DATING OF BUSH TURKEY ROCKSHELTER 3

in the Calvert Ranges establishes Early Holocene Occupation of the Little Sandy Desert, Western Australia

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Abstract

Systematic excavation of occupied rockshelters that occur in ranges along the Canning Stock Route of the Western Desert has seen the establishment of both a Pleistocene signal (c.24ka BP) as well as the fleshing out of a Holocene sequence. Recent dating of a perched rockshelter in the Calvert Ranges, east of the Durba Hills, has provided a Holocene record filling in previous occupational gaps from the Calvert Ranges. The extrapolated basal date of the site is in the order of 12,000 BP. Assemblages from this site illustrate repeated occupation through the Holocene with a notable shift in raw materials procured for artefact production and their technology of manufacture in the last 1000 years. Engraved and pigment art is thought to span the length of occupation of the shelter. The site illustrates a significant increase in the discard of cultural materials during the last 800 years, a trend observed at other desert sites. Much of the pigment art in this shelter seems likely to date to this most recent period.

Introduction

In this paper we describe the dating of a cultural assemblage from Bush Turkey Rockshelter 3 in the Calvert Ranges (Kaalpi), Western Australia (Figures 1-2). The Calvert Ranges are located some 80km east of Well 15 on the Canning Stock Route, well within the linear dunefields of the Little Sandy Desert. This is the second rockshelter excavated and dated in these very remote ranges of the Western Desert (Veth *et al.* 2001). Bush Turkey Rockshelter 3 is significant in that it:

- extends the known occupation of the interior of the Little Sandy Desert back to the early Holocene;
- has several phases of lithic production illustrating changes in raw material use and implement types through the Holocene; and
- provides a dated occupation sequence that may be correlated to different phases of pigment and engraved art found both within and adjacent to the shelter (McDonald and Veth in press).

Eight dates were obtained from a test excavation which reached a maximum depth of 86cm below surface level (bsl). These dates, combined with evidence for recent Martu occupancy, reveal repeated occupations from 8202–8414 cal BP through to the contact period.

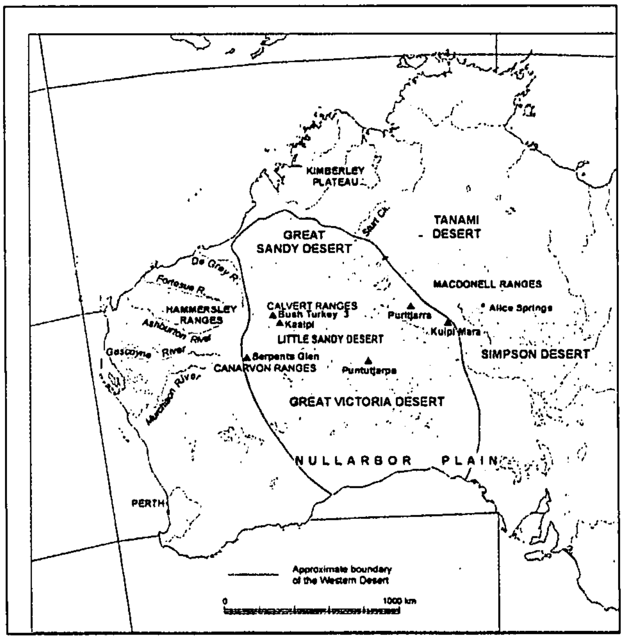

Figure 1 Location of Bush Turkey Rockshelter 3 at Kaalpi (Calvert Ranges), Little Sandy Desert, Western Australia.

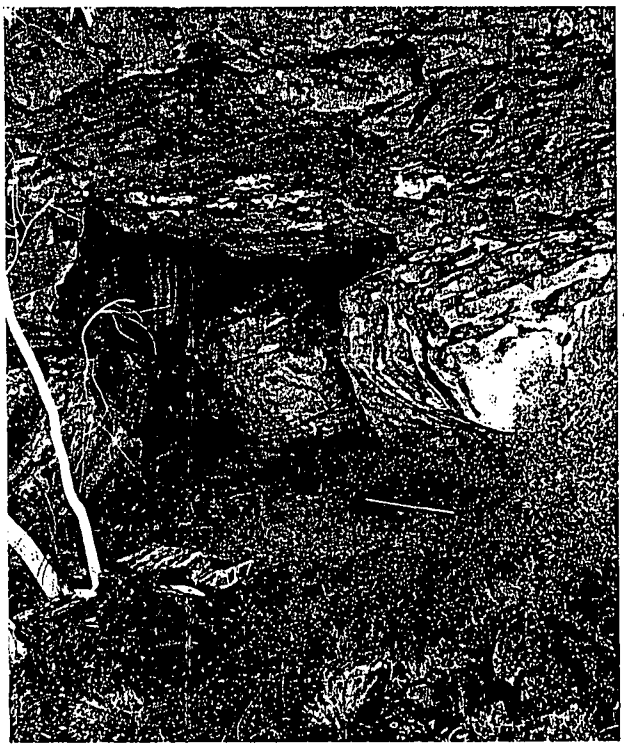

Figure 2 Bush Turkey Rockshelter 3 at completion of excavation. Engravings are found on the slabs to the left of frame. Pigment art covers the back wall and overhanging ceiling (Photograph: Peter Veth).

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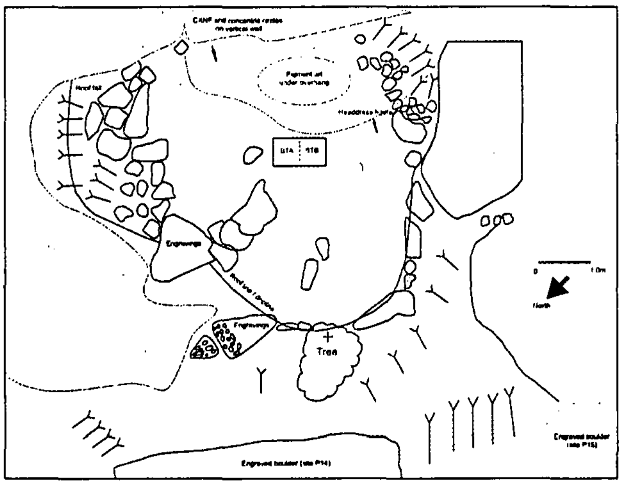

Figure 3 Plan of Bush Turkey Rockshelter 3, showing location of excavation and art panels.

The shelter contains sediments and a human occupation record from the early Holocene. Artefacts were recorded in spits adjacent to bedrock from below the lowest dated charcoal sample, meaning that this date is a minimum age for occupation of the Calvert Ranges and indeed the Little Sandy Desert.

Excavation Context and Method

The previous absence of mid-to-late Holocene sequences from shelters located within valleys of the Calvert Ranges may be due to the scouring out of their deposits during heavy and localised rain storms. While average annual precipitation for this area is low (<300mm), rain storms are significant and swollen creeks have etched into lower elevation shelters and their deposits. Bush Turkey Rockshelter 3 is a perched shelter and not subject to these geomorphic processes.

The shelter is 8m above and some 30m distant from a creekline to the west that had slow-flowing water in it from the Kaalpi spring at the time of excavation in July 2005. The mouth of the shelter faces west.

Excavation at the Bush Turkey Rockshelter 3 site involved two adjacent 50cm x 50cm test pits (BTA and BTB) (Figure 3). Both squares were initially excavated to a depth of c.50cm (spit 14) at which time the intrusion of roof fall made further excavation in BTA difficult. Excavation continued in square BTB (spits 15-24) as a column measuring 50cm x 30cm.

All excavated deposit was wet-sieved through 1mm mesh with initial sorting carried out in the field. Volumetric measurements were made by using spit depths and all non-cultural material larger than 5cm diameter was separately measured for volume and weight. Below the scuff zone, faunal and floral remains were negligible. At the time of excavation the deposit was quite moist due to recent rains; faults in the metamorphosed sandstone tend to seep waters for months after rainfall. The extreme wet and dry cycles in these range uplands would be highly aggressive to the preservation of macro-floral and faunal remains and charcoal.

Stratigraphy and Dating

Bedrock of the shelter is metamorphosed sandstone with pebble-sized quartzite clasts. Large roof fall boulders have entrapped sediments from several sources including via a chute in the northwest of the chamber, *in situ* weathering of the metamorphosed sandstone and aeolian sands. Four stratigraphic layers are identified (Figure 4):

Layer I – Compacted red-brown sediment with brown/grey laminae. At its surface, the scuff zone is loose red-brown and charcoal-rich with scats and macro-floral remains.

Layer II – Compacted red-brown-grey sediment with brown/grey laminae, same texture as Layer I, but with more ash.

Layer III – Fine red-brown sand with increasing roof fall/boulders.

Layer IV – Dark red indurated sand with increased proportion of grit and roof fall fragments.

Charcoal was present in variable amounts with little surviving below 50cm depth. The eight charcoal samples submitted for

Table 1 Radiocarbon dates for Bush Turkey Rockshelter 3. Conventional radiocarbon ages were calibrated using CALIB (v.5.0.2) (Stuiver and Reimer 1993; Stuiver *et al.* 2007) and the Southern Hemisphere calibration dataset (McCormac *et al.* 2004). Ranges marked with a '0*' are suspect owing to impingement on the end of the calibration dataset (Stuiver *et al.* 2007). NZA-codes are AMS dates.

Sample #	Layer	Spit	Description	Lab. No.	^{14}C Age (years BP)	Calibrated Age BP 2σ (probability)
1	I	2	In scuff zone	Wk-15271	197±34	0*-30 (9.5%) 58-121 (17.6%) 135-296 (73%)
2	I/II	8	Hearth at boundary	NZA-20627	386±39	320-491 (100%
3	II	5	Upper Layer II	NZA-20626	422±33	326-409 (37.5%) 436-505 (62.5%)
4	II	9	Middle of Layer II	NZA-20629	793±32	654-732 (100%)
5	III	14	5cm below boundary with Layer II	NZA-20630	3013±36	2985-3259 (100%)
6	III	16	Middle of Layer III	NZA-20631	2942±35	2880-2910 (4.6%) 2919-3161 (95.2%) 3194-3196 (0.2%)
7	III/IV	17	Boundary Layer III/IV	Wk-15277	3665±63	3720-4090 (99.4%) 4130-4138 (0.6%)
8	IV	20	Middle of Layer IV	NZA-20632	7584±44	8202-8265 (17.6) 8282-8414 (82.4%)

radiocarbon determination were mostly recovered during excavation *in situ* or from the south section (Table 1, Figure 4). The lowest sample (from spit 20, 65-70cm bsl) was collected from the sieves. Most samples weighed less than 10g and were thus dated by AMS.

Only one sample was recovered from Layer IV (in Spit 20). A further 16cm of deposit was recovered from beneath this spit (yielding nine artefacts). These deeper artefacts were deposited prior to the earliest radiocarbon date of 8202–8414 cal BP. The radiocarbon dates generally occur in correct chronostratigraphic order, with a minor inversion between the conventional ages of NZA-20630 and NZA-20631, although the calibrated ages overlap at two standard deviations. This reinforces the field observation that the deposits appeared to have a good level of integrity. There is no evidence for a disconformity between Layers III and IV. Sedimentation was more or less continuous and with increasing compaction with depth and age giving an extrapolated basal date for the site of c.12ka BP.

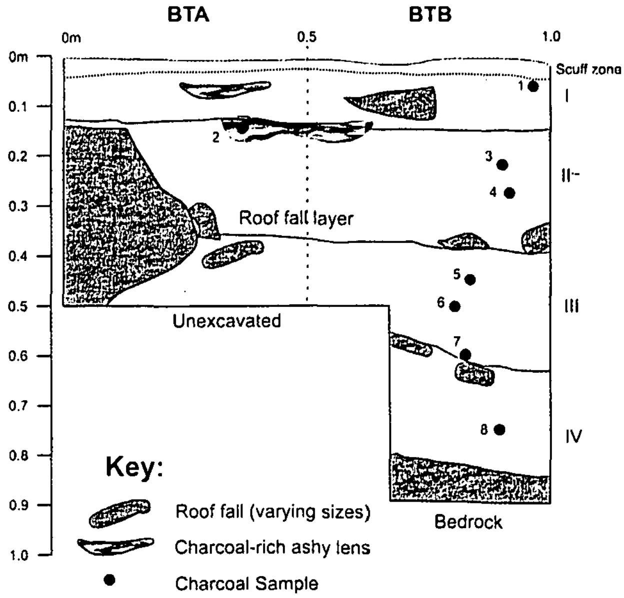

Figure 4 Bush Turkey Rockshelter 3, south sections, squares BTA and BTB, showing large intrusive boulder in BTA and column taken down to bedrock in BTB.

Analysis of Lithic Assemblage

The lithic analysis addressed the following issues:

1. Identification of artefacts. Some of the raw materials from which artefacts have been made occur naturally in the shelter walls. Identification of lithics as artefacts rather than naturally-fractured stone required special consideration. A total of 466 lithic pieces have been identified as artefacts.
2. Raw material use and technological strategies. A variety of stone material types have been used to manufacture artefacts and an analysis of technological variables can lead to the identification of different strategies relating to raw material use (e.g. conservation and rationing of non-local chalcedony and more expedient use of locally available quartzite pebbles; cf. Hayden 1977).
3. Changes in artefact assemblages over time. The use of different raw material types, especially chalcedony and quartzite, show change over time and this can be understood as change in technological strategies.

Artefact Identification

Stone artefacts were identified using technological criteria (Cotterell and Kamminga 1987; Holdaway and Stern 2004; Speth 1972). Many flakes have been broken, either during flaking or afterwards by trampling, burning in hearths or by natural weathering processes. Where lateral or distal portions have been broken the artefact is classified as a broken flake. Flakes broken longitudinally are classified as cone-split broken flakes. Sometimes only a fragment or piece of a flake was recovered (e.g. a distal or medial piece) and these are classified as flake fragments. As some of the raw material types used for artefact manufacture occur naturally in the shelter, fractured pieces without signs of flaking were not identified as artefacts, even though it is possible that some may be fragments of broken artefacts.

Conservation Strategies and General Comments on Artefact Use

Substantial research has been carried out on the behavioural aspects of stone artefact production, particularly in relation to settlement organisation and mobility (cf. Andrefsky 1998; Hiscock 1988). Mobility is a particularly important consideration when studying stone artefacts left by people who frequently changed their place of residence, and who regularly moved from residential sites into surrounding foraging areas. Such groups would only carry limited equipment with them, especially if they also had to carry small children, food and other resources. People clearly developed strategies – often referred to as conservation or rationing strategies – for dealing with the constraints posed by mobility. Such strategies include light-weight and multifunctional tools (Hayden 1977; Hook 1999; Mulvaney 1975:73), use of locally available stone (Byrne 1980; McNiven 1993), heat-treatment (Lurie 1989) and transportation of high quality stone with predictable flaking qualities (Morwood and L'Oste-Brown 1995). Available stone supplies may have been conserved by discarding cores and tools less often. Groups could make more tools than usual from available supplies, by fashioning smaller tools (Morwood and L'Oste-Brown 1995). These strategies could result in fewer artefacts, lower densities of artefacts on archaeological sites and smaller artefacts. More artefacts which might otherwise have been discarded as debitage could have been used as tools; so the ratio of tools to debitage might be high. People could have extended use-life via greater core rotation, flaking cores to exhaustion, or by adopting bipolar flaking at the final stages of core reduction (cf. Summerhayes and Allen 1993).

The practical limitations of transporting stone are clear from some of the arid zone literature. Sharp blades were difficult to carry as the edges could easily be dulled. Blades were wrapped in bark, and paper-bark pouches were carried under the arms or in string belts or string bags (Binford and O'Connell 1989; Jones and White 1988; Paton 1994). Flake tools and/or women's knives were sometimes carried by women in their hair (Binford 1989:164). Large choppers were not usually transported (Gould 1977:164). Large grinding stones were particularly inefficient to carry long distances (Hamilton 1987), although exceptions to this have been noted.

Gould (1977:163) notes that stone materials were obtained from either specific quarries where usable stone was known and used repeatedly, or from non-quarried stone which was obtained from the surface at or near where it was needed for a particular task:

> [M]uch more quarried than non-quarried raw material appears in habitation campsites, despite the fact that quarried stone represents only a minute fraction of stone used in the total cultural system. The only exception to this is when surface scatters of stone are found occurring naturally near the campsite [such as is found on the sand plain outside Bush Turkey Rockshelter 3] ... Adze flakes and adze slugs tend to be common in habitation sites, where they are most often manufactured, used, maintained, and replaced. Along with these one may also expect to find some hand-held flake scrapers and spokeshaves ... 'Chopper-planes' are left where they were used and can generally be found lying near the base of any mulga tree which shows a scar on its trunk to indicate removal of a slab of wood ... Flake knives are also left where they were used, most often in close proximity to earth ovens, where they were used in butchering and dividing meat after a successful hunt (Gould 1977:166).

The utility of the quarry/non-quarry dichotomy has been tested with data from the Pilbara (Veth 1982) and found to be a useful explanatory approach when considering lithic procurement, reduction and discard strategies. Other archaeologists have reported variations on this general distinction between quarried and local stone. Binford and O'Connell (1989:144) also note that stone from quarries was transported to habitation sites and could also be used in an expedient fashion for making tools for immediate tasks.

Raw Material Use at Bush Turkey Rockshelter 3

Analysis of the Bush Turkey Rockshelter 3 artefact assemblage indicates that several raw material types were used – chalcedony and quartzite being dominant (37% and 36% respectively). Around 12% of artefacts have been made from silcrete and 8% from quartz. Five minor lithic categories contribute the remaining 10%.

Quartzite is available at and near the site as both pebble-sized inclusions in the shelter walls and in the creek bed. A source for the chalcedony is not known locally although large outcrops are known from the Canning Stock Route some 80–100km to the north and west (Veth 1993). Strong difference between the uses of these raw materials is found at this site.

The assemblage includes a broken quartzite cobble which appears to have been used as a combination anvil and hammer stone (Table 2). A small fragment of a grindstone (in an unidentified material) has grinding on one surface. A tula adze slug and three other retouched artefacts of chalcedony (including one cuspate retouched tool) were recovered. There were no chalcedony cores. Conversely, bipolar cores and debitage in both quartzite and quartz were recovered.

While chalcedony dominates the assemblage by count, most of these artefacts are small: all but four are <20mm-long. The chalcedony artefacts combined weigh less than 30g, with a very low mean weight (<0.2g/artefact). In contrast, artefacts made from quartzite, silcrete and quartz vary more widely in size and have much higher average weights (≥2g/artefact). This stark difference in the size of chalcedony artefacts compared to those of quartzite, silcrete and quartz points to a marked difference in the strategy of reducing chalcedony. This is consistent with its prized isotropic qualities and endurance for hardwood processing tasks and the assumed distance of its supply zone.

Chalcedony and silcrete artefacts at this site seldom retain cortex. In contrast, almost one-third of the quartzite artefacts and nearly half of the quartz artefacts have cortex (Table S1, supplementary information). The dorsal faces of some of the quartzite artefacts are entirely covered with cortical and weathered surfaces and it is likely that some were struck from locally weathered pebbles. Conversely, it appears that cortex was removed from most of the chalcedony and silcrete artefacts off-site. This pattern is consistent with the assumed local and 'exotic' provenience of these raw materials.

It is also likely that variation in the flaking quality of different stone materials has contributed to different transportation and reduction strategies. Most (86%) chalcedony artefacts are of high quality isotropic stone, as are over half of the silcrete artefacts (61%). Conversely only a small proportion of the quartz (14%) and quartzite (7%) artefacts are of unflawed stone (Table S2, supplementary information).

Chalcedony artefacts are generally very small, mostly of high quality and largely without cortex: a typical assemblage for a well-reduced transported stone, prepared off-site and already well-utilised before discard at this site. The tula adze slug and small chalcedony cuspate retouched flake (both <5g) are a predictable aspect of this strategy (Hiscock and Veth 1991).

Silcrete artefacts, while slightly less common, are often made on high quality stone. These are generally larger in size than chalcedony and often lack cortex. Silcrete artefacts were probably also prepared before transport to the site.

Quartzite is almost as common as chalcedony. It is of poorer isotropic quality and often retains cortex. Most quartzite bipolar cores have cortex and can be identified as flaked pebbles or pebble pieces (Table 3). It is likely that quartzite, possibly also quartz, were local adjuncts to higher quality imported stone. Bipolar flaking of quartz and quartzite was part of the repertoire for exploiting local pebbles.

A total of 14 (mostly quartzite) bipolar cores were recovered, of which 12 were unbroken. Ten of these unbroken cores have a striking axis of between 18mm and 26mm. Only two unbroken cores have shorter lengths (Table 3). While the bipolar cores vary considerably in weight (from c.20g to <2g) there may have been a threshold beyond which the size of most flakes struck from these cores were not considered useful.

Platforms on flakes and broken flakes are predominantly plain (Table 4). Focal, crushed or partly crushed specimens are also present in high proportions. Platforms on chalcedony flakes and broken flakes are predominantly plain (42%) – as is the platform on the tula adze slug. These plain platforms, along with the few cortical and ridged platforms, probably resulted from unifacial (unidirectional) flaking. Also present are many small focal platforms, probably resulting from attempts to detach small flakes in the conservation of this prized material.

A number of chalcedony flakes and broken flakes also have crushed or partly crushed platforms, indicating that some platforms were too small to support force applications. No chalcedony bipolar artefacts were identified in the assemblage, and nor were any chalcedony cores.

Table 2 Bush Turkey Rockshelter 3: Raw materials and artefact types. FGS = Fine-grained siliceous.

Material	Anvil/Hammer	Ground Fragment	Tula Slug	Retouch/Use-Wear	Possible Use-Wear	Core	Bipolar Core	Bipolar Debitage	Debitage	Total	Total Weight (g)	Mean Weight (g)
Chalcedony	0	0	1	3	0	0	0	0	168	172	26.5	0.15
Quartzite	1	0	0	1	1	0	7	9	147	166	474.6	2.86
Silcrete	0	0	0	1	1	0	0	0	52	54	106.7	1.98
Quartz	0	0	0	1	1	0	5	1	29	37	94.2	2.55
FGS	0	0	0	0	0	0	0	0	11	11	5.4	0.49
Chert	0	0	0	0	0	1	2	0	7	10	35.4	3.54
Sandstone	0	0	0	0	0	0	0	0	4	4	3.6	0.90
Silicified Wood	0	0	0	0	0	0	0	0	1	1	2.6	2.60
Unidentified	0	1	0	1	0	0	0	0	9	11	219.4	19.95
Total	**1**	**1**	**1**	**7**	**3**	**1**	**14**	**10**	**428**	**466**	**968.4**	**2.08**

Table 3 Bush Turkey Rockshelter 3: Bipolar cores.

Spit	Material	Quality	Size (mm)	Weight (g)	Body	Cortex	Comments
8	Chert	Medium-high	21-25	6.7	Indeterminate	<30%	Striking axis = 18mm
8	Chert	High	21-25	5.2	Pebble	31-69%	Striking axis = 23mm
9	Quartzite	Poor-medium	26-30	9.3	Pebble frag.	31-69%	Striking axis = 20mm
9	Quartzite	Medium	21-25	6.8	Pebble frag.	31-69%	Striking axis = 19mm
9	Quartzite	Medium	21-25	4.8	Pebble frag.	31-69%	Striking axis = 21mm
9	Quartz	Poor-medium	26-30	7.9	Indeterminate	<30%	Broken. Heavy battering along ridge
10	Quartzite	Poor-medium	31-35	19.8	Indeterminate	<30%	Blocky core with bipolar flaking. Striking axis = 26mm
10	Quartz	Medium-high	31-35	14.2	Pebble	31-69%	Striking axis = 26mm
10	Quartz	Medium-high	26-30	4.1	Indeterminate	0	Broken. Striking axis = 27mm
11	Quartzite	Medium-high	21-25	7.5	Pebble	>70%	Striking axis = 23mm
11	Quartzite	Medium-high	21-25	3.0	Indeterminate	<30%	Striking axis = 22mm
11	Quartzite	Medium-high	16-20	2.0	Indeterminate	<30%	Striking axis = 13mm
11	Quartz	Poor-medium	25-30	7.3	Pebble	>70%	Striking axis = 24mm
20	Quartz	Medium-high	16-20	1.4	Indeterminate	31-69%	Striking axis = 14mm

Table 4 Bush Turkey Rockshelter 3: Platforms on flakes and broken flakes >5mm in size. * Three quartzite bipolar platforms have been flaked directly from cortical surfaces. Ind.=Indeterminate.

Material	Cortex	Plain	Ridged	Scars	Focal	Bipolar	Crushed & Partly Crushed	Total	Ind.
Chalcedony									
Debitage	5	40	3	0	32	0	15	95	1
Tula adze	0	1	0	0	0	0	0	1	0
Retouched Flake	0	0	1	0	0	0	0	1	0
Quartzite	5	16	2	2	3	4+3*	16	51	0
Silcrete	0	10	1	1	2	0	8	22	1
Quartz	0	2	0	0	1	1	1	5	0
Others	0	6	1	0	1	0	4	12	2
Total	**10**	**75**	**8**	**3**	**39**	**8**	**44**	**187**	**4**

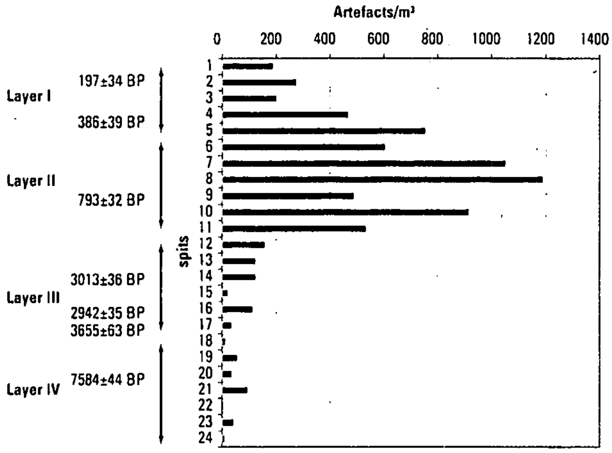

Figure 5 Bush Turkey Rockshelter 3: Vertical distribution of artefacts.

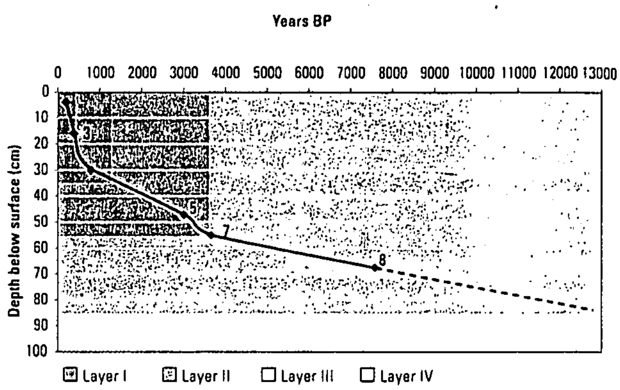

Figure 6 Bush Turkey Rockshelter 3: Age-depth curve. Samples 2 and 6 are omitted from this graph. Conventional ages for the samples are used.

The quartzite platform sample is small but plain platforms and crushed/partly crushed platforms are most frequent. Unifacial flaking was an important flaking technique along with bipolar flaking. Some of the crushed platforms may have resulted from this latter technique. Two quartzite flakes have scarred platforms which indicate that they may have been struck from bifacial cores.

The small sample of silcrete platforms shows they are mostly plain and crushed. As with the chalcedony, silcrete appears to have been flaked unifacially, with some attempt to conserve the material. The sample of platforms for other raw material types is too small for meaningful comment.

Technological Strategies

The assemblage from Bush Turkey Rockshelter 3 demonstrates two different technological strategies. These are temporally discrete (see below). One of these has been used for chalcedony (and to a lesser extent silcrete) while the other has been used on quartzite.

Conservation strategies were in place for the high quality chalcedony assemblage. Special long-life tools (Gould 1977, 1980; O'Connell 1977; Veth 1993) such as the tula adze and a cuspate retouched flake were made from this material. A low cortex incidence indicates extensive previous flaking. Small artefact size and detached flakes with small platforms indicate extensive knapping and restricted discard. The absence of cores from the assemblage suggests the removal of (already small) chalcedony cores for further use elsewhere.

Non-artefactual quartzite pebbles and weathered pieces are common in the deposit and the largest of these weighs c.80g. The quartzite artefact assemblage shows expedient use of this locally available material, which flakes less predictably than other stone materials and was not used for long use-life implements. Overall, larger artefact sizes indicate less intensive reduction. Cortical rates in local raw materials are higher than in imports indicating less preparation of the stone before transport to the shelter. There is evidence for primary flaking of weathered pebbles. Both unifacial and bipolar flaking have been employed. Bipolar flaking was probably used here as a practical technique for reducing round pebbles into cores. Most bipolar cores were discarded when their striking axes were >20mm-long and they weighed >5g. The bipolar cores in this assemblage indicate that viable raw materials were discarded here rather than being removed for use elsewhere.

Chronological Change in Technological Strategies

The sample of artefacts decreases with depth (Figure 5, Table S3, supplementary information). Artefact numbers are highest between spits 4 and 11; but the volume of excavated deposit per spit diminished significantly below spit 15.

The site appears to have been occupied most intensively between c.400–1200 BP (i.e. spits 6–11). Occupation of the site just prior to contact seems to be lower than the peak period, while before c.1200 BP occupation was sporadic (Figure 5).

A rate of artefact discard per 100 years has been calculated using the depth age curve (Table 5, Figure 6). These data suggest that the highest artefact discard rate occurred in the last 1000 years and that artefact discard rates before this time, certainly pre-3600 BP, were extremely low.

Are these variations in artefact deposition rates related to changes in technology? Debitage was found throughout the deposit except in spit 22 (Table 6). Retouched and bipolar artefacts were recorded in spits 7–11 (Layer II) and in spits 19–23 (Layer IV). Retouched/utilised artefacts represent only a minor component of the overall assemblage: a combination anvil-hammer was recovered from spit 19; the tula adze slug was recovered from spit 6; the ground fragment from spit 2.

Layers I and II represent the last 1200 years of occupation and appear to be part of a single technological phase (Table 6). Layers III and IV have been combined to create a more viable artefact sample for these discussions, despite the obvious long timeframe, because of similarities in stratigraphy and assemblage characteristics.

The vertical distribution of artefacts of different raw material types (Tables 6-7) indicates change over time in raw material use. Chalcedony is dominant in Layers I and II (51%), while locally available quartzite is prevalent in Layers III and IV (62%). Technological analysis of these two raw material types indicates different reduction strategies for chalcedony and quartzite. Change over time in the use of these two raw material types may have resulted from shifts in exchange networks, changing residential mobility and more logistical provisioning linked with the use of changing technological strategies.

Table 5 Bush Turkey Rockshelter 3: Calculated artefacts per 100 years based on the age-depth curve and calculated volume of artefacts retrieved from each layer. NB: Layer IV may have taken even longer to accumulate.

Layer	Total Artefacts	Years Accumulated	Years	Artefacts/100 years
I	109	170-400 BP	270	18.8
II	306	400-1200 BP	800	47.8
III	33	1200-3600 BP	2400	5.9
IV	18	3600-12000 BP	8400	2.9

Table 6 Bush Turkey Rockshelter 3: Summary distribution of artefact types.

Layer	Spits	Anvil/Hammer		Ground Fragment		Tula Slug		Retouched/Use-Wear		Possible Use-Wear		Core		Bipolar Core		Bipolar Debitage		Debitage	
		#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%
I	1-5	0	0	1	0.9	0	0	0	0	0	0	0	0	0	0	0	0	108	99.1
II	6-11	0	0	0	0	1	0.3	6	1.9	2	0.7	1	0.3	13	4.2	7	2.3	276	90.2
III	12-17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	33	100
IV	18-24	1	5.6	0	0	0	0	1	5.6	1	5.6	0	0	1	5.6	3	16.7	11	61.1

Table 7 Bush Turkey Rockshelter 3: Summary distribution of raw materials.

Layer	Spits	Chalcedony	Quartzite	Silcrete	Quartz	Others	Total
I	1-5	51	35	8	6	9	109
II	6-11	116	99	38	26	27	306
III	12-17	2	21	6	3	1	33
IV	18-24	3	11	2	2	0	18

Table 8 Bush Turkey Rockshelter 3: Artefact weight (g) by layer.

Layer	Spits	0.0-0.5	0.6-1.0	1.1-1.5	1.6-2.0	2.1-2.5	2.6-3.0	3.0-3.5	3.6-4.0	4.1-4.5	4.6-5.0	5.1-5.5	5.6-6.0	6.1-6.5	6.6-7.0	Total No.	Total Weight	Mean Weight
I	1-5	5	67	29	6	2	0	0	0	0	0	0	0	0	0	109	15.7	0.1
II	6-11	7	112	80	41	26	22	7	5	2	1	2	0	0	1	306	674.3	2.2
III	12-17	0	2	10	11	3	2	3	0	0	0	1	1	0	0	33	109.9	3.3
IV	18-24	0	1	4	5	2	2	0	2	0	1	0	0	1	0	18	168.5	9.4

Table 9 Bush Turkey Rockshelter 3: Proportion of artefacts with cortex.

Layer	Spits	0%	<30%	40-60%	>70%	Total	% Artefacts with Cortex
I	1-5	103	3	1	2	109	5.5
II	6-11	237	30	18	21	306	22.5
III	12-17	24	2	3	4	33	27.3
IV	18-24	10	3	1	4	18	44.4

Table 10 Bush Turkey Rockshelter 3: Flaking quality.

Layer	Spits	Poor	Poor-Medium	Medium	Medium-Good	Good	Poor-Good	Total	N/A	% Good Quality
I	1-5	1	5	15	28	57	1	107	2	53.3
II	6-11	8	27	51	72	142	5	305	1	46.6
III	12-17	0	8	12	10	3	0	33	0	9.1
IV	18-24	0	2	3	9	3	0	17	1	17.6

Change over time in artefact size is also indicated. In Layer I, all artefacts are <25mm in size and have a very low average weight (Table 8). While artefact size in these upper spits may be influenced by the small size of chalcedony artefacts, artefacts of other raw material types are also relatively small in these spits.

In Layer II the modal artefact size is larger (11–15mm) than in Layer I, and almost the full range of size categories are represented by this larger sample of artefacts. Average artefact weight is significantly greater than in Layer I (2.2g/artefact). In Layers III and IV there are very few artefacts <10mm in size. Modal size increases to 11–20mm, and average artefact weight exceeds 3g/artefact in Layer III and 9g/artefact in Layer IV. The larger number of small artefacts in the upper layers indicates more intensive flaking of lithic materials in the past 800 years or so.

The proportion of artefacts with cortex is lowest in Layer I in all raw material types (Table 9). In both Layers II and III slightly less than a third of all artefacts have cortex. Here, the higher numbers of artefacts with cortex correlate with the increased use of local quartzite pebbles.

Analysis of the flaking quality of artefact stone indicates a greater reliance on high quality stone in Layers I and II, while local materials which dominate the earlier two layers, generally have a lower flaking quality (Table 10).

The vertical distribution of artefact types (Table 6) illustrates increased use of bipolar reduction below spit 12 with greater reliance on plain and focal platforms in the upper layers (Tables 11-12). Plain platforms possibly relate to tula technology and the production of flakes with wide broad platforms.

Summary of Assemblage Characterisation

On the assumptions that the chalcedony recovered from Bush Turkey Rockshelter 3 was procured from a distant quarry source (such as Kaalpa at Well 23 on the Canning Stock Route) and that quartzite is an abundant local stone found within the shelter wall and the local creek, then the observed shift through time in raw material use and reduction strategies suggests changes in the way the site was occupied though time. Occupation from the early Holocene to just before the last millennium reflects longer duration occupations and lower mobility at Bush Turkey Rockshelter 3 and the Calvert Ranges, during which time local stone was used predominantly for a range of tasks. Within the last millennium, site usage changed exhibiting a greater proportion of exotic lithics and increased reduction of all raw material classes. During this time quarried stone was procured elsewhere, curated, rejuvenated and then discarded here in much greater proportions. A chalcedony tula adze slug and an arenaceous grindstone fragment were discarded during this more recent time period. The presumed strategic importance of the Calvert Ranges as an aggregation centre with reliable water might explain this increase in the proportion of exotics, higher discard rates and increased reduction of all lithics. A shift from an embedded to a logistical procurement strategy is suggested as is the greater frequency of occupation visits (of shorter duration) especially during the last millennia (cf. Holdaway and Stern 2004; Sellet *et al.* 2006). The later signal suggests an increased use of the ranges as an aggregation locale (*sensu* Conkey 1980), with various groups of people coming from afar for a range of domestic and ceremonial activities and focusing on this landscape more intensively. This pattern is supported by the Calvert Ranges rock art which reveals increasing complexity in its most recent art phases. While our rock art analyses are still only preliminary, both the occupation and art evidence supports increasing and repeated use of the dunefields and the resource-rich ranges in the recent past (see McDonald *et al.* 2008; Veth 1995).

The Rock Art

On bedrock at the front of the shelter and on large boulders outside the shelter (site P14) a series of Panaramitee-style (*sensu* Maynard 1977) and more recent figurative engravings are present. These are mostly heavily weathered and patinated engravings of tracks, circles, complex non-figurative and geometric motifs as well as figurative motifs such as life-size bush turkeys and a human. These clearly post-date the shelter's formation through roof collapse, but pre-date the smaller roof fall event(s) documented in the excavation. On its back wall and ceiling are c.100 motifs, mostly monochrome (87%) and bichrome (11%) paintings. There is also one red hand print. The pigment assemblage comprises several phases of production and includes anthropomorphs, concentric circles and other geometric motifs (Table 13). A single faded red and white anthropomorph with distinctive headdress is painted in isolation high on the wall at the north of the shelter. The pigment art includes black (charcoal), red, white, orange and pink coloured ochres: white and red are the most common (Table 14).

Table 11 Bush Turkey Rockshelter 3: Type of platforms on flakes and broken flakes.

Layer	Spits	Cortex	Plain	Ridged	Scars	Focal	Bipolar	Crushed & Partly Crushed	Total	Indeterminate
I	1-5	2	24	4	0	17	0	6	53	1
II	6-11	8	48	2	3	21	6	30	118	2
III	12-17	0	3	1	0	1	0	4	9	0
IV	18-24	0	0	1	0	0	2	5	8	1

Table 12 Bush Turkey Rockshelter 3: Type of platforms on flakes and broken flakes (% frequency).

Layer	Spits	Cortex	Plain	Ridged	Scars	Focal	Bipolar	Crushed & Partly Crushed	Total
I	1-5	3.8	45.3	7.5	0	32.1	0	11.3	53
II	6-11	6.8	40.7	1.7	2.5	17.8	5.1	25.4	118
III/IV	12-24	0	17.6	11.8	0	5.9	11.8	52.9	17

A superimposition sequence has been identified in this pigment art assemblage which starts with a fine (brush-painted) cherry-red set of motifs (including phytomorphs and complex pole designs and concludes with an assemblage of thickly painted (finger application) motifs in orange and white of anthropomorphs, lizards, tracks and concentric circles (Table 15). Not all art components within the shelter occur in superimposition relationships, meaning that these cannot be placed in this relative sequence. A bichrome headdress figure, located in isolation high on the shelter's back wall is one such example. Its style and general condition (and superimpositions noted elsewhere in the Calvert Ranges) suggest that this could be amongst some of the older art in the pigment assemblage (but possibly not as old as the defined Phase I which has been painted with a fine brush/twig).

Intuitively we would propose that the majority of the pigment art's production (Art Phases 2–4 in Table 15) correlates with the major phase of shelter occupation (i.e. within the last millennium). The oldest pigment art is relatively sparse and much more weathered. It seems reasonable to suggest that this art pre-dates the site's main occupation period, and could be correlated with either the early or late Holocene occupation of the site. The engravings could have been produced at any time in the shelter's occupation: unfortunately, no engraved art is directly or indirectly dateable in this site. Samples from several of the site's red motifs have been collected (McDonald and Veth 2006a) but dating results for these motifs are not yet available. The dating techniques being employed are reported elsewhere (McDonald and Veth in press; McDonald *et al.* 2008).

Table 13 Bush Turkey Rockshelter 3: Motif and technique information.

Motif	Monochrome	Bichrome	Print	Engraved	Total
Abraded Grooves	0	0	0	1	1
Bird Track	1	0	0	1	2
Complex-Non-Figurative	0	2	0	1	3
Scats	0	0	0	1	1
Oval	2	0	0	2	4
Anthropomorph	8	0	0	0	8
Arc	1	0	0	0	1
Barred Circle	1	0	0	0	1
Barred Oval	2	0	0	0	2
Circle	1	0	0	0	1
Concentric Circle	5	0	0	0	5
Fern	0	1	0	0	1
Hand	0	0	1	0	1
Headdress Figure	0	1	0	0	1
Lizard	1	0	0	0	1
Lizard Man	1	0	0	0	1
Phytomorph	1	0	0	0	1
Macropod Track Trail	1	0	0	0	1
Snake	1	0	0	0	1
Simple-Non-Figurative	5	1	0	0	6
Solid Unidentified	7	0	0	1	8
Unidentified Line	3	0	0	50	53
% Pigment Assemblage	87.2	10.6	2.1	0	100
Total	**41**	**5**	**1**	**57**	**104**

Table 14 Bush Turkey Rockshelter 3: Proportions of different coloured pigments used in the pigment art assemblage (note, the site's other motifs are engraved).

	Black	Orange	Pink	Red	Red/White	White	Total
Motifs	3	6	7	12	5	14	47
%	6.4	12.8	14.9	25.5	10.6	29.8	100

Table 15 Bush Turkey Rockshelter 3: Superimposition sequence for pigment art.

Phase	Technique	Motifs
1 (Oldest)	Fine cherry-red painted (brush) outline and infill (including geometric infill)	Phytomorph, complex pole design, concentric circles
2	White (and pink) painted outline	Anthropomorph, simple-non-figurative
3	Black washy painted outline	Simple-non-figurative, circle
4 (Most recent)	Orange and red thick painted outline (finger)	Anthropomorph, lizard man, bird track, concentric circle

Discussion and Conclusions

Research Problems in the Sandy Deserts

The initial occupation of the Western Desert has been placed at c.24,000 BP at Serpents Glen (Katjarra) in the Carnarvon Ranges to the southwest of the Calvert Ranges (O'Connor *et al.* 1998; Veth 2000, 2005; Veth *et al.* 2000). Serpents Glen is located on the margin of the Little Sandy Desert dunefields and contains a major multiphase painted art corpus. There were no cultural materials registered at Serpents Glen for most of the duration of the Last Glacial Maximum (after Lambeck and Chappell 2001). Reoccupation occurred during the mid-Holocene with low discard rates until the last several hundred years, when occupational intensity increased significantly: nearly 97% of the artefacts deposited at Serpents Glen date to the last several hundred years. A similar pattern of intensive occupation with higher implement diversity was noted at Kaalpi Rockshelter (Veth *et al.* 2001).

Kaalpi Rockshelter is located in a major valley southeast of Bush Turkey Rockshelter 3. This site registered a significant increase in its discard rates of flaked and ground artefacts during the last millennium and a shift towards 'formal' wet-milling grindstones made in arenaceous sandstone from an earlier assemblage of amorphous basal grindstones fashioned from quartzite (Veth *et al.* 2001). At this time there was also an increase in ochre fragments. This pattern is essentially the same as found in another seven shelters excavated in the wider region including the Rudall River, Mackay Range and the Durba Hills in the Little Sandy Desert (Veth 1993). Significantly, Bush Turkey Rockshelter 3 fills a chronological 'gap' by providing well-dated cultural materials spanning the Holocene while reinforcing the wider trend of an increase in the discard rates of artefacts and sedimentation during the last millennium.

In a recent paper on the artefact assemblages from Puritjarra Rockshelter, at the eastern margin of the Western Desert, Smith (2006:406) makes two conclusions regarding changes occurring there during the last 800 years. He identifies a major increase in the use of the rockshelter with increased artefact discard rates, more features and ochre, more formal grindstones, and the highest indices for the diversity and richness of tools. This is interpreted as the archaeological expression of Puritjarra becoming a core residential site linked to improved summer rainfall between 1000 to 1500 years ago. During this period Smith posits that there was a dual pattern of occupation with frequent cycling of people through the site intercalated with extended periods of occupation at the site.

A switch in provisioning strategies, from embedded procurement (for both stone and ochre) to a logistical pattern of direct procurement is also suggested as use of the shelter intensified (Binford 1989; Holdaway and Stern 2004; Smith 2006:404; Veth 1993). Smith favours an explanation whereby a 'dual' system of occupation occurs during the emic cycle: with core habitation sites being the focus of more extended occupation as well as being frequently visited outside of these 'aggregation' events (Veth 1993). By calculating rank order scores for residential mobility at the Puritjarra sequence, Smith (2006: Table 19) illustrates a steady decrease in mobility in the last 800 years. While we believe a similar dual system operated in the Calvert Ranges, a combination of increased exotics, their heavy reduction and increased discard rates argue for an increase in mobility and likely more frequent site visits.

The Contribution of Bush Turkey Rockshelter 3

Our recent excavation of Bush Turkey Rockshelter 3 has filled a major gap by establishing a record of early Holocene occupation in the Little Sandy Desert and resolving a long debate about the antiquity of occupation in this region. As well as demonstrating occupation at 8202–8414 cal BP, the major occupation phase here is older than the main phase at Katjarra (98% of the artefacts at Bush Turkey Rockshelter 3 were deposited in the last 1200 years but only 24% were deposited in the last 500 years or so). It has also refined and extended the sequence found earlier at the Kaalpi Rockshelter located around 5km south in a separate valley of the Calvert Ranges (Veth *et al.* 2001).

Bush Turkey Rockshelter 3 has two distinct phases of lithic production which illustrate changing raw material use and technological organisation through time. Changes in residential mobility patterns and the nature of site occupation are predicted to correlate with different phases of pigment art production.

We propose that from c.8400–1200 cal BP (effectively Layers III and IV) this rockshelter was used for longer periods of time by small groups exploiting an extensive territory. The majority of stone used throughout this time is local quartzite. There is no evidence for core exhaustion or intensive stone curation/rejuvenation. Non-local materials such as chalcedony are present but only in very low proportions. In Layer II, post-dating 1200 cal BP and peaking around 735 cal BP, there is evidence for curation and increased conservation strategies with an appreciable shift towards:

- predominant use of chalcedony and other non-local high quality raw materials;
- a significant decrease in mean size and weight of artefacts;
- a major decrease in the proportion of artefacts with cortex;
- a high proportion of plain and small focal platforms on chalcedony flakes;
- the presence of a hafted artefact; and
- a significant increase in artefact deposition rates.

These changes reinforce the findings made earlier at Kaalpi, where there was a notable influx in ochre and formal grindstones and mullers in the deposit after 1300 cal BP. Interestingly at that site, the artefact discard rate halved in the most recent millennium (Veth *et al.* 2001:13). We believe that these combined changes over time reflect shifts in exchange networks, increased artistic activity, increasing residential mobility patterns and more logistical provisioning of tool kits.

The nine sites excavated within and adjacent to the Little Sandy Desert over the last 20 years (Kaalpi Rockshelter, Calvert Range Rockshelter, Durba Hills Rockshelter, Karlamili Rockshelter, Yulpul Rockshelter, Jalpiyari Rockshelter, Winakurijuna Cave, Serpents Glen (Katjarra) Rockshelter and Katampul Rockshelter) display a broadly similar trend with a greater proportion of exotic lithics and increasing conservation strategies for all raw materials over time (cf. Smith 1989, 2006; Smith *et al.* 1997, 1998). This inter-regional pattern is best explained by:

- establishment of homelands and relative circumscription of territory (with a narrowing of ochre catchments and the development of regionally distinct graphic vocabularies in the pigment art);
- intensifying trade/exchange networks reflecting increasingly complex social relations (with ramified kinship systems underwriting reciprocity and exchange networks both as a social lubricant and a risk-minimising strategy);
- a shift from an embedded to a logistical pattern of direct procurement of stone and ochres (as estates and their resource zones became socially proscribed);
- higher residential mobility with lower duration of occupations;
- a dual system of land-use embracing frequent domestic visits by bands as well as aggregation events including multidialect meetings; and
- economising of lithics as these took on multivalent values (long use-life, multifunctionality, standardisation and sacred elements linked with the *Jukurrpa*).

Western Desert rock art provides evidence that the widely ramified open social networks functioning at contact, have changed through time (McDonald 2005). Arid art systems appear to have functioned to provide broad-scale intergroup cohesion over vast periods of time as well as demonstrating, more recently, distinctive group-identifying and bounding behaviour. We have argued elsewhere (McDonald and Veth 2006b) that the high degree of stylistic variability displayed in the Calvert Ranges art province strongly suggests that this place has acted as an aggregation locale over a considerable period of time.

At Bush Turkey Rockshelter 3 we have demonstrated a changing pattern of site use from the early Holocene through to a time just before contact. This reinforces the patterning found at Kaalpi, while showing a slightly different signature of lithic behaviour (i.e. only one ground fragment was retrieved from the top layer of Bush Turkey Rockshelter 3 compared with the c.50 grindstones found in Kaalpi; see Haley 1999). Interestingly the rock art assemblages in these two shelters also are widely dissimilar, while sharing broad stylistic traits. The Kaalpi Rockshelter contains a complex assemblage of 370 (mostly pigment) motifs (cf. Table 13). No doubt the two sites represent different nodes in a complex local occupation pattern. Both would appear to have represented residential bases, especially after c.1300 BP – although the intensity and nature of occupation in these two shelters in this time period varies. Our dating work on the Calvert Ranges art phases has involved the collection of samples from Kaalpi as well as Bush Turkey Rockshelter 3 (McDonald and Veth in press; McDonald *et al.* 2008). These rock art assemblages, with their complex graphic vocabularies in the recent past, add to this picture of increased dynamism.

The arid landscapes of the Western Desert provide a strong archaeological signature for intensifying social relations in the recent past. It is perhaps ironic that the strongest case for an archaeological expression of intensification (Lourandos 1985; Veth 2006) comes not from the fertile plains or tropical seascapes of eastern Australia, but rather Australia's arid zone, where effective social strategies for successful survival were crucial. The stone-working strategies and highly diverse graphic vocabularies in these isolated but resource-rich ranges continue to demonstrate the complexities of these strategies.

Supplementary Information

Supplementary information for this article is available online at www.australianarchaeologicalassociation.com.au.

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