid zone (McDonald 2005); some complex bodies and headdresses which are unique to the Western Desert are found here (Figure 7);
- Large decorative infilled anthropomorphic figures;
- Pecked anthropomorphic figures, small to medium scale with sinuous arms and dot infill (Figure 8);
- Small infilled terrestrial animals;
- Abraded outline, lightly pecked infill figurative motifs mostly life size animals and birds (Figure 9); and,
- Battered figurative motifs.

It is assumed that stylistic variability in the petroglyphs can be explained by their having been produced over a long period of time; the different characteristics described here are given in best-guess chronological order, based on rare superimpositions, patination and weathering states. Some engraved art has stylistically contemporaneous pigment analogues, but most of the engraved Western Desert art predates the pigment art styles from this region. None of the engraved art is yet dated, but our model for settlement patterns provides a temporal scale which we hope to test by various dating methods in future research.

An Arid Zone Settlement Pattern with Rock Art Correlates

Occupation of the Australian arid zone commenced more than 45,000 years ago (Veth et al. 2009) by, we assume, small highly mobile groups of people (Williams et al. 2013). By the Holocene, occupation patterns demonstrate phases of dynamic social and economic transformation. We have previously modeled how rock art may fit into a more general occupation model for the arid zone using IET (McDonald and Veth 2006, 2007). This modeling has been based on environmental data, regional occupation indices as derived from excavations (O'Connor et al. 1998; Smith 2006; Veth 1993, 2008; Veth et al. 2000, 2011; Williams et al. 2013) and direct radiocarbon (AMS) dating of the most recent phases of pigment art in a number of Western Desert style provinces (McDonald et al. in press).

From the plethora of recent mitigation excavations, the earliest Pilbara published dates lie at ca 41,000 cal. BP and there is increasing evidence for occupation during the Last Glacial Maximum (LGM) (Law et al. 2010; Morse 2009; Ryan and Morse 2009; Sinclair and Wright 2012; Slack et al. 2009).

Environmental reconstructions suggest that, while conditions would have been generally wetter than today at the time of

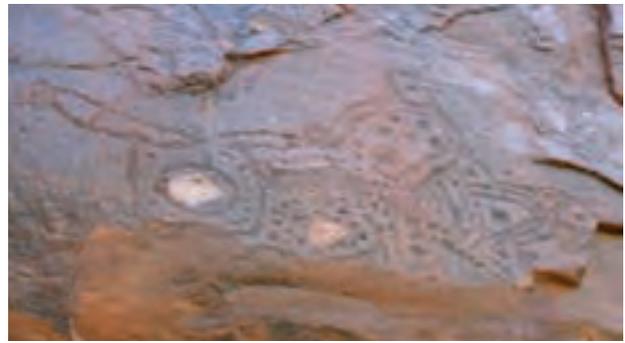


Figure 7 Example of a Calvert Ranges Archaic Face (top) and an Archaic Face with ornate body, lying sideways (below).

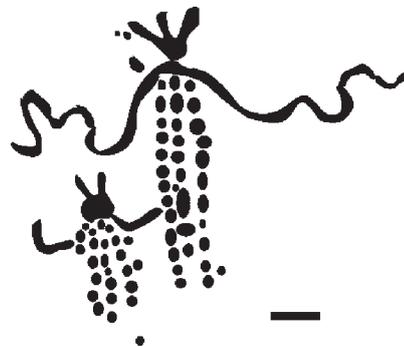


Figure 8 Example of dot and sinuous line anthropomorphs (scale is 10 cm).

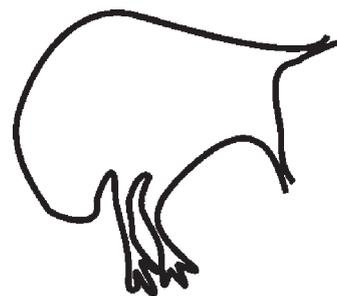


Figure 9 Detail of abraded outline emu, this is 1.5 m tall. The head is 'missing'; the motif ends at the edge of the rock.

colonisation of the Pilbara and Western Desert, other factors may have promoted early movement inland. Hiscock and Wallis (2005:35) argued that, in the case of Australian deserts,

In many regions it is likely that up until 45,000 years ago—and perhaps to 30,000 years ago in some locations—the availability of fresh surface water would have been at least as good, if not better, than during the Holocene ... The greater relative availability and predictability of resources ... would have facilitated exploration and exploitation of these unique interior landscapes.

By contextualising rock art correlates with archaeological phases we have modeled diachronic change in social identifying behaviour (Table 1). Based on occupation indices and IET, we argue that rock art could be seen as a form of negotiated identity throughout the entire human occupation of the arid zone.

Initial settlement of both arid regions was in the Pleistocene and likely well before 40,000 years ago. We have argued elsewhere that, at a theoretical level, art formed an integral part of the cultural baggage necessary to colonise these arid lands (Balme et al. 2009; McDonald and Veth 2010; Veth et al. 2011). Panaramitee style art (following Franklin 2004; Maynard 1979), with its open-signalling graphic repertoire (Munn 1973) located prominently at and around permanent water across the arid zone, is the type of homogeneous art body that we argue reveals long distance connections. This was the colonising repertoire for people who moved into the arid zone during this earliest occupation phase, and to which they added diverse motifs (with increasing stylistic heterogeneity and regional variety) when their occupation became more permanent.

Between 30,000 and 22,000 BP, with the onset of Oxygen Isotope Stage 2 (OIS2), there was a slow reduction in surface water availability and the reduction and/or eventual drying out of Lakes Gregory and Woods in the north and, in southeastern Australia, most notably Lake Mungo. This extended but gradual phase of desertification is inferred to have resulted in groups displaying higher levels of residential mobility and the adoption of increasing broad dietary breadths (see also O'Connell and Allen 2012). While residential mobility configurations are likely to have differed between regions, they will have been higher within the desert lowlands—hence the pull-push factor towards refugia may have been greater in the Western Desert than the Pilbara, though significant variability in both bioregions is expected (Smith 2013; Veth 1995; Veth et al. in press). Shared motifs found in the Dampier Archipelago and Calvert Ranges (McDonald 2005; McDonald and Veth 2006, 2008; Mulvaney 2010, 2013), separated by approximately 1000 km, signal chains of connection at this early time, but also illustrate the first development of regional art signatures. Our model sees a tightening of social and territorial organisation just before the LGM, following a long phase of high mobility and likely multivalent art. We would argue that archaic faces and their subsequent regionalisation, as identified by the development of local characteristics including the intaglio technique (e.g. on the Burrup; see Mulvaney 2010), and the addition of bodies and/or headdresses in the Calvert Ranges (McDonald 2005), are evidence for this type of 'chain of connection' through the desert. While human faces may have a 'universal' distribution (see for example the 'Austronesian' examples dated to the late Pleistocene

in East Timor; O'Connor et al. 2010), the Australian distribution of these early examples appears limited to the northwest arid zone around the latitude of the Tropic of Capricorn (see Veth et al. 2011). More complex graphics, such as 'climbing-men' grouped anthropomorphs, well documented on the Burrup and present in small numbers in the Calvert Ranges, represent another clear example of distinct stylistic connection over significant distance.

Occupation evidence reveals that groups persisted in refugia in the Pilbara Uplands during the LGM and peak aridity, albeit with territorial retraction (e.g. Slack et al. 2009). Throughout the period of maximum aridity, less well-watered areas dropped from peoples' normal territories. Some Western Desert ranges appear to have dropped out of use during this time, with people retreating into more reliable refugia within the larger ranges in the deserts and most certainly within the Pilbara Uplands. Rock art may have been produced less frequently during this period—either due to the absence of people or because of groups' social isolation—negating the need for signalling behaviour. The time bracket between 17,000 and 13,000 years ago—immediately following peak aridity—is often characterised by minimal occupation and sedimentation in rockshelters. It is possible that rock art production ceased completely during this period or was so intermittent as to be archaeologically invisible. It is also possible that during this time period small, highly mobile groups ranged across the entire territory and that this was a time which, again, could be expected to display stylistically homogeneous art. Possibly at this time, the engraved repertoire included the large naturalistic animals produced using a wide-grooved abraded outline. These are found in all art provinces across the Pilbara and Western Desert, and include the fat-tailed macropods (Brown 1983) which Mulvaney (2009) interpreted as representing a now locally extinct species.

Between 13,000–6000 BP there was a phase of gradual climatic amelioration, and sea level rose to its current stand by ca 6000 BP. Islandisation of the Dampier Archipelago (Murujuga) occurred during the later stages of this phase and populations increased dramatically, with the marine transgression drowning a 100+ km wide coastal plain. There is evidence across both arid landscapes for a re-colonisation of territorial ranges, with systematic and increasing use of all lands. Our model contends that rock art was again used to establish territoriality, with an amplified demonstration of identifying behaviour in core territories. A switch to a maritime art focus on Murujuga reflects eustatic sea-level rise and changes towards an estuarine environment. This switch clearly demonstrates that petroglyph production occurred both before and after sea-level rise.

Between 6000–1500 years ago, particularly in the Pilbara, we envision the emergence of increased territoriality and tightened social networks more like those in place today. We posit that increasing social pressure accompanied the reorganisation of territories following the reduction of the Abydos Plain. The increased assertion of territoriality with the movement of people, languages and social capital would have created the appropriate social conditions (Wiessner 1990) for the development of the distinctive group-identifying Pilbara-Western Desert style provinces during this timeframe.

In the Western Desert from approximately 1500 years ago there appears to be a major increase in site numbers and artefact densities, and this has been argued to coincide with the spread

Occupation Phases	Region	Linguistic Correlations	Occupation Model	Likely Art Correlate
Phase 1 > 40,000–30,000 BP Wetter interglacial conditions	Pilbara Uplands and Western Desert	Non-Pama-Nyungan speakers.	Early colonisation phase. All land systems in use with a broad-based economy. Pluvial phase wider spread of lake-full conditions.	Sporadic art production reflecting small population groups at occupation nodes. Dynamic population with homogenous art demonstrating movement of people moving into naïve landscapes and over vast distances.
Phase 2 30,000–22,000 BP Onset of desertification	Pilbara Uplands and Western Desert	Non-Pama-Nyungan speakers.	Onset of OIS2. Slow reduction in surface water availability and increasing dietary breadth.	Increasing aggregation at key locales (refugia). Art production at focal points demonstrates stylistic heterogeneity as increasing aridity triggers stress and more territorial attachment to refugia.
Phase 3 22,000–17,000 BP (LGM) Intensified aridity—generally colder and drier conditions	Pilbara Uplands	Non-Pama-Nyungan speakers.	Groups persisted by retracting to upland refugia during LGM.	Broad-scale social cohesion, with territorial tethering at upland refugia. Art production episodic.
	Western Desert	Major reconfigurations of demography and residential mobility patterns.	Lowlands used opportunistically, with refugia heavily relied on.	Broad-scale social cohesion needed to maintain connections. Art production probably episodic, but also possibly indicating increasing territories of small, highly mobile groups.
Phase 4 17,000–13,000 BP Low precipitation	Pilbara Uplands	Non-Pama-Nyungan speakers.	Smaller population groups with high residential mobility. Sparse archaeological signatures registered in refugia.	Groups become isolated and broad-scale social networks break down. Information exchange breaks down—art not used/used far less as signalling behaviour?
	Western Desert		Little occupation dated to LGM (currently only from Puritjarra and possibly Parnkupirti).	People establish new ranges from their refugia, possibly retracting further into less arid refugia. Art not used as signalling behaviour?
Phase 5 13,000–6000 BP Climatic amelioration, sea-level rises to current stand by ca 6000 BP	Pilbara Uplands and Dampier Archipelago	Non-Pama-Nyungan speakers.	A broadening of territorial ranges with systematic and increasing use of all landscapes.	Art used to establish territoriality, with an increased demonstration of identifying behaviour. Art on the Dampier Archipelago switches from a terrestrial to a maritime focus with encroachment then stabilisation of sea-levels.
	Western Desert		Ephemeral lands used more systematically. Ranges and cryptic refugia become a focus of more intensive occupation.	Art used to establish territoriality, with an increased demonstration of identifying behaviour in core territories (homelands).

Table 1 Occupation models for the Western Desert and Pilbara with proposed art correlates*. This table describing our model was first developed for a paper presented at the SAA conference in Atlanta. It was published in a transitional form in Italy (McDonald and Veth 2007). The model has been modified in light of more recent excavation results from the Pilbara and our ongoing dating of pigment art in the Western Desert (continued overleaf).

of the Western Desert language out of the Pilbara (McConvell 1996; Smith 2013). The spread of the Western Desert language and its myriad dialects was accompanied by accelerated ritual and ceremonial cycles and an increase in long distance exchange networks (Veth 2000). Based on linguistic stratigraphy we assume that the ramified Western Desert social networks described by anthropological research (e.g. Tonkinson 1974) have functioned for at least 1500 years (and see Ross 2013; Smith and Ross 2008),

while those in the Pilbara may have been in situ for possibly as long as 6000 years (McConvell 1996; Palmer 1975).

The Western Desert pigment art we have dated to this time period demonstrates dialect-group identifying stylistic diversity (McDonald and Veth 2008, 2012; McDonald et al. in press). It is unclear whether the engraved repertoire continues in this time frame, since there is no evidence for dual-media art production in the recent past, i.e. there are no Western Desert engraved and

Occupation Phases	Region	Linguistic Correlations	Occupation Model	Likely Art Correlate
Phase 6 6000–1500 BP	Pilbara and Dampier Archipelago	Pama-Nyungan family. Ngayardic languages established across the Pilbara Uplands.	Occupation of all upland eco-systems; language and population expansion out of the Pilbara into Western Desert. Dampier Archipelago becomes a major regional focus for aggregation as a resource-rich island chain with easy mainland access.	Art used to negotiate both broad-scale and local group identity. Social pressures (population increase?) result in renegotiation of territories, with assertion of identity becoming increasingly important. Maritime art focus at Murujuga, combined with extreme stylistic heterogeneity (e.g. in headdresses) on the Dampier Archipelago, demonstrates this is a major aggregation locale.
	Western Desert	Ngayardic language (Wati) spreads into the Western Desert.	Occupation of all desert ecosystems and the development of relatively fixed territorial ranges. Re-establishment of regional exchange and information networks.	Pilbara art graphic moves into the Western Desert. Social pressures and tensions result from occupation by new groups. Rock art used to establish territoriality, with localised style regions evolving.
Phase 7 1500–500 BP	Pilbara Uplands and Dampier Archipelago	Ngayardic subgroup persists and Pilbara Culture Bloc established.	Increased intensity of site occupation. Accelerated ritual and ceremonial cycle. Increase in long-distance exchange into Western Desert.	Established use of art as a form of negotiated broad-scale and local group identity. Distinctive localised style regions in full production; use of stone structures to delimit sacred spaces in the ceremonial cycle.
	Western Desert	Spread of Wati language—current Western Desert culture bloc develops; some loan words from northern languages. Contact with Central Australia.	Increased intensity of site occupation. Accelerated ritual and ceremonial cycle. Increase in long-distance exchange from the coast.	Established use of art to negotiate broad-scale and local group identity in distinctive localised style regions; art reveals contacts with the north and coast. Stone arrangements move into Western Desert as a means to delimit space in ceremonial cycle.
Phase 8 500 BP to contact	Pilbara and Dampier Archipelago	Western Desert cults move west into the Pilbara Uplands.	Increased influence from social networks from Western Desert; increasing population levels and social dynamism.	Changing use of art to negotiate broad-scale and local group identity. Petroglyph production declines to be replaced by extensive construction of stone arrangements at aggregation locales. Pigment art in the east Pilbara (Hamersley Range) and along the Fortescue River; introduction of pigment use of in shelters/gorges.
	Western Desert	Western Desert speakers intensify interaction from homelands into Central Australia and also westwards into the Pilbara.	Increased social dynamism and interaction with social networks in Central Australia and Pilbara.	Accelerated use of pigment art to negotiate broad-scale and local group identity. Shared graphic vocabularies from Central Australia and Pilbara. Pigment art and body painting share graphics; petroglyphs drop out of art repertoire. Stone arrangements construction increases as a mechanism to negotiate identity.

Table 1 cont.

recent pigment motifs in similar styles (cf. the Sydney region; McDonald 2008). For this phase of occupation we see Pilbara engraved art production in full swing, with many provinces developing distinctive localised traits. Continuing increases in population and social dynamism in the recent past create the potential for high levels of inter-regional stylistic variability.

We suggest that the production of engravings (petroglyphs) may have largely ceased in both arid regions during the last 500 years. The pigment repertoire continues to change in this time period and in the Western Desert becomes increasingly focused on the use of local white pigments. There are no fresh contrast-state Western Desert engravings, and the most recent pigment style, (thick, simple figurative with predominantly small scale anthropomorphs and large snakes), is not matched by an engraved repertoire.

While contact subject engravings (specifically, horses, ships and dressed humans) have been documented in a number of pastoral settings around the Pilbara (Paterson and Wilson 2009), we argue that the social context for this production changed and that this engraved form is likely to have been produced well after 'first contact' in the region. Pilbara 'contact' motif production seems restricted to various pastoral stations, and contact motifs are otherwise non-existent or rare in Pilbara style provinces. Inthanoona, established in 1864, is a key pastoral site with 55 contact motifs in an assemblage of 263 motifs (Paterson and Wilson 2009:104). This art depicts both pearling and pastoral themes and is spatially focused on the head station. Four sets of initials at this location led Paterson and Wilson (2009:109) to suggest that Europeans as well as Aboriginal people produced the engravings. It is notable that the Dampier Archipelago—first visited by William Dampier almost 170 years earlier, in 1699—has only one recorded possible contact motif (out of more than an estimated 50,000 motifs). This motif—on Dolphin Island and interpreted as a pearling lugger—has initials engraved nearby; Mulvaney (2010:Figure 1.3) concluded that this was probably executed by a pearler rather than an Aboriginal person. Similarly, in the Western Desert over the last 12 years we have not recorded recognisable contact art motifs in either pigment or engraved repertoires, although dated pigment art production (McDonald et al. in press) continues into the contact period, which was as late as 1963.

With the cessation of engraving we propose that—in the Pilbara particularly—other forms of symbolic behaviour may have become established as a mechanism for signalling identity. There is a proliferation of stone arrangements throughout the Pilbara and an incredibly high density of these features in a number of landscapes where engravings of varying antiquity are found. The Dampier Archipelago has one of the highest recorded densities of these features anywhere in Australia (McDonald and Veth 2009). Recent work dating these features in the Pilbara has demonstrated that they seem to date to the last millennium (Hook et al. 2012). While further research into the timing of this type of feature as an alternative mode of marking territory and asserting ritual ascendancy is clearly needed, we suggest that stone arrangements and the use of *Thalu* sites (standing stones used in regenerative ceremonies; Daniels 1990) may have increased, perhaps replacing engraving as the major contributory component of the ceremonial repertoire in the recent past.

Mulvaney's Murujuga Artistic Phases

Mulvaney (2010:238) has recently developed a five phase sequence described as a 'speculative chronology ... based on climatic events, archaeological data and probable scenarios that would stimulate changes in the ways of producing images' (although also see Mulvaney 2013:105). Based on contrast state and superimposition analysis, these phases broadly correlate with significant climatic events and dates, such as the onset of the LGM and the re-establishment of monsoonal conditions (Mulvaney 2010:236, 238; although see Mulvaney 2013:Table 1):

- Phase 1: 25,000 BP±5000
- Phase 2: 18,000 BP±3000
- Phase 3: 12,000 BP±3000
- Phase 4: 7000 BP±3000
- Phase 5: 4000–ca 150 BP

It is worth exploring the similarities and differences between Mulvaney's model and ours. Ours is geographically more widely focused and allied with behavioural correlates based on environmental phases and a range of archaeological signatures, including age determinations for the more recent pigment art. The major area of divergence between the two models is in the recent past—where, based on archaeological phases, we infer there to have been significant shifts in signalling behaviours through the mid- to late Holocene, while Mulvaney's last phase spans almost 4000 years.

Our model sees the so-called Panaramitee as the first phase of petroglyph production in both regions. Located around major waterholes, and many times spatially separated (i.e. often on horizontal surfaces, unlike subsequent styles which are often on vertical surfaces), this lower density signature is generally replaced by subsequent art production. Unlike Mulvaney, we perceive that this style is present on the Dampier Archipelago, but here it is likely swamped by the overprinting of subsequent styles—many also containing tracks and geometrics—and masked by landscape parameters (i.e. jumbled boulder fields) and a geology (granophyre) very different to the fine-grained rock (mudstones, sandstone and quartzites) found throughout most of the arid zone. We see a tightening of social and territorial organisation just before the LGM, following a long phase of high mobility and likely multivalent art. Our Phase 2 is visually (stylistically) similar to Mulvaney's (2010:238) Phase 1 for the Dampier Archipelago.

The timing for Mulvaney's Murujuga Phase 2, with large outlined fauna and tracks (2010:238), straddles our Phases 3 and 4, where we see art production as episodic and (in Phase 4) perhaps even dropping out of the repertoire for a considerable period of time. Given the widespread distribution of large macropods of this style through the Pilbara (Mulvaney 2010:Figure 10.1) and out into the Western Desert, we propose that Mulvaney's Phase 2 might be better placed in the 22–17,000 BP age bracket.

Mulvaney's Phase 3 is identified as early Holocene (straddling our Phases 4 and 5). Given the switching behaviours signalled by the broader occupation model in our Phase 5, we would argue that Mulvaney's Phase 3 for Murujuga fits better into our Phase 5 timeframe (13,000–6000 BP). Our model predicts that art would have been used to establish territory and increasingly to assert identity in this phase. Mulvaney noted (2010:226) that,

as well as marine subjects becoming more frequent, distinctive anthropomorphic figures, such as the Murujuga 'rainbow-man', appear in this Phase.

Mulvaney's Phase 4 also falls within the time frame for our Phase 5, straddling this and our Phase 6. From his characterisation of Murujuga Phase 4, with the dominance of fish and other marine fauna—as well as the increasing depiction of group scenes and characteristic Burrup forms—we suggest that this style phase fits better into the timeframe of our Phase 6, where we model art as a signalling mechanism with the movement of Pama-Nyungan languages into the Pilbara. Mulvaney's Phase 5 fits well in this likely set of behaviours and it is with the further establishment of distinctive forms (such as proportionally exaggerated human figures and distinctive maritime themes, including turtle compositions and rarer crustacea), that leads us to suggest that this could be better placed within our Phase 7 (between 1500–500 years BP).

Obviously, with no firm dates both our model and Mulvaney's schema remain speculative, and we concur with his conclusion (2010:240) that more archaeological work is required to further refine time periods and improve our understanding of how art has operated in this environment.

A Spatial Analysis of Arid Style Provinces

While stylistic heterogeneity *within* the Calvert Ranges petroglyph province can be explained by long-term aggregation behaviour (Conkey 1980; McDonald and Veth 2012), this does not necessarily explain the generally high levels of stylistic diversity demonstrated by the various style provinces *across* the arid Pilbara region. Stylistic diversity shown *between* rock art provinces in the Pilbara can, however, still be explained in terms of information exchange theory as the demonstration of territorial social organisation (McDonald 2008; Wiessner 1989; Wobst 1977). Across the Pilbara, where there was a greater population pressure and distinct language groups compared to the Western Desert, people appear to have used petroglyphs to demonstrate the language group they belonged to, as well the broader social network in which they participated.

At many of the Pilbara petroglyph sites there are obvious palimpsests of artistic activity and, in some, intimations of greater time depth for production (e.g. Murujuga). Diachronic change is an obvious explanation for the complexity demonstrated within many of the recorded Pilbara art locales. There are, however, various distinctive style provinces and in this paper we begin to test the possibility that the stylistic patterning across the Pilbara might be explained in terms of distinct and comparatively well-defined territorial groups. Social boundedness and high levels of territoriality demarcated by distinct language groups (criteria defined by Sackett 1990 and Wiessner 1990 as triggers for art production signalling between-group distinctiveness)—despite the aridity—provides the obvious explanation for the extreme stylistic heterogeneity observable between style provinces in this region.

Several of the Pilbara style provinces fall within the boundaries of Tindale's sociolinguistic mapping for the region. The Port Hedland style province (Franklin 2004; McCarthy 1962; Wright 1968) falls within the Kariara boundaries, while the Depuch Island style, which extends up the lower Sherlock River (Berndt 1964; Crawford 1964; McCarthy 1961), falls

within Ngarluma territory. The Hamersley Gorges style, which includes the Juna-Ophthalmia sites, is similarly located within the boundaries of a single group—the Pandjima.

There are a number of exceptions to this neat fit, however. The extraordinary Upper Yule petroglyph assemblages, found mostly within the Woodstock-Abydos pastoral stations (Petri and Schultz 1951; Worms 1954; Wright 1968) but also at several other locations further south, cross-cut the defined language boundaries for three language groups (Nyamal, Yindjibarndi and Panjima). Similarly, sites in the Cooya Pooya 'style' can be found in both the Ngarluma and Yindjibandi territories.

Principal components analysis (PCA) was used to analyse the published Pilbara assemblages (Wright 1968:Table 4) to quantify these similarities and differences. The SPSS programme PASW Statistics 18 was used for this purpose. Petroglyphs from the Calvert Ranges were included in this analysis, as was a sample from a recent survey in Murujuga (Deep Gorge; JMCHM 2009), to supplement the sample for coastal Pilbara (not recorded by Wright) and to give a transect through the region. Ten assemblages were used (Table 2) to provide an initial sample, given that there are few language areas—or style provinces—represented by more than one assemblage (Figure 1). Assemblage sizes vary markedly across these samples and hence bivariate (i.e. presence/absence) data was used to ensure that sample size did not affect the results. This intraregional comparison of engraved assemblages is the first statistical analysis carried out since Wright's pioneering work, and represents the first stage in a multi-phase program of analysing the massive assemblages of stylistically diverse art across the Pilbara.

Anthropomorphic depictions dominate all assemblages, except in the Calvert Ranges and at Sherlock Station (Table 2). Where anthropomorphs were dominant, these varied in proportion between 85% at Cooya Pooya and 28% in Upper Yule. The dominant motif choice in the Calvert Ranges was bird tracks, while at Sherlock Station it was macropod tracks. Anthropomorphs were, however, present in all of the assemblages. Interestingly, the style of the anthropomorphs is the dominant evidence for stylistic variability between the Pilbara provinces.

Only three assemblages used in this analysis contain Archaic Faces: those from the Western Desert, Deep Gorge/Murujuga and Woodstock-Abydos (see Brady and Carson 2012; McDonald 2005; Mulvaney 2009; note, Ken Mulvaney reports that there are more now known from the eastern Pilbara, pers. comm. 2013). Motifs which may relate to the earlier arid zone Panaramitee track and geometric style (Maynard 1979) are distributed fairly widely as relatively minor components in larger assemblages; these only occur in larger proportions in the Calvert Ranges and at Sherlock Station. In the former, these earlier motifs are more heavily patinated, and spatially distributed in a different way from more recent styles: the Panaramitee panels are exclusively located on horizontal slabs in the inner gorges and around the periphery of the Ranges, while the more recent styles tend to be located on vertical surfaces within the interior valleys (Jo McDonald pers. obs.).

PCA demonstrates broad-scale cultural affiliation between the Pilbara Upland assemblages (with 65% of the variance accounted for by the first two components) and a strong separation between these and the Western Desert assemblage from the Calvert Ranges (Table 3, Figure 10). Interestingly, the Deep Gorge Murujuga assemblage is also quite distinct from both the Western Desert

and the Pilbara Upland assemblages. Two other assemblages, from Juna Downs (an east Pilbara assemblage) and Chiratta Station (in the Martuthunera language area), cluster relatively closely, but are distinct from all other groups.

The range of motifs and design themes—the ‘isochrestic choices’ (Sackett 1990)—depicted across the Pilbara Uplands seem to reveal broad scale cultural identity, with the only distinct local-group identifying behaviour being demonstrated by assemblages which are from the Western Desert, eastern Pilbara (Juna Downs) and Murujuga, as well as on the coast (Chiratta Station). The Ngarluma, Yindjibarndi and Nyamal sites all seem to cluster closely, although stylistically the art from these different areas looks significantly different (see Figures 3–5).

The clear presence of multiple ‘styles’ in several locations, e.g. the Calvert Ranges (McDonald and Veth 2012), Murujuga

(McDonald and Veth 2009; Mulvaney 2010, 2013) and at three rockhole locations on Hamersley Station (Wright 1968:17), suggests that at least some of these assemblages may have been aggregation locales throughout time. The PCA results suggest that the Deep Gorge Murujuga sample is significantly different from two smaller Pilbara assemblages (Juna Downs and Chiratta Station)—as different as the Western Desert assemblage is from the bulk of the Pilbara art styles. The issue of assemblage size (e.g. single/multiple art episodes versus aggregation locales) is an obvious area requiring further investigation.

Given the dominance of anthropomorphs in most Pilbara assemblages, we decided to explore the differential depictions of gender in the anthropomorphs across the sample to see whether this may be a more sensitive indicator of local stylistic traits (see McDonald 2012). Again, we used data collected by

Motif	Murujuga	Chiratta Station	Cooya Pooya	Black Hill	Sherlock Station	Nungerry Creek	Hooley Station	Upper Yule	Juna Downs	Calvert Ranges
Anthropomorphs	833	106	371	143	30	72	111	715	31	42
Archaic Face	2							1		7
Arc	91		7	14	7	6	16	71		6
Parallel arcs	29	3		2				212		1
Shield				2	1	3	4	1	1	1
Spear	25	1	4	6	3	10	4	63	3	
Emu		1						8	1	1
Other birds	99	3	5	19	4	7	3	16	2	1
Snake	16	1	4	4	3	1	1	51		1
Lizard/goanna	45	1			2		7	56		3
Macropod	264	10	3	9		4	3	30	8	5
Echidna	17					1		7		3
Thylacine	12								1	1
Quadruped	39	16	5	12	2	1	3	15	1	
Macropod tracks	107	26	4	19	41		4	420		13
Bird track	375		4		13		6	319	1	45
Human track	19			2	11		3	246		
Oval/circle	245				12		7	167		5
SNF	199		27	13	3	2	14	110		18
CXNF	228			8	1	3	1	40	2	18
Marine	159		4		4	1	0	8		
Total	2804	168	438	253	137	111	187	2556	51	171

Table 2 Motif data from the ten art assemblages analysed (Murujuga from JMCHM 2009; Calvert Ranges data from ongoing CSR project; remaining data from Wright 1968:Table 4).

Art Provinces	Component		
	1	2	3
Deep Gorge	.186	-.721	.527
Chiratta Station	.385	.476	.627
Cooya Pooya	.749	-.133	.294
Black Hill Pool	.760	.165	.127
Sherlock Station	.737	-.306	-.322
Nungerry Creek	.589	-.087	-.391
Hooley Station	.837	.113	.042
Upper Yule	.682	.079	-.264
Juna Downs	.219	.716	-.066
Calvert Ranges	-.313	.331	.093

Table 3 PCA components matrix of the 10 compared art provinces’ assemblages.

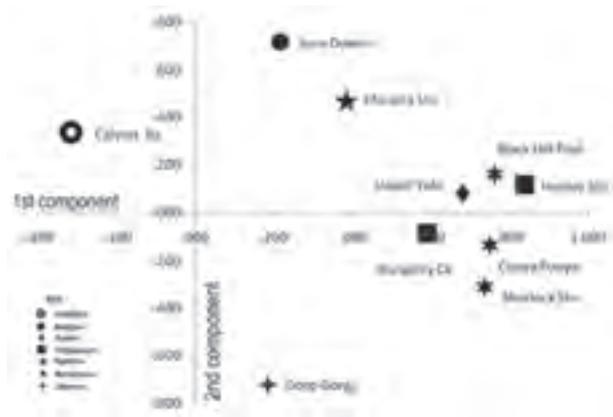


Figure 10 PCA bivariate graph showing component scores for the ten art assemblages from the Pilbara (9) and Western Desert (1). Analysis based on total assemblage characteristics. Assemblages coded for language area (see key in figure).

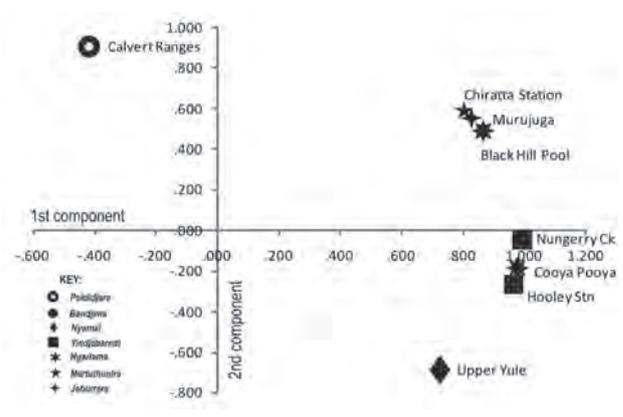


Figure 11 PCA bivariate graph showing component scores of the eight art provinces from the Pilbara (7) and Western Desert (1). Analysis based on gender characteristics. Assemblages coded for language area (see key in figure).

Wright (1968:Table 5), supplemented by data collected from the Dampier Archipelago (JMCHM 2009) and the Calvert Ranges.

Only Pilbara assemblages with >70 anthropomorphs were included in this analysis and therefore only eight assemblages were analysed; percentage figures were used as the basis for this comparison (Table 4). The Calvert Ranges sample is smaller but, given that this is a clearly distinct style compared to the Pilbara assemblages (Figure 10), this sample was included for comparative purposes. The fact that this art province contains almost no gendered anthropomorphs amongst its petroglyph assemblage separates it conspicuously from the Pilbara assemblages, where the majority of all anthropomorphs are male and female petroglyph proportions vary markedly.

The PCA results show definitively that the Western Desert assemblage is different from the Pilbara assemblages (Figure 11). Here 100% of the variance was accounted for by the first two components—possibly due to the small number of variables and the fact that percentages rather than counts were used. This analysis separates the Woodstock-Abydos province from the other Pilbara provinces. This is no doubt due to the distinct gender demarcations (60% are male, while 40% are female), with only a small proportion of non-gendered motifs in this province. The significance of the gendered nature of these assemblages has been discussed elsewhere (McDonald 2012; Worms 1954; Wright 1968).

Based on gendered depictions, most of the Pilbara assemblages again appear to cluster across language boundaries. Sites from across the Ngarluma and Yindjibarndi language boundaries cluster together, suggesting stylistic/cultural similarity. The Murujuga assemblage (Jaburara) clusters with geographically proximal assemblages, but is separate from the more distant language areas of Ngarluma and Martuthunira.

Several visually distinct Pilbara art provinces (Port Hedland and Depuch), not subject to the current statistical analyses, fall clearly within the (contact) Pama-Nyungan language boundaries (Figure 12). Further analyses of these two provinces are required before comparable data is available to test similarity or difference in the same way.

The results of the current analysis of the Pilbara assemblages, however, suggest that the visually distinct style provinces cluster on the basis of something other than language. Possibly the petroglyph style provinces are *older* than the contact language boundaries? Perhaps this stylistic patterning reflects a previous social organisation? More detailed research, undertaking analysis at the trait level on specific motifs, and rock art dating, is required to disentangle the diachronic features of the Pilbara petroglyph provinces.

These results reveal a strong separation between the Western Desert and the Pilbara in the way that petroglyphs are produced and composed as graphic systems. The distinctly different social and economic organisation (as defined by different territorial configurations, population density and dietary breadth) in these neighbouring landscapes can only partially explain these differences.

Given that petroglyphs in both regions are perceived by contemporary peoples as deriving from the Dreamtime, and not as a function of human production (Palmer 1977; Tonkinson 1974), this stylistic separation suggests a deep-seated set of human artistic responses to these two environments: further evidence for the Pleistocene development of distinct regional art symbols from the earliest phases of human settlement around the continent (Balme et al. 2009; Veth et al. 2011; and see Mulvaney 2013).

	Deep Gorge	Chiratta Station	Cooya Pooya	Black Hill Pool	Nungerry Creek	Hooley Station	Upper Yule	Calvert Ranges
Male	59.0	54	67	63	60	46	58	4
Female	3.5	8	20	1	19	29	38	2
Indeterminate*	37.5	38	13	36	21	25	4	94
Sample size	720.0	106	371	143	72	111	715	42

Table 4 Percentages of male, female and non-gendered anthropomorphs across the seven Pilbara and one Western Desert assemblages. * indicates anthropomorphs where no gender information is shown, or where the depiction is ambiguous.

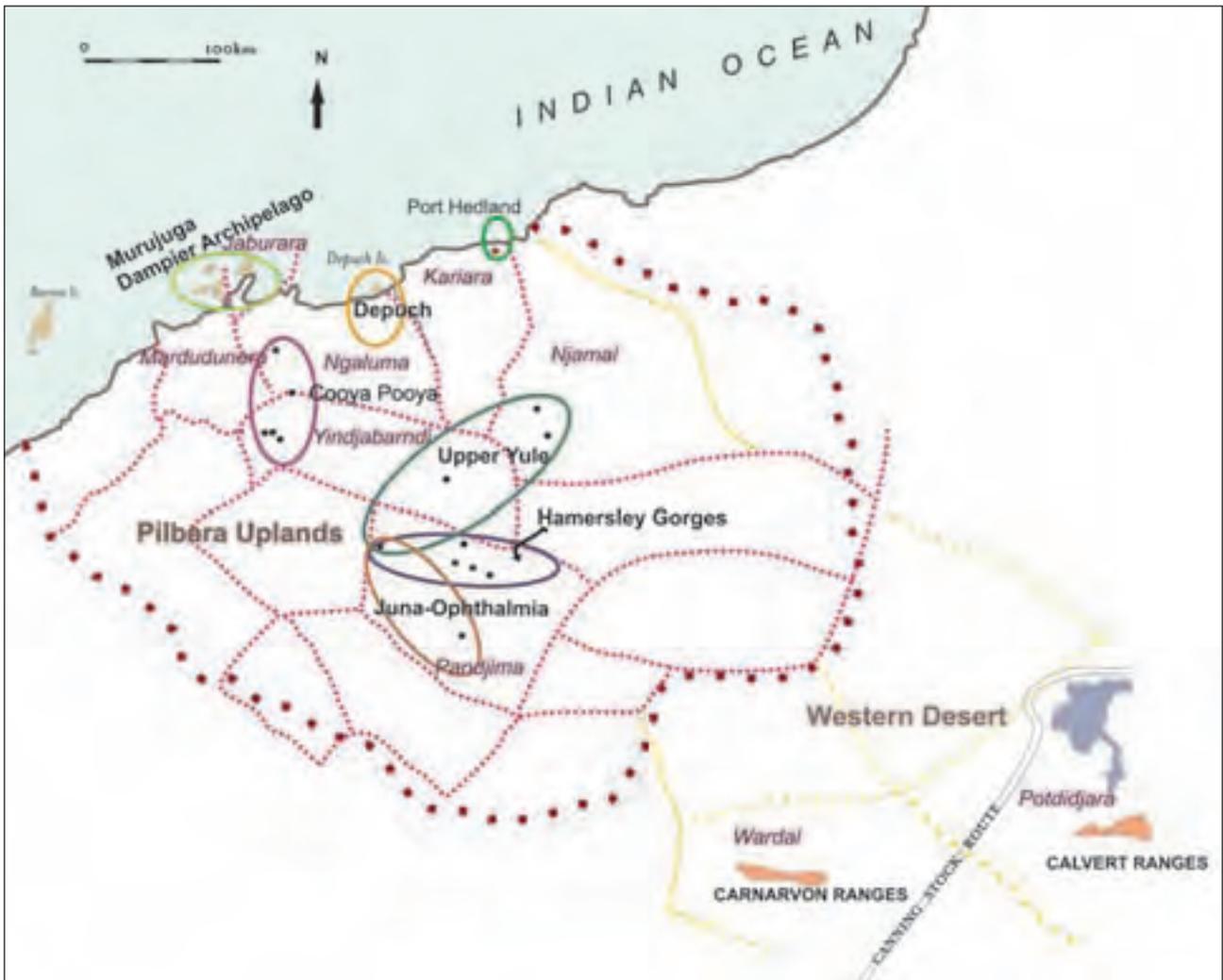


Figure 12 Distribution of identified Pilbara style provinces (assemblages classified visually) overlain on language boundaries.

Conclusions

Comparing social networks and art production across the Pilbara with those found across the Western Desert has great research potential. More detailed analyses (both recording and dating) will allow us to test our models of changing art production through time in both of these regions. By identifying varying social and physiographic landscapes within the arid zone we have further explored a contradiction previously identified with information exchange theory: i.e. the precept that arid environments and open social networks will produce stylistic homogeneity, while fertile environments generate stylistic heterogeneity (e.g. Gamble 1982; Smith 1989). Extreme stylistic heterogeneity across the arid Pilbara cannot easily be related to social organisation based on contact language boundaries. By exploring how physiographic parameters in the arid zone influenced social landscapes we are developing a more nuanced view of both style as social strategy, and perceptions of how rock art was used in the complex network of personal and social identifying behaviours through time in these landscapes.

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