Journal of the Australian Association of Consulting Archaeologists

Volume 2, 2014

AACAI

JAACA 2014 Volume 2

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Front cover: On-site sieving in the Chichester Range, Pilbara, Western Australia

ISSN 2202-7890

Editorial Comments and Advice

Editorial Comments and Advice will occasionally appear in JAACA to promote mentoring—an important objective of the journal.

The first instalment is from Peter White and outlines key steps in writing articles. Peter's contribution to archaeological writing is significant, with more than 30 years as Editor Archaeology in Oceania and a long list of books and articles, more than a couple of which are on this topic.

Thinking about writing: some basics

Peter White (University of Sydney)

The purpose of writing is to communicate, so start with:

1. What do I need to write? Is it the full report of excavation or surface collections, a summary of this, a series of recommendations, a report to a community or other stakeholders, an academic thesis, an article or something else? An answer to this will tell you what **needs** to go in and what should be **left out**.

When you have decided this, write a plan of what needs to go in. You don't have to stick to it, but a written plan is a useful reminder. In many cases the basic scientific structure of Aims, Background, Methods, Results, Conclusions will be the best.

2. Who is my audience? This is partly answered by your answer to the first question, but being clear in your mind about this also takes you to the next question, which is:

What language do I use? While KISS (Keep it simple, stupid) should always be your aim, there are different levels of simplicity. The language in which you **could** write your piece will be needed for one kind of written work and not another. Think about it.

3. Writing simply and clearly isn't easy. You will need to work at it. This means several iterations. Write it, put it away, read it again, re-write it. Do this a couple of times. Then get grandma/friend to read it. (Don't be offended by their comments!) Check back to your plan. Think about your language. No-one ever gets it right first time.

Check the following: Are you using the right words? Does each sentence say what you mean? Is the overall structure what you want? Re-write.

4. Figures, pictures, tables. These are all necessary parts of many written pieces. Rough these out while you write. But again KISS. What does each actually add to the overall effect? Do you **need** each one? Is each understandable? Decide, then ask grandma.

5. References. GET THEM RIGHT! Sloppy referencing implies the rest of the work may be dubious

Panting to read more?

White P 2014, 'Writing the Past' in *Archaeology in practice: a student guide to archaeological analysis*, 2nd edition, eds J Balme & A Paterson, Wiley Blackwell, Chichester, U.K., pp. 436-450.

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Time and efficiency in data recovery: an experiment comparing wet and dry sieving in Pilbara rockshelter excavations

CAROLINE BIRD, ADAM DIAS, FIONA HOOK, MONICA JIMENEZ-LOZANO & HELEN TIERNEY

Caroline Bird (Archae-aus; Department of Anthropology and Archaeology, Western Australian Museum, carolineb@archae-aus.com.au)

Adam Dias (Archae-aus)

Fiona Hook (Archae-aus; Department of Archaeology, University of Western Australia)

Monica Jimenez-Lozano (Archae-aus)

Helen Tierney (Archae-aus)

There has been considerable discussion in archaeology about the benefits of sieving in terms of recovery of particular classes of archaeological material. Less attention has been paid to questions of efficiency and cost effectiveness in the context of consulting archaeology. An experiment was conducted on excavated assemblages from inland Pilbara rockshelters comparing the results of wet and dry sieving in terms of time expended. The results suggest that the additional time spent in wet sieving can be largely offset by greater efficiency in recording and analysis. This, together with the undoubted benefit of improved recovery of archaeological material, confirms the value of wet sieving for reliably assessing sites.

Introduction

It is commonly understood by archaeologists that failure to sieve means significant quantities, and in some cases, whole classes of archaeological material will not be recovered. Use of different combinations of mesh sizes and wet and dry sieving will also recover different types of remains. This may introduce significant bias into archaeological assessments and interpretations. However, it is also recognised that using smaller sieve meshes, incorporating washing and flotation can introduce considerable costs and that there are archaeological contexts and situations where total sieving is impractical, or where the costs of recovering and processing the additional material cannot be justified in terms of information gained. In consulting archaeology, practice with respect to sieving is partly a commercial decision in which the recovery of adequate samples of archaeological material must be both cost effective and efficient. While differential recovery of archaeological material has been widely debated, and the effects of different methods are relatively well known, archaeologists seem to have paid little or no attention to questions of efficiency and effectiveness within a consulting context.

Background

It is difficult to generalise about use of sieves in archaeology because of the diversity of the discipline. Generally speaking, the archaeologist excavating large urban sites must be the most selective in use of sieving, while the Palaeolithic or Neolithic specialist will ideally sieve as much of the deposit as possible and will also use wet sieving and flotation (Renfrew and Bahn 1991:95). Aboriginal archaeological sites in Australia fall into the latter category as sieving only through a coarse mesh would mean missing

Article History: Received 12/12/2013, Accepted 7/3/2014, Published 2/4/2014

significant proportions of lithic and faunal assemblages (McNiven 2008:79). The decision how much to sieve and the method used is thus a matter for professional judgment and depends on the type of site, and the field situation. The issue is best considered as one of sampling (compare Orton 2000: 151, 163-166).

There is a large literature discussing the use of sieving to recover samples of organic material including the use of appropriate sieve mesh sizes, wet sieving, flotation and washing of samples. Key experimental studies in the 1960s and 1970s in the USA and the UK demonstrated that significant amounts of archaeological material were missed by using only relatively coarse mesh sizes, such as ¼" or 6 mm. They also showed that wet sieving and flotation meant that material such as seeds and other plant remains could be recovered (Orton 2000: 150). Standard practice in the USA has long been at least to sieve all deposits through a ¼" mesh (Joukowsky 1980: 165ff, Kipfer, quoted in McNiven 2008: 79, Thomas 1989: 215-217). In the UK the wide variation in site types means that practice is very diverse (Roskams 2001: 221-223). Taking bulk samples for extremely fine sieving is, however, normal practice (Campbell, Moffet and Straker 2011).

The necessity for sieving in the excavation of Aboriginal sites has been well understood by Australian archaeologists for decades. The issue was formally debated as early as 1969, when aspects of Richard Gould's preliminary excavations at Puntutjarpa were criticised, including the fact that he did not use sieves (Glover and Lampert 1969, Gould 1969). Glover and Lampert (1969: 223) noted that: "Even using ¼" or $^{3}/_{16}$" mesh sieves, which is a pretty well standard practice among archaeologists in Australia, some flakes will be missed." Sieving was standard practice at the Victoria Archaeological Survey by the 1970s (Coutts 1977:54-55), and all material was passed through nested sieves down to 3 mm with bulk sediment samples taken for processing by flotation in the field or retained for subsequent laboratory analysis (e.g. Coutts and Lorblanchet 1978: 6).

Johnson (1980) discussed excavation techniques in use in Australia at a 1978 conference. He presented an excavation recording system and methodology which has arguably become a de facto standard. In his discussion of sieving and flotation, he emphasised that

> .... a clear and explicit screening strategy is one of the most essential parts of any excavation. Crucial to such a strategy must be the specification of a minimum size above which collection of artefacts can be confidently stated as approaching 100%. Apart from a few exceptional sites, this can only be assured by wet sieving and sorting verified by a competent person. (Johnson 1980: 101)

Johnson recommended the use of 6 mm and 3 mm sieves for dry sieving, with retention of residues for wet sieving. He considered the use of the 3 mm sieve a 'reasonable compromise between collection efficiency and sorting speed' with the added proviso that this was the smallest residue that could be sorted reliably under field conditions. He also recommended bulk sampling for laboratory sorting using finer meshes, and this should certainly be done if larger mesh sizes were used in the field for any reason (1980: 102). Johnson's general recommendations have been widely followed, although there have been variations in practice depending on local conditions and circumstances. The most recent Australian field manual discusses sieving in general terms and notes that the decision about mesh size depends on the nature of the site and the questions to be answered (Burke and Smith 2004: 147). However, for most Aboriginal archaeological sites in Australia, using only a 6 mm sieve would mean

> ... considerable proportions of stone artefact and faunal assemblages would be missed. In Australia, most skilled practitioners would recommend that 2 to 3 mm should be considered the standard

> screen size, supplemented by 1 mm mesh sieves where required and samples of sediment that pass through the final sieve for each spit. (McNiven 2008: 79)

Complementing the considerable international literature on issues related to sieving and recovery of various classes of archaeological material, there are a number of discussions of the use of sieving and flotation in an Australian context. Most deal with enhanced recovery of organic material such as plant material (e.g. Hope 1983, McConnell and O'Connor 1999), animal bones (e.g. Williams 1999) and fish bones (e.g. Vale and Gargett 2002, Ross and Tomkins 2011). The topic has been particularly well studied with regard to excavation of shell middens where the large quantities of material recovered mean that sampling is mandatory (e.g. Bowdler 1983, 2006, Jenkins 2006). The recovery of small artefacts has received less systematic attention. However, the re-excavation of Nauwalabila 1 [Lindner Site] in Kakadu recovered more than four times the number of flaked stone artefacts recovered in the original excavation (Jones and Johnson 1985: 183). Both excavations used 3 mm sieves. The difference could be attributed to the use of wet sieving in the second excavation, supplemented by a larger trained team. McDonald's (1991) comparison of the 7 mm, 3 mm and 1 mm sieve fractions from two spits at Bone Cave in Tasmania also showed differences between the stone artefacts and faunal remains with, for example, some raw materials only represented in the 3 mm and 1 mm sieves.

While it is well recognised that sieving and flotation increase the representation of particular classes of archaeological material, the effect of observer error has generally not been investigated (Graesch 2009). Graesch (2009: 762) suggests a range of factors that might influence recovery of material in sieves, including experience and training of the fieldworker, weather conditions, lighting, fatigue and attributes of artefacts. Graesch compared the recovery of different classes of archaeological material in situ and on site sieving over two field seasons with laboratory sorting of dry sieve residues. All sediments excavated in the field were passed through 3.2 mm mesh (⅛"). Recovery rates varied considerably but the best achieved in the field was only just over 50% (Graesch 2009:766). Overall Graesch (2009: 775) concluded that 'single-episode (field only) screening resulted in the discovery of less than 25 percent of combined lithic and faunal artifacts, most of which were small enough to pass through 6.4 mm mesh'. When experience and training were taken into account, inexperienced teams averaged only 16.8% recovery, in contrast to experienced teams (with 64 hours or more of laboratory experience), who recovered on average 58.1%. Mixed teams had intermediate results (47.5%). Inexperienced teams also had the widest variability in results (5.8 to 33.2%), while the recovery rates of experienced teams ranged from 50.5 to 61.5%. As might be expected, laboratory sorting was also critical for recovering smaller objects and rare items. He concluded that 'full recovery or even a representative sample of artifacts cannot be assumed simply because deposits are screened in the field' (Graesch 2009: 776).

Use of sieves in Pilbara excavations

The vast majority of excavations in the Pilbara uplands have occurred in the context of development. There has been little or no academic research conducted although some material has been reviewed for theses or other academic publications (e.g. Brown 1987, Marwick 2002) and notable results from some excavations have been reported in archaeological journals. These are generally preliminary reports and rarely present comprehensive analyses (e.g. Maynard 1980, Veitch et al. 2005, Edwards and Murphy 2003, Slack et al. 2009, Law et al. 2010, Hughes et al. 2011). Evaluating the effectiveness of various sieving and sampling regimes is particularly important in this context. The use of particular strategies is a commercial decision which directly impacts the quality of advice given to clients.

Mesa J – excavation of J24 and other sites – 1991-1992	"In an 18km^2 area of Mesa J, 33 rockshelter archaeological sites were recorded along the mesa scarp. Test excavations were carried out in all shelters which had the following characteristics: a thickness of deposit >100mm when probed with a thin steel peg; sufficient roof height to have allowed previous occupation; and most of the deposit unaffected by water scouring. In total 20 rockshelters met these criteria and were test-excavated (0.25m^2) and the material sieved through 5 mm and 2 mm screens. No artefacts were recovered from the excavations in seven (35%) of these shelters. In another nine (45%) between one and six artefacts were recovered from the deposit." (Hughes et al. 2011: 58).
Djadjiling	"All excavated sediment was sieved through 6 mm and 3 mm nested sieves and were subject to flotation and sorting in controlled laboratory conditions." (Law et al. 2010: 68).
Juukan 1 and 2.	Does not specify (Slack et al. 2009).
Malea	Unspecified in the published note (Edwards and Murphy 2003). However, the consultancy report (McDonald Hales and Associates 2001: 51) states that the test pitting program followed "standard archaeological excavation techniques". This included "all excavated sediment was passed through a 2 mm sieve. Sieve residues were examined and any identifiable artefactual or faunal material removed and bagged separately in order to minimise damage during transportation. The remainder of the sieve fraction was bagged in its entirety to be sorted under laboratory conditions."
Packsaddle Ridge excavations– four sites	All material not collected as a bulk sample was sieved through a 3 mm mesh sieve. Bulk samples were floated. (Brown 1987: 40)
Newman Rockshelter	All material sieved through a 3 mm mesh sieve. Analysis of the bulk samples not specified, but would presumably have been wet sieved (Troilett 1982, quoted in Brown 1987: 27)
Newman Orebody XXIX	Method not specified – "suitable for a test pit". Excavation halted for practical reasons well before bedrock (Maynard 1980). Bulk samples collected, but not clear if analysed – assemblage reanalysed by Brown (1987: 23-25)
Milly's Cave	Excavated in 1990-1991. Excavated material was passed through 6 mm and 3 mm sieves. (Marwick 2002: 25)

Table 1 Summary of information about use of sieves in selected Pilbara excavations

Table 1 summarises published information about recovery methods in a selection of excavated Pilbara sites, with excavation and recovery methods described when available. The use of 3 mm sieves clearly has a long history in the region, but it is difficult to determine how widespread wet sieving has been.

The experiment

Aim

Archae-aus follows the 'Johnson bucket' method in its excavations (Johnson and Jones 1985). All the 3 mm sieve residues are retained in the field and transported to Perth for laboratory processing. A sample of these residues is wet sieved and processed under laboratory conditions. The results are recorded and incorporated in the analysis of the excavation.

The purpose of the experiment was to compare dry sieving and wet sieving of the same samples from the 3 mm sieve residues in order to evaluate efficiency in terms of the expected additional time taken for wet sieving and accuracy of results.

Methods

Four samples were compared from two rockshelter excavations conducted as part of normal compliance work in the Chichester Range. Three of these came from one site, while the fourth provided a comparison from a site in a different project area.

The samples were first processed following Archae-aus standard laboratory procedure but without wet sieving. This involved the following steps performed by a single experienced archaeologist with over 200 hours' laboratory sorting experience:

1. weigh sample
2. sort sample into categories
3. weigh and record results on standard recording forms

A second experienced archaeologist then checked the identification of artefacts, weighed each confirmed artefact and recorded type, lithology and weight on standard recording forms.

The process was then repeated by the original experienced archaeologist following Archae-aus standard wet sieving procedure. Times were recorded to the nearest minute for each stage of the process.

Results

Activity	Site A			Site B
	Spit 1	Spit 2	Spit 3	Spit 1
Weigh sample	7	1	3	2
Sort sample	197	156	164	151
Record and weigh artefacts	45	40	30	20
Weigh other excavated materials	3	3	2	2
Total processing time	252	200	199	175

Table 2 Dry sieving processing time (minutes)

Activity	Site A			Site B
	Spit 1	Spit 2	Spit 3	Spit 1
Weigh sample	7	1	3	2
Wash sample	16	17	19	26
Tray sample	6	6	5	11
Sort sample	224	241	157	173
Record and weigh artefacts	20	20	8	13
Weigh other excavated materials	2	2	2	2
Total processing time	275	287	194	227

Table 3 Wet sieving processing time (minutes)

Table 2 shows the times taken for dry processing for both sites and Table 3 shows the times taken for wet processing. As would be expected, wet sieving tended to extend overall processing time, although the time taken to process the wet sieved sample from spit 3 in Site A was slightly shorter. Comparison of the time taken to complete individual tasks indicates that the amount of time added by the actual washing process is broadly similar for each sample (average time 20 minutes). The time taken to sort the sample varied considerably. In three out of the four samples, wet sieving increased sorting time, while the fourth sample took less time. However, the increased sorting time was largely offset by a reduction in the time taken to record the artefacts.

The artefacts are the only objects from these excavations that are certainly cultural and it is therefore especially important to assess this component accurately and effectively in providing sound advice to clients. This issue is particularly problematic in many Pilbara sites where raw materials are diverse and may occur naturally in shelters. Table 4 summarises the numbers of artefacts identified during initial sorting and confirmed as artefactual following inspection and recording. This clearly shows for Site A that dry sieving produced large numbers of false positives in initial sorting. Correcting these errors meant that the dry sieved sample took at least twice as long to record as the wet sieved sample. Wet sieving also increased the number of artefacts recovered, by a small amount. This suggests the unexpected reduction in artefact weight noted in Table 5 is probably due to removal of adhering matrix. For Site B the same number of artefacts was recovered in both wet and dry sieved samples. However, washing the sample reduced recording time.

			Initial total	Confirmed total
Site A	Spit 1	Dry	196	37
		Wet	40	40
	Spit 2	Dry	191	38
		Wet	44	44
	Spit 3	Dry	143	17
		Wet	19	19
Site B	Spit 1	Dry	10	10
		Wet	13	13

Table 4 Number of artefacts identified in initial sorting and subsequently confirmed in recording

Table 5 summarises assemblage composition by weight following both dry and wet sorting. It is clear that the results differ quite markedly. Some categories of material were only recognised in the wet sieved samples, namely ochre and skin fragments. Wet sieving reduced the representation by weight of most categories of material with the exception of charcoal. It is possible that washing reduced the amount of sedimentary matrix adhering to the sample. Furthermore some categories of material (such as kangaroo scats) disintegrate during wet sieving and thus some additional material passes through the sieve. It is also possible that reduced error rates contributed to the change in representation by weight. The relative ease of sorting the wet sieved sample resulted in fewer false positives. The results of the more detailed investigation of the artefacts suggest that both more accurate sorting and the removal of sedimentary matrix were likely contributors to the observed differences in assemblage composition.

Conclusion

The experiment reported here confirms that the use of wet sieving generally increases processing time. However, the actual increase in processing time varies considerably and is at least partly offset by efficiency gains in artefact recording time and accuracy. All the sorting was conducted under optimum laboratory conditions by experienced archaeologists. Wet or dry sieving and sorting under laboratory conditions will always be more accurate and efficient than in the field. It would therefore be useful to consider this when estimating field costs and the time and effort required under the often difficult field conditions encountered in the Pilbara. The use of trained archaeologists also represents an efficiency gain (compare Graesch 2009).

Formal standards are generally lacking in Australia. Both Victoria and New South Wales have guidelines (DECCW 2010, DPCD nd) for the conduct of test excavations and salvage excavations on Aboriginal sites. Both mandate total sieving through at least a 5 mm mesh, supplemented in the case of Victoria by a smaller mesh size for particular classes of archaeological material. Use of wet sieving is also required where appropriate, such as for clay soils. There are no comparable standards in Western Australia. However, dry sieving through 6 mm and 3 mm sieves supplemented by wet sieving of samples is a well-established practice in Western Australia and should be regarded as the minimum standard.

In a discussion of the evidence for complex behaviours in Pleistocene Sahul, Langley et al. (2011) discuss aspects of methodology, including size of excavations and sieves used, and the likely impact on sample size and thus representation of evidence of particular types of complex behaviour in sites. They note that:

> An analysis of reported sieve sizes for 93 excavations reveals that 33% of excavations employed sieves greater than 3 mm, suggesting that many small bones, fragments, beads, and other rare items such as exotic raw materials are unlikely to have been retrieved from as much as a third of past excavations. (Langley et al. 2011: 204)

The Pilbara has now yielded evidence of occupation earlier than 40,000 years ago. The large number of archaeological investigations offers an opportunity to examine fine-grained patterns of long term change and adaptation in this region bordering the arid zone. The use of wet sieving under laboratory conditions provides the best method for recovering accurate samples of archaeological material from rockshelter excavations in this region. While considerations for development works must factor in the additional time that may be required, it should be remembered that in many cases this will be completely offset by efficiency gains achieved through identifying and assessing cultural remains more effectively.

The use of wet sieving must be considered essential to developing a regional archaeology which is both fine grained and long term. It fulfils our obligation to provide the best archaeological evidence and interpretation to assist any negotiations between Traditional Owners and Developers that may be based on cultural heritage considerations.

Site	Spit	3mm Sample weight (g)	Method	Artefacts	Bone	Charcoal	Ochre	Insect nests	Insect remains	Scat - macropod	Scat - other	Skin	Hair	Plant - leaves and twigs	Plant - roots	Plant - seeds and nuts
A	**1**	1008	Dry	7.3	0.5	0.5	-	0.3	0.5	6.1	-	-	0.3	5.4	0.6	0.8
			Wet	4.9	0.4	0.6	1.3	0.3	0.5	3.1	-	0.3	0.3	3.7	0.3	0.9
	2	1025	Dry	6.4	0.4	0.2	-	0.6	0.6	8.4	-	0.5	0.3	4.4	-	0.8
			Wet	3.2	0.2	0.3	1.5	0.6	0.5	6.1	0.3	0.2	0.1	3.6	-	1
	3	1009	Dry	2.3	0.2	0.2	3	0.8	0.8	6.9	0.2	-	0.1	3.2	0.2	0.4
			Wet	1.5	0.3	0.4	0.8	0.4	0.5	1.2	-	0.2	0.3	1.8	-	0.5
B	**1**	1001	Dry	1.4	0.4	3.5	-	0.4	0.3	4.5	0.1	-	-	2.9	-	0.3
			Wet	1.4	0.6	25.4	-	0.6	0.7	9.4	-	0.2	0.2	3	0.3	0.7

Table 5 Results of sorting dry and wet sieved samples (weight in g)

Acknowledgments

Thanks to Colin Pardoe for his helpful comments on a draft of this paper and to Nilusha Chandresana who assisted with processing the samples. The sites discussed are in Nyiyaparli country and we gratefully acknowledge the support of the Nyiyaparli people.

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Journal of the Australian Association of Consulting Archaeologists, Volume 2: 9-14

New radiocarbon dates from the Chichester Range, Pilbara, Western Australia

ADAM DIAS & STUART RAPLEY

Adam Dias (Archae-aus, adamd@archae-aus.com.au)

Stuart Rapley (Archae-aus, stuart@archae-aus.com.au)

This paper presents preliminary data from the excavation of 13 rockshelters in the Chichester Range in the inland Pilbara, Western Australia. Archae-aus conducted these excavations between 2010 and 2012 for Fortescue Metals Group in advance of the development of their Christmas Creek mine. The results indicate that the surface characteristics of rockshelters are a weak predictor of the presence and abundance of subsurface cultural deposits. Radiocarbon determinations from these sites are the first demonstration of Pleistocene occupation of the Chichester Range. A comprehensive analysis of these sites is in progress.

Introduction

The Chichester Range has received little archaeological attention in comparison with the better known Hamersley Range, but has been subject to extensive cultural heritage management studies, including rockshelter excavations, since Fortescue Metals Group (FMG) began developing their Cloudbreak mine in 2004 and their Christmas Creek mine in 2009. The results of the excavation programme, in particular, have shed light on an area previously poorly documented in the archaeological discourse. It establishes use of the area in the Pleistocene and offers first order insights into understanding occupation in the area. The programme provides an example of the potential of consulting archaeology to contribute new information to wider discourse. It also highlights the need for a conservative approach when deciding which shelters to investigate.

The Chichester Range

The Chichester Range is in the east Pilbara, approximately 260 km from the coast (Figure 1). It is a range of low hills trending east-west, with the Fortescue Valley to the south and the Abydos Plain to the north. The Range is relatively low, with Mt Herbert at 367 m being the highest point (Beard 1975). Volcanic tuffs and basalts overlain by the Marra Mamba Iron Formation form the range surface. Geologically, the area is similar to that of the nearby Hamersley Range which, as Brown (1987: 5) noted, is rich in a range of different raw materials ideal for stone tool production.

The area is relatively well watered, although subject to the same erratic and unreliable rain fall patterns experienced in the rest of the inland Pilbara. Several rivers, including the DeGrey, Oakover, Nullagine and Sherlock Rivers, drain the range to the north. To the south is the Fortescue River and the Fortescue Marsh, which is the most significance water source in the area and holds freshwater at and just below the ground surface for varying lengths of time following cyclonic storms.

The Project Area

The Christmas Creek/ Cloudbreak project area is on the southern side of the Chichester Range and is approximately 80 km by 15 km (Figure 1).

Article History: Received 18/12/2013, Accepted 29/04/2014, Published 14/07/2014

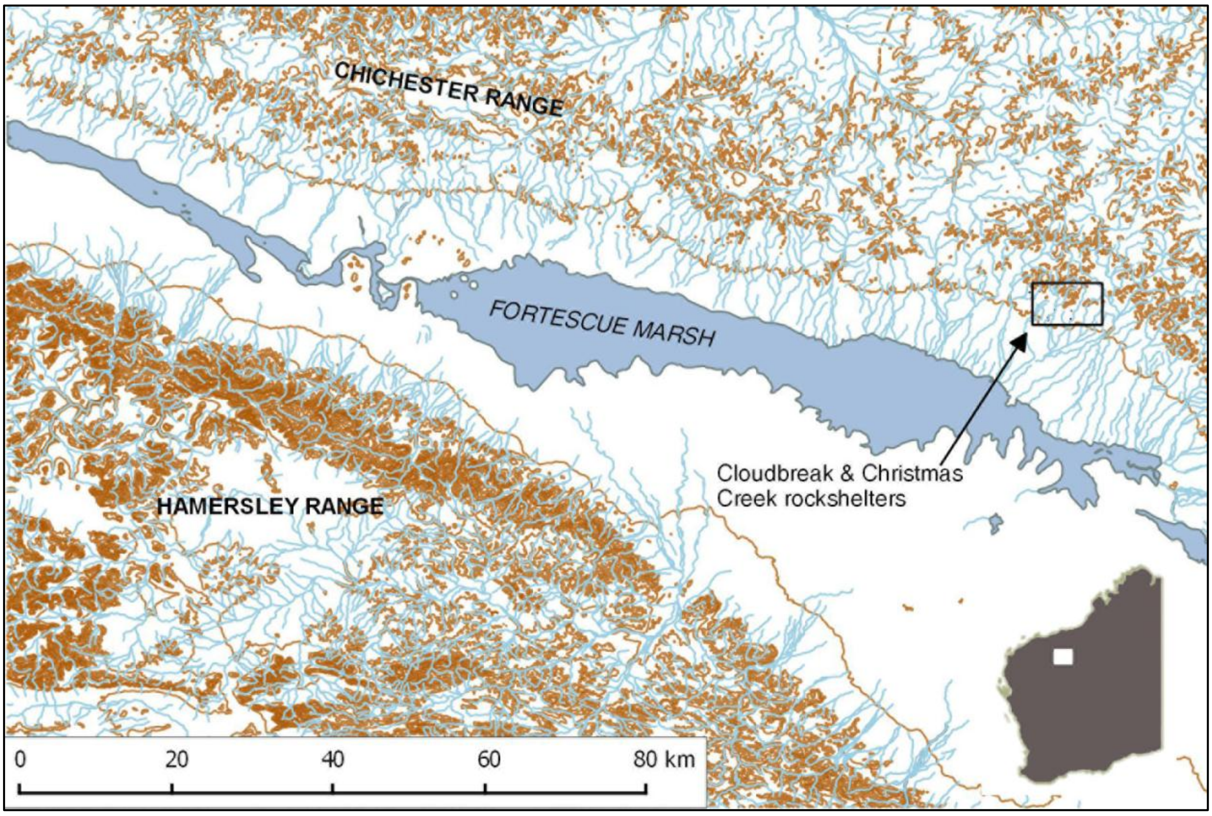

Figure 1. Location of project area

Figure 2. Selected rockshelters in the Cloudbreak Christmas Creek area, Chichester Range (Top left: CB10-93; top right: CB10-92; bottom left: CB08-500; bottom right: CB08-427)

Here the range consists of relatively gentle hills with drainage flowing south to the Fortescue Marsh. Since 2006, Archae-aus has provided archaeological consulting services to FMG. This has involved the archaeological survey of more than 430 km². More than 1800 sites have been identified and recorded, including 45 rock shelters.

The archaeology of the Inland Pilbara is mainly known from archaeological investigations in the Hamersley Range to the south of the Chichester Range, where several significant studies have been conducted (Brown 1987; Ryan and Morse 2009; Slack, Fillios, and Fullager 2009). All archaeological investigations in the eastern Chichester Range have been consultancy studies, typically conducted as part of the mining development cycle, although some early academic studies occurred in the Western Chichester Range (Dortch and Bordes 1977).

Methods

Within the project area all recorded rockshelters that met certain criteria were flagged for further investigation. These criteria included accessibility, sufficient head room for a person to stand or crouch, and the occurrence of at least 10 cm of deposit. Excavation was recommended for all these sites to determine their archaeological potential and significance.

Thirteen shelters met these criteria. The shelters are on the southern side of the eastern Chichester Range, spread over an 8 km by 4 km area of low hills and distributed along five, second/third order water courses that flow south to the Fortescue Marsh. All of the creek lines are ephemeral but substantial and fill quickly with water following seasonal rains. They contain numerous stone and food resources. All of the shelters are easy to access and are generally less than 50 m from the creek lines.

The shelter walls consist of degraded banded iron formation slabs and conglomerates, which in many cases has resulted in substantial roof fall events. Deposits consist of matrices of fine sediment interspersed with fine gravels and larger rocks. No signs of scouring or flooding were observed and deposits appeared relatively well-preserved.

Most the shelters were small, with a median floor area of 44 m² and a range of 14.4 m² (CB10-123) to 352 m² (CB10-133). In terms of ease of movement, the shelters varied from relatively low and cramped through to quite spacious (Table 1, Figure 2).

Site	Floor area (m²)	Height at dripline (m)
CB10-123	14.4	2.5
CB10-93 (Kakutungutanta)	17.3	3
CB08-427	21	1.4
CB09-55	22	3.3
CB10-88	42.5	4.6
CB10-92	42.9	1.7
CB10-98	44.7	1.4
CB08-500	53	4
CB10-147	54	2.1
CB09-249	56	2.4
CB10-116	64	1.9
CB10-117	88	2.4
CB10-133	352	3.3

Table 1. Shelter size

The placement and extent of excavations were influenced by the physical characteristics of the shelters. Different areas of a shelter were unlikely to have the same archaeological potential. Some parts were too low, too dark or had shallow or disturbed deposits. The excavations were therefore targeted in those areas where several conditions indicated a higher probability of recovering cultural material including height, slope and depth of deposit, obstruction by roof fall, ventilation and adequate lighting. At ten sites single excavation squares of 1 x 1 m were excavated owing to the small size of the deposit. At three sites (CB10-117, CB10-133 and CB10-500) the higher probability area was larger and thus two or three squares were excavated.

Results

A detailed discussion of the excavation results is beyond the scope of this paper. A full description of the sites is currently in preparation. Here we focus on two factors: the relationship between the surface features of the shelters and the nature of the subsurface deposits, and the dating.

Characteristics of cultural deposits

All shelters proved to have at least some sub-surface cultural material. Most were quite shallow (less than 30 cm), although Kakutungutanta (CB10-93) and CB10-92 were substantially deeper (up to 87 cm and 85 cm respectively). There is no clear relationship between floor area and the depth of subsurface deposit and the two deepest deposits were uncovered from relatively small shelters (Figure 3).

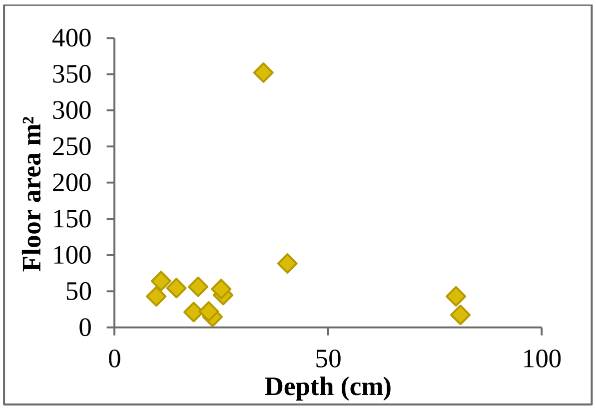

Figure 3. Relationship between depth of deposit and floor area

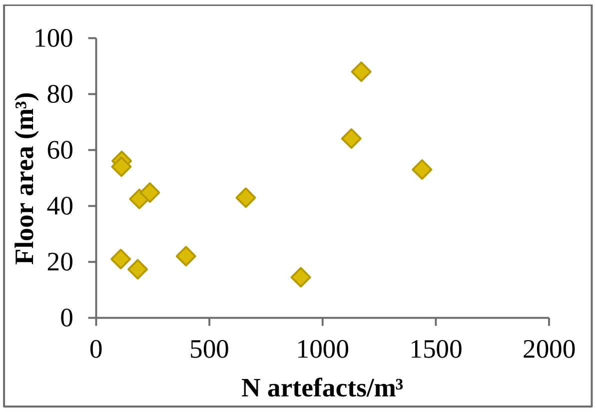

Figure 4. Relationship between quantity of artefacts and floor area (CB10-133 omitted)

The relationship between quantity of artefacts and size of shelter is also weak (Figure 4). Indeed, CB10-92 contained one of the deepest and richest deposits despite being a small and relatively cramped shelter.

This highlights the importance of including even small caves in any research design, rather than concentrating on shelters that appear more accommodating. Indeed evidence from the Hamersley Range would suggest that on the whole Pleistocene deposits are in shelters that have a mean floor area of 55 m^2, with Djadjiling measuring 76 m^2, Newman Rockshelter measuring 36 m^2 and Yirra measuring 75 m^2.

Dating

As with any excavation programme dating the cultural material is paramount. Small hearths were identified at four sites but generally, charcoal was small and fragmented, with most recovered during sieving in the 3 mm fraction.

Thirty-four radiocarbon determinations were obtained, with at least two from each site except CB10-88 (Table 2). Samples were taken by preference from hearths. Otherwise, preference was given to in situ samples, then 6 mm sieve pieces. All samples came from units containing cultural material.

These new dates substantially increase the data set for the eastern Chichester Range. Previously the only dating evidence came from the BC Iron project (J Dortch pers. comm.). Most of these were less than 1000 calBP. Only the excavation of BC09-26 indicated occupation from about 6000 years ago.

The result from Kakutungutanta (CB10-93) indicates occupation of the Chichester Range before 40,000 years ago and suggests a similar antiquity to the use of the Hamersley Range (Morse 2009). The determination of 40,647 calBP (Wk-33656) does not date the earliest occupation at this site with artefacts occurring below the date for a further 55 cm. All other dates are Holocene in age, although CB10-117 indicates use of the area in the early Holocene, with a basal date of

8255 calBP (Wk-30942). Six sites (CB10-123, CB08-427, CB09-249, CB10-133, CB10-98 and CB10-147) seem to have been first occupied in the mid-Holocene with the remainder showing initial use from about 2300 years ago. This pattern broadly follows that of the Hamersley Range, where the number of sites with dates increases substantially from the mid-Holocene onwards with marked increase in the number of sites occupied for the first time after 1000 years BP. This suggests that the rate of change in shelter use alters dramatically in this latter period. While this may be the result of better preservation for the younger sites it does provide some supporting evidence for the suggestion that the last 1000 years was a period of change perhaps as a result of increased population and altering territorial boundaries (Veth 2006: 242-253).

Conclusion

The excavation programme at FMG's Christmas Creek Mine has provided valuable insights into the use of the Chichester Range. Results from Kakutungutanta (CB10-93) indicate the area has been occupied for more than 40,000 years, with use of the remaining sites dated to early, mid- and late Holocene. These results greatly expand upon the previous excavations in the Chichester Range and follow patterns similar to that of the Hamersley Plateau, with an increase in site numbers dated towards recent times.

While detailed analysis of the excavated assemblages is still ongoing, the generally low numbers of artefacts and shallow depths of cultural deposit point towards an intermittent use of these rockshelters, with long periods of abandonment. However, this should not be seen as representative of occupation of the area in general.

These results highlight the importance of investigating all rockshelters with any potential for subsurface material. Several shelters that yielded important results of considerable antiquity were apparently small and unprepossessing. We therefore conclude that priority should be given to the potential for subsurface material, rather than criteria based on shelter dimensions or other physical attributes, in assessing site significance and making recommendations for further investigation to test the archaeological potential of rockshelters. Such a cautious approach towards identifying rockshelters as unsuitable for excavation is essential lest the opportunity for important insights be lost.

Acknowledgements

The authors would like to acknowledge the Nyiyaparli people, whose traditional land the work was conducted on, whose members aided in the excavation work and whose enthusiasm for sharing the results of the programme has allowed us to publish. We would like to thank the staff of the FMG heritage office, for their assistance in organising and conducting the excavations, and for their financial support in the presentation of these results. Our thanks go also to the many Archae-aus staff members that aided in the excavations, sorting and analysis. Without their efforts this work would not have happened. Caroline Bird, Fiona Hook and Sean Ulm provided helpful comments on previous drafts of this paper.

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Site	Lab Code	Estimated age	Error	calBP 68%		calBP 95%		calBP median	δ13C (0/00)	Context	Depth below surface (cm)
				from	to	from	to				
CB08-500	Wk-24826	281	51	437	152	461	74	298	-24.9±0.2	Sq.1, EU5, in situ	14
	Wk-24828	159	35	266	...	278	...	113	-24.2±0.2	Sq.1, EU7 in situ hearth	17
	Wk-24827	205	35	286	143	298	...	186	-25.3±0.2	Sq.1, EU8 in situ hearth	19
CB09-249	Wk-28866	968	30	905	792	920	769	848	-24.3±0.2	EU1, in situ	5
	Wk-28867	973	30	905	796	920	772	850	-25.1±0.2	EU2, in situ	9
	Wk-28868	5862	30	6672	6564	6728	6507	6627	-24.2±0.2	EU3, in situ	10
	Wk-28869	4192	30	4818	4615	4828	4569	4692	-23.2±0.2	EU3, in situ	12
CB08-427	Wk-28060 (AMS)	1371	30	1296	1188	1300	1185	1250	-24.8±0.2	EU1, 6mm sieve	0-4
	Wk-28059	5020	44	5843	5619	5891	5601	5707	-24.8±0.2	EU4	11-15
	Wk-28061 (AMS)	5917	33	6739	6658	6790	6567	6697	-25.4±0.2	EU5, 6mm sieve	15-19
CB10-92	Wk-33646	1336	25	1271	1185	1285	1177	1226	-24.8±0.2	EU1, 6mm sieve	0-5
	Wk-33647	2167	25	2151	2060	2299	2012	2110	-21.5±0.2	EU8, 6mm sieve	35-40
	Wk-33648	2134	25	2091	2015	2148	2006	2064	-21.7±0.2	EU10, 6mm sieve	43-49
CB10-147	Wk-33650	598	30	623	530	631	518	550	-23.5±0.2	EU1, 6mm sieve	0-5
	Wk-33651	4478	36	5271	4892	5283	4872	5040	-23.8±0.2	EU3, 6mm sieve	9-15
CB10-88	Wk-33652	499	25	518	499	536	491	509	-22.4±0.2	EU2	10
CB10-98	Wk-33653	1721	32	1687	1537	1701	1526	1584	-23.2±0.2	EU2	7
	Wk-33654 (AMS)	4493	34	5274	4973	5288	4882	5101	-22.5±0.2	EU4, 6mm sieve	15-21
Kakutungu -tanta (CB10-93)	Wk-33655 (AMS)	2473	30	2678	2361	2701	2353	2475	-23.9±0.2	EU2, 6mm sieve	4-9
	Wk-33656 (AMS)	36039	272	40981	40315	41290	40012	40647	-22.4±0.2	EU5, 6mm sieve	20-27
CB10-116	Wk-30933	329	53	446	300	491	155	378	-25.1±0.2	EU1, 6mm sieve	0-2
	Wk-30934	234	60	313	12	438	...	198	-25.4±0.2	EU3, 6mm sieve	5-11
CB09-55	Wk-30935	1146	59	1063	938	1178	919	1012	-25.2±0.2	EU2, 6mm sieve	4-10
	Wk-30936	1567	25	1425	1365	1511	1351	1401	-23.8±0.2	EU4, 6mm sieve	13-15
CB10-133	Wk-30937	455	25	505	470	514	338	488	-23.4±0.2	Sq.A, EU2	9
	Wk-30939	565	25	546	523	555	509	534	-23.8±0.2	Sq. A, EU3, 6mm sieve	9-13
	Wk-30938	2366	39	2421	2212	2489	2180	2344	-23.6±0.2	Sq. C, EU1, 6mm sieve	0-5
	Wk-30940	3221	47	3456	3356	3557	3251	3403	-23.2±0.2	Sq. C, EU4, in situ	18
	Wk-30941	3119	81	3379	3174	3459	3007	3272	-25.0±0.2	Sq. C, EU5, in situ	23
CB10-117	Wk-30942	7461	50	8313	8188	8375	8061	8255	-23.3±0.2	Sq. B EU4, 6mm sieve	13-17
	Wk-30943	709	52	665	564	684	549	617	-25.6±0.2	Sq. A, EU2, in situ	8
CB10-123	Wk-34982	535	28	535	509	547	501	523	-24.3±0.2	EU2, in situ	9
	Wk-34983	5741	37	6530	6414	6632	6402	6483	-24.0±0.2	EU4, in situ	17

Table 2. Radiocarbon determinations from rockshelters in the Chichester Range. Calibrated using OxCal v.4.2.3, SHCal13 curve (Bronk Ramsey 2009; Hogg et al. 2013). All dates on charcoal.

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ISSN 2202-7890