Analysing Australian stone artefacts: An agenda for the twenty first century

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Over the last twenty five years we have had repeated evaluations of the history of stone artefact analysis in Australia (e.g. Mulvaney 1977; Hiscock 1983, 1998; Fullagar 1994; Holdaway 1995). Each of these reviews brought a different emphasis to the quest for an understanding of the trends, motive factors and constraints in archaeological investigations of bygone years. Although it is pleasing to observe the progress of analytical practice it is equally clear that the major benefit of these historical reviews is their ability to identify those subject areas requiring remedial attention and warranting emphasis in future investigations. With this point in mind it is not our intention to revisit the intellectual history of artefact analysis, but to concentrate on developing a summary of issues that might be the focus of our research efforts over coming decades. Our purpose is to define elements of a research agenda for the study of archaeological stone artefacts, and to this end we do not offer solutions to those problems that remain but seek to identify components of research design deserving attention.

We have chosen a number of methodological and substantive issues to explore and that remain problematic in archaeological research within Australia. Because scientific research designs are primarily concerned with investigating problems in our current knowledge base, the key to refining them is to identify those issues that problematise the existing discipline or sub-discipline. Hence our interest here is to list some of the numerous problems that remain to be adequately addressed in artefact analysis in Australia; and we take this project to be central to the improvement of analyses of Australian stone artefacts. Our general approach is to emphasise a need for more explicit discussion about the nature of our questions, the theory underlying our methods, and the connection between the two. The specific questions and methods that we raise in the context of this discussion are intended as a means of initiating a dialogue about research direction in artefact analysis and are not intended to be proscriptive.

Methodological issues

Discussions of research design have been a rarity in analyses of Australian stone artefacts over the last century. One consequence is that standardised systems of measurement have been applied without evaluating the relevance of those approaches to the research questions. This has meant that alternative approaches or methods in need of refining and testing have not always received the attention that might have been desirable. As a way to initiate consideration of rarely debated analytical problems we discuss a series of methodological issues:

Measuring uniformity and variability

Many of the questions posed by Australian archaeologists centre around measuring the variation in assemblages of stone artefacts. For instance, while the implements of the Late Holocene are seen to be standardized and typologically diverse, the artefacts from Pleistocene assemblages have been portrayed as unstandardised and typologically limited (eg. Lampert 1971; Jones 1977; - see Lorblanchet and Jones 1979; Allen 1998; Shawcross 1998; McNiven 2000; Hiscock and Allen in press for alternative views). Further investigations of questions such as these would profit from the development of techniques capable of measuring variation in robust and powerful ways. A number of key issues will need to be incorporated in such analyses. Some of these include the quantification of size and shape characteristics and the manufacturing processes producing them; consideration of assemblage richness and evenness in the light of sample size and recovery methods, and exploring the effects of differences in the local organization of technology such as proximity to resources, quality of stone materials, extent of transportation, use-life and resharpening.

Classification and interpretation

Most examinations of stone artefact assemblages in Australia have proceeded by applying a conventional and widely accepted classification. Many kinds of classifications are conceivable, and yet those that have been applied display many of the same characteristics: such as a focus on retouched flakes and objects shaped by grinding, the presumption that they are designed tools, and therefore that the morphology and function are inextricably linked. Given the common intellectual lineage of earlier classifiers this similarity should not surprise us, although alternative approaches have always been available (see Hiscock 1998; also Dunnell 1986). However, since classifications must provide information appropriate to the questions being posed future research projects should be designing classifications suited to their needs rather than being constrained within traditional typologies. For example, a number of recent projects have attempted to develop classifications that describe manufacture and use without invoking intentionality or design (e.g. Wright 1972; Hiscock 1993b, 1994a; Clarkson and David 1995; Lamb 1996a), explore the dynamics of flake production (e.g. Hiscock 1988a, 1993b; Cundy 1990), depict the complexity of reduction processes (Hiscock 1980, 1988a, 1994a; Hiscock and Veth 1991; Allen et al. 1997; Roddom 1997), examine the procurement and use of artefacts in their landscape setting (e.g. Byrne 1980; Saggers 1982; Bird 1985; Gould and Saggers 1985; McNiven 1991, 1993, 1994; Holdaway and Cosgrove 1997; Hiscock and Allen in press), infer changes in mobility and foraging range (Hiscock 1996; McNiven 1999), and measure taphonomic alterations to assemblages (Hall and Love 1985; Hiscock 1985, 1990; Mitchell 1988; Lamb 1996b).

Creatively exploring new ways to measure assemblage composition and variation along these lines may be a productive direction to pursue. But in developing new approaches it is important to distinguish the system of classification from the terminology we use to discuss it. The

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language used in articles sometimes obscures the linkage between research questions and classifications, allowing older approaches to be employed in inappropriate ways. For example, it is now common for conventional implement typologies to be employed but to be labelled as a 'technological analysis' even though they infer mental templates, focus on end-products, and describe reduction processes only in terms of simple stage models. This dressing up of old approaches with new terminology may succeed in making them more presentable, but it does not alter their basic premises or make them any more relevant to research questions.

Studies of reduction technology

A number of Australian archaeologists have been prominent in the development of new perspectives on reduction technology and forms of analysis capable of measuring them. In particular these efforts have been directed towards describing the complexity of knapping (by studying error rates, variations of knapping strategies, strategy switching, responses to raw material properties, and so on) and the economic context of the knapping activities (use, rationing, exchange, etc.) One of the important features of this work is that while these researchers have drawn upon notions developed elsewhere, such as North America, they have endeavoured to selectively use those notions and improve them rather than simply transferring wholesale the analytical approaches popular overseas. This has been particularly important in allowing the creation of analytical methods that avoid the failings of the reduction-stage models and replicative experiments so commonly employed in the New World. Continuing to explore ways of investigating prehistoric technology will be a cornerstone of an enhanced description of assemblage composition.

Choice of attributes

In any analysis the initial, and most important, decision is the selection of variables to be measured. While such decisions are influenced by time and cost, the most crucial consideration must be the analytical power of the attribute and its relevance to the questions posed. As noted earlier the application of a single standardised method of analysis, including the use of a standard set of attributes, is not an appropriate response because different observations will be needed for each new question and in each archaeological context (see above). However, for any particular question there may be a number of relevant attributes, and it is valuable to also consider the power of equally relevant variables. For example, one alarming trend is the substitution of total weight of artefacts per analytical unit for other measures of abundance in discussions of chronological change in artefact discard (e.g. Lilley 1993; David and Chant 1995). While the use of weight may in one sense measure abundance it merely measures the amount of rock present within an excavated unit and provides no information as to the composition of the assemblage. As such it is a relatively uninformative statistic. A more powerful measure would be the use of artefact counts, which also measure overall assemblage composition (e.g. number of flake removals, ratios of flakes : cores, degree of fragmentation and nature of taphonomic process). In choosing attributes analysts should consider a wide range of possible measurements, while maximising both relevance and power in relation to the research design.

Identification of artefacts

Most analyses in Australia proceed from a belief that artefacts are accurately distinguished from non-artefacts, and that each class of artefact is unambiguous. In fact a number of studies have suggested that the identification of artefacts has not always been accurate (e.g. Hiscock 1985, 1988b, 1993b; Kamminga 1985; Hiscock and Veth 1991), raising uncertainty about the reliability of identification and classification generally. The importance of this issue has been highlighted in recent years as court cases involving prosecutions for destruction of relics have revolved around the accurate recognition of rocks as artefacts. Several points can be made on this issue. Firstly, that it would be useful for future investigations to employ recording/analysis procedures that might in some way measure the reliability of identifications. Secondly, that categories allowing ambiguity to be recorded may be highly advantageous as a way of evaluating the reliability of inferences. Examples of such recording systems are available in the literature (e.g. Hiscock 1984) and are to be encouraged. Thirdly, we should not underestimate the level of skill required to accurately identify stone artefacts, and therefore it is important that the discipline should not be complacent in providing adequate training and rigorous evaluation of individual's abilities. Presumably universities must take a central role in the provision of education of this kind, but the onus remains on all professionals to enhance their proficiency in this regard.

Dealing with taphonomic changes to stone artefacts

Since all archaeological materials undergo taphonomic alterations, identifying the nature and extent of those changes must be an essential step in the interpretation of stone artefacts (see Hiscock 1985, 1990). Post-depositional modification of artefact location is widely explored (eg. Gifford-Gonzalez et al. 1985; Hofman 1986), and has long been acknowledged by Australian researchers (e.g. Stockton 1973; Hughes and Lampert 1977; Richardson 1992), although it would be desirable to have the phenomenon investigated at every site, almost as a matter of course. In conjunction with details of recovery methods and depositional history this information about post-depositional relocation may help define the scale of time-averaging being encountered (see Jones 1980; Frankel 1988). Investigations of assemblage contemporaneity may also be assisted by information on the condition of the artefacts themselves, although a concern for the extent of taphonomic changes has been displayed only rarely by Australian archaeologists. And yet the implications of those changes are basic to analyses of assemblage composition and variation. For example, fragmentation of artefacts may adversely affect the accuracy of identifications and may confound attempts to quantify abundance (is a flake broken into six bits, one artefact or six?). Even the use of weight (see above) as a measurement is made problematic by breakage when fragments become unidentifiable or are not recovered. Furthermore, some Australian researchers have explored the capacity for mechanisms damaging artefacts to preserve information (e.g. Hall and Love 1985; Mitchell 1988; Hiscock 1990; Lamb 1996b). A consideration of taphonomic processes is essential for almost every conceivable analysis, and a greater emphasis on this issue should be allocated in future analyses.

Sample size

All of the assemblages analysed by Australian archaeologists comprise samples of the archaeological record. The size of samples that have been employed has varied greatly between archaeologists and projects, and more consideration needs to given to the implications of those variations. For example, sample size is well known to have a profound effect on the richness and evenness of spread of materials represented in an assemblage, particularly the occurrence of rarer items such as formal implement types or trade items (e.g. Smith 1982; Hiscock 1993a, in press; Clarkson and David 1995; Gorecki et al. 1997; Hiscock and Allen in press). For this reason proper consideration of sample size needs to be built into research designs and the number of assemblages and the number of specimens in each needs to be considered when addressing specific questions, particularly those revolving around dating, abundance and types of artefacts present in sites. It is important to realize that no arbitrary number of items is sufficient in addressing sample size issues and that the context of analysis, and the context of the problem are vital. Several tests for the effects of sample size on assemblage diversity exist (see Leonard and Jones 1989) and need to be incorporated as a routine procedure in assessing spatial and temporal trends.

Experimental investigations into fracture

Since replicative studies of stone artefacts have little to contribute to archaeological interpretations archaeologists have increasingly searched for approaches capable of yielding reliable principles with which to infer manufacturing and use behaviour from archaeological artefacts. Controlled laboratory experiments have proved extremely valuable in identifying variables controlling fracture, and the ways these can be investigated on archaeological assemblages (e.g. Speth 1972, 1974, 1975; Dibble and Pelcin 1995; Pelcin 1997a, 1997b). Australian researchers have played a significant role in the production of this experimental knowledge (Cotterell and Kamminga 1979, 1987; Saggers 1984; Cotterell et al. 1985; Domanksi and Webb 1992; Domanski et al. 1994). Research of this kind continues to be productive and further investigations into the interrelationships between fracture variables should be encouraged. However, it is a mistake to think that our understanding of the relationships of fracture features must be derived solely from experimentation. The archaeological record contains huge numbers of artefacts that have been created by fracturing, and preserve an image of not only the underlying relationships but also the complexity and variation that occurs in non-laboratory circumstances. Testing the principles derived from laboratory experiments against archaeological specimens has the capacity to extend our understanding of knapping and artefact use, and this work can be accomplished with the databases already being compiled by many Australian archaeologists.

Articulating stone with other evidence

Attempts have been made to integrate studies of stone artefacts with discussions of changing population size, art styles, and foraging strategies (e.g. Clegg 1977; Morwood 1979; Bowdler 1981; Hughes and Lampert 1982; David et al. 1994; Attenbrow et al. 1995; Cosgrove 1995). Since at least some questions are concerned with the broad operation, and change to, behavioural systems the desire of researchers to understand the interconnections between different dimensions of these systems is justified. However, greater consideration of the methodological complexities is needed to accurately measure those interconnections. Most of these analyses employ an examination of the covariation of the abundance of artefacts and materials such as fauna or ochre. The question that remains to be answered is whether the abundance of recovered artefacts is an appropriate or adequate variable for measuring change in the overall behavioural system and for comparing dimensions of human activities. Multiple factors are known to affect the quantities of artefacts produced, discarded and preserved (see Ammerman and Feldman 1974; Schiffer 1976; Hiscock 1981). Explicit theorizing is needed in order to clarify the role of stone in economic life, and how examinations of stone artefacts can help test models about economic organization derived from the study of other kinds of archaeological residues.

Investigations of use

Use-wear and residue studies are increasingly instrumental in discussions of artefact and site use. The future application of these exciting techniques must evaluate which questions they are successful in answering. In particular, it remains to be determined with what specificity and reliability statements about tool use can be made, and how the knowledge of the use of particular tools can be integrated into regional-scale models of economy and settlement (see Schiffer 1979). The first concern, of specificity and reliability in inference, arise from the many problems demonstrated to exist in the comparability and consistency of wear and residue identification (e.g. Keeley and Newcomer 1977; Odell and Odell-Vereecken 1980; Bamforth 1988; Fiedel 1996), as well as the superimposition of multiple use events, and the effect of different rock materials and depositional environments. These factors raise methodological and interpretive complexities in many cases, and must be addressed in future studies. In particular we emphasise the tendency for previous studies to be limited in scale to very small samples, which are often un-representative of the assemblage as a whole (e.g. perceived formal 'types'). In many instances the restriction of use-wear and residue analyses to those biased samples presupposes that tools can be identified on the basis of gross morphology, a link between artefact form and function that has never been demonstrated. Ultimately the value of these techniques for broad archaeological theorizing will only be realized when site-scale studies of artefact use are integrated with regional-scale models of technology and land-use.

Dating artefact assemblages

A number of the models constructed by Australian archaeologists purport to describe chronological changes in the abundance and size of sites as a means of investigating demographic and social processes. These endeavours require some means of assigning ages to the sites identified, but in reality some kinds of sites have proved intractable and remain significantly under-represented in discussions of change. Perhaps the best example of this is the artefact scatters that occur across the continent, but other less common sites such as stone arrangements fit this description. Where open artefact scatters have been examined the contemporaneity of specimens is often assumed, and although our interest is in dating the assemblage this has frequently been accomplished by reference to the inferred age of individual specimens of distinctive form. This procedure is suspect on a number of grounds, including the possibility that assemblages represent palimpsests, and that the presence/abundance of individual specimens is simply a function of sampling (see above) or site function.

Even in sites such as rockshelters or middens, where radiometric dates on other materials can be obtained, these inferences about the antiquity of artefact assemblages rely on interpretations of association. Recent discussions of site formation processes such as vertical movement have illustrated the danger of relying on unqualified associations (e.g. Richardson 1992; Shawcross 1998). Estimating the age of assemblages in these ways must take into account the range of possible errors and the magnitude of those errors. At present this issue is not being adequately addressed. Profitable directions might include the development of methods for dating stone artefacts themselves, either directly dating individual specimens using radiometric techniques or estimating the relative age of assemblages, and refining the quality of stratigraphic associations by more detailed investigations of formation processes. However, even new dating procedures will not avoid the necessity of defining the resolution inherent in the record and its adequacy for research questions being posed.

Symbolism and stone artefacts

A number of Australian archaeologists have sought to explain the form and appearance of implement types and configuration of assemblage patterning in terms of symbolic functions of those artefacts. A seemingly endless variety of functions have been proposed including the acquisition of status by manipulating symbolic associations of artefacts, the signification of identity, establishing and reinforcing boundaries of groups and alliances between them, controlling political and religious power through the restriction of knowledge, and conveying information about mythological associations and social institutions (e.g. Bowdler 1981; Cane 1984; Smith and Cundy 1985; McBryde 1986; Paton 1989; Tacon 1991; Allen 1996; Evans and Jones 1997; Layton 1997; McNiven 1998). These propositions largely arise from ad hoc use of analogical arguments with very little consideration given to how these can be tested against the archaeological record. Advocates of arguments that invoke symbolic explanations of change will need to provide specific archaeological tests that will confirm the operation of those processes.

Substantive issues

Methodological concerns of the kind discussed above exist in the context of substantive questions being addressed by the discipline. A discussion of unanswered questions about Australian prehistory provides information about the construction of our research designs. The core subject matter of archaeology, like any science, may be revealed in the nature of problems considered worth solving. The brief comments we make below focus on problems concerning the kinds of behavioural processes[1] that are responsible for prehistoric changes reflected in archaeological assemblages and how these can be modelled. This framework offers a very different structure to the conventional kinds of questions that captivated the attention of Australian archaeologist in the latter part of last century, such as 'how do we explain the Kartan', 'where is the northern boundary of backed artefact distribution', or 'what caused assemblage contrasts between plain and plateau'? We are not saying such questions are unworthy, indeed we retain a strong interest in the explanation of particular regional patterns, but we suggest that the design of research problems focused at a broader level is more likely to encourage theorising and is therefore more suitable in defining a research agenda. And so having discussed key issues of method we now turn to some of the more pressing substantive issues in Australian prehistory concerning stone artefacts:

Sequence of typological change

Following a period of broad agreement about the existence of a three-phase sequence of chronological change in implement types (e.g. Mulvaney and Joyce 1965; Mulvaney 1969; Lampert 1971; Gould 1977a, 1977b; Campbell 1982), models proposing different numbers of phases are again being proposed and debated (eg. Bowdler 1996). Certainly it is no longer clear that even typological forms such as points and backed artefacts are as temporally restricted as was once believed (e.g. Hiscock and Attenbrow 1998). Typologically minded archaeologists will need to explore the capacity of competing models to depict variation in the archaeological record.

Time sensitivity of assemblage characteristics

Given recent re-evaluations of the purported trends in Australian implement types, in particular the refutation that there is a simple time-trend towards diminution of implement size and greater regularity of implement shape, archaeologists should perhaps review the evidence for directional trends as depicted through typological data (see Draper 1987; Hiscock 1993; ; Hiscock and Allen in press; McNiven 1994; McNiven 2000; Bowdler 1996; Allen 1998; Shawcross 1998). This raises the question of which characteristics are most time sensitive, and how they may best be observed and depicted. For example, it may be that it is not variables of artefact size that vary systematically through time but characteristics of the behaviour of making artefacts. It is even conceivable that there are no directional trends across the entire continent, and instead of searching for a single trend we should focus on exploring variability through time (or space, see below). Indeed, it may not be an image of a trend that is most informative but the identification of changes in the variability of technological behaviour and the resulting artefacts.

Exploring the variability of assemblages

What has emerged in recent papers is an acknowledgement of far greater variability in assemblages of all ages. This is not surprising in view of the differences in raw material and economic systems in each region, combined with the limitations of the typological observations (see discussion above). In order to observe any trends that might underlay this variation, it may be profitable to study the regional constraints affecting the direction and variability of assemblages before attempting to isolate trends at a continental level. To accomplish this it will be necessary to examine factors that may be causing assemblage variation.

Why do assemblages vary?

An exploration of the factors and conditions in which assemblages vary, the nature of that variation, and the level of response to those factors, remains a primary concern. The results of such explorations will be critical for not only explanations of the archaeological assemblages, but also for modeling systems of land use, territoriality, demography, etc. While a small number of ethno-archaeological investigations

1 We use this term broadly, in the manner of O'Connell and Allen (1995) to describe population density and distribution, subsistence economy, stoneworking, and socio-political organization.

have emphasized this approach (e.g. Gould 1966, 1980, 1991; White 1967; Hayden 1977, 1979; O'Connell 1977), archaeological investigations have been limited to a consideration of only a few factors. For example in the literature of the 1970's only a few factors were actively discussed; primarily raw material and different site functions, with characteristics not explicable in those terms being explained as style. More recent archaeological investigations, many still in progress, have begun to take account of a wider range of assemblage forming factors, expanding on newer developments in hunter-gatherer theory (e.g. Ebert 1979; Keeley 1982; Torrence 1983; Bamforth 1986, 1990; Shott 1986; Kelly and Todd 1988; Bettinger 1991; Nelson 1991; Kuhn 1992, 1995; Schiffer and Skibo 1997). Arguments focused on the effects of mobility, risk and emerging territoriality have emerged from this work (Hiscock 1994b, 1996; McNiven 1994, 1999). Further research designs centered around those theories should be a priority. However, it must be accepted that identifying the factors at work in creating any particular set of assemblages may not be straightforward. For instance, there is no reason to think that we have yet identified all mechanisms creating assemblage composition, emphasizing the importance of continued theorizing on the subject. Furthermore, we might expect the interplay of these factors to be complex, and may vary between landscapes and perhaps through time.

Distance to source

One of the most obvious factors influencing assemblage characteristics is the economics of raw material procurement, often discussed in terms of raw material rationing as distance to source increased. Several projects have demonstrated aspects of this mechanism operating in Australian assemblages (e.g. Gould 1977a, 1977b; O'Connell 1977; Byrne 1980, Bird 1985; Cundy 1985, 1990; Gould and Saggers 1985; Hiscock 1986, 1988a; Hiscock and Allen in press; McNiven 1993). What is clear is there is no fixed rate at which assemblages change as knappers respond to altered access to replacement material. Instead, the way in which material is transported, utilized and conserved reflects the movement of people within the environmental and social settings, and can be expected to vary. Consequently, the specific effects of these factors will need to be established in each study area, a consideration that should be built into research designs. Since the operation of this factor will alter with changes to the socio-economic system we could expect the effects of this factor to also vary temporally. The possibility of variation in artefact densities through time and space as a result of factors such as distance to source (or mobility — see below) complicates any simple correlation between the abundance of material and intensity of site use. This is not to say that models of processes such as change in population size cannot be developed, but that they must be embedded in an analysis of settlement subsistence patterns.

Mobility

Another factor receiving attention in recent projects is the technological difference that might accompany differences in mobility[2]. Models describing the relationship between the structure of manufacturing activities and the organization of stone procurement in relation to other foraging practices, residential mobility, foraging range, and territorial boundaries have been presented overseas (e.g. Keeley 1982; Torrence 1983; Bamforth 1986, 1990; Shott 1986 ; Parry and Kelly 1987; Kelly and Todd 1988; Goodyear 1989; Nelson 1991; Kuhn 1992, 1995; Feblot-Augustins 1993; Schiffer and Skibo 1997) and are being explored in Australia (e.g. Byrne 1980; Gould and Saggers 1985; Witter 1990; Hiscock 1994b, 1996; McNiven 1994). The ability to measure these aspects of land-use in the structure of artefact assemblages provides an insight which can complement inferences from other categories of archaeological debris such as faunal analysis, and which is largely unexplored in Australia. We believe the ability to reconstruct patterns of mobility using artefact assemblages is achievable, and suspect that if mobility could be defined other aspects of settlement and demography may be more accurately modeled.

Production for trade

One further factor widely discussed as a cause for assemblage structure and variation is production of artefacts for exchange. This has been explored in syntheses (e.g. Torrence 1986) but has not been extensively studied at Australian quarries (but see Baker 1987; Lamb 1996a; Mulvaney 1997), although numerous sourcing studies have examined the dispersal of artifacts through trade systems. Researchers should continue to refine analytical methods that will allow different forms of exchange to be identified archaeologically, particularly to distinguish between the archaeological signatures of trade and of direct access. Nevertheless, this should not deter investigations of production related to trade. For instance, detailed studies of material extraction and artefact manufacture at quarries might help illuminate production for trade. Even outside the context of trade thorough studies of quarry sites will provide information on the scale of quarrying and reduction, the standardization of production, the strategy of reduction, and selection of artefacts for transportation off-quarry.

Colonising

While the initial colonization of Australia has captured most of the headlines it is increasingly clear that the arrival of humans in Sahul was simply the first of a number of colonising events. Recolonisation of abandoned landscapes following the LGM, the occupation of 'marginal' landscapes in the mid-late Holocene, and recolonisation of islands are all examples that have been documented (see Bowdler 1980; Ross 1982; Flood et al. 1989; Hiscock 1988a; Veth 1993). Archaeological questions about these colonizing events that are yet to be answered include the rate and process of each event and the degree to which they operated in similar ways or were individually distinct.

A further question that has received little attention is concerned with the role that technology may have played in each colonization episode, and in particular the connection with organization of stone artefact production. A number of theoretical models have discussed the advantages of particular tool kits for colonizing groups, often emphasizing the benefits of artefacts that are reliable, transportable, and multifunctional (Bleed 1986; Kelly 1988). While these kinds of models have occasionally been proposed in the Australian situations (e.g. Hiscock 1994) it is worth considering the possible structures of technology that might be advantageous to a colonising group.

Unresolved questions include whether we have identified all of the tool kit characteristics valuable to colonising groups,

2 By mobility we mean all levels of residential movement along a continuum between highly mobile and sedentary. In this way we avoid the misuse of 'mobility'as a synonym of 'highly mobile'.

and what are the relative weightings given to each characteristic in different circumstances faced during the colonizing event. Another issue is whether it is necessary or even appropriate to look to formal implement types as the focus of those models, since they need not be the only ones with characteristics of reliability, transportability, multifunctionality, etc. In Australia at least some of the colonising events appear to have taken place without typologically standard implement forms, and it may be that a focus on features of past economic systems such as exploitation of raw materials, organisation of production, mechanisms for extending artefact use-life, the operation of stone artefacts as part of composite tools may be more productive in addressing questions about the ways people occupied new landscapes. The colonization issue we have discussed here is an example of the relevance and utility of incorporating analyses of artefacts into studies of economic change, as one of multiple strands of investigations.

A variant of this issue is the process of colonising occupied landscapes and the implications for the re-organisation of procurement and technology. This is a subject of study in both the Old and New Worlds (e.g. Rick 1996; Rosen 1996, 1997; Trigger 1990). In Australia, the most obvious example of this is the culture contact between Aboriginal people and other peoples such as the Macassans and Europeans, which involved the introduction of previously unknown materials such as glass, iron and ceramics (e.g. Sharp 1952; Schrire 1972; Clarke 1994; Mitchell 1994a, 1994b, 1996; Wolski and Loy 1999; McNiven and Russell in press). Questions that have been raised about the process of procuring these items include the operation of trade and negotiation between groups and the implications this has for political status, the growth of trade systems, and the re-organisation of items within the system of value and use. Other questions that might be raised relate to the modification of manufacturing activities in response to the properties of these new materials, the adoption of new technologies, and/or alterations to pre-existing technological systems in response to restructuring of economic activities including re-ranking of resources, changes to mobility and group size, intensifying production for trade, shifts in territorial boundaries and demographic change. These processes resulting from culture contact need not be thought of in terms of external contact or recent contact alone, but may also have been involved in contact between groups within Australia during the prehistoric period. The hypothesized spread of Pama-Nyungan speakers during the Holocene is one possible case in which we might consider the operation of these processes. If we are to pursue these issues it is vital that suitable archaeological methods are developed to identify the operation of these processes.

Association with hominid forms

In many different ways Australian archaeologists have hypothesised situations in which distinct cultural differences exist between contemporary groups in geographical proximity. For instance, models of physically different populations in near genetic isolation (e.g. Thorne 1977), and models of ethnicity/territoriality that may effect gene flow and is visible in parietal art (e.g. David and Chant 1995; David and Lourandos 1998; Pardoe 1988, 1994, 1995; Pate 1995, 1997, 1998), have been developed but not tested against the most abundant form of archaeological material. In testing models such as these it might be worthwhile exploring whether cultural differences correspond to differences in the composition of material culture such as stone artefacts. However, the interpretation of assemblage variation that could be viewed as revealing 'identity'must be made in light of the factors affecting assemblage variation discussed above. An example of the complexity of interpreting artefact assemblages in this way can be seen in the ongoing debates about the explanation of variation in Western Arnhem Land (see Allen and Barton n.d.; White 1967a, 1967b, 1971; White and Peterson 1969; Schrire 1982; Hiscock 1996, 1999).

Conclusions

Stone artefact analysis in Australia at the turn of the millennium exists in a paradoxical state. Artefact studies are undertaken universally in both research and cultural resource management, and yet in many ways the study of artefact assemblages has been neglected and archaeologists dispirited about the capacity of artefactual material to test questions about prehistoric life. This unfortunate state has arisen from the conjunction of a number of factors, of which we will mention two: the mechanical application of standard measurement procedures, and a lack of appreciation of the specialised nature of artefact analysis.

Perhaps no aspect of the approach to stone artefacts in Australia has been as stultifying as the mechanical application of standard procedures of measurement. As we noted earlier the basis of any research design must be the selection of a recording system that provides systematic observations that are relevant to the question(s) being posed. By definition a single standard procedure will prevent articulation of question and observation unless it can be argued that we all ask the same question, and since this is not the case a standard procedure acts to deter the development of sophisticated research designs. The typical justification of a standard procedure as producing comparability fails to recognise the high level of error and idiosyncratic differences in measurement, and focuses the issue of comparison at a methodological level rather than facilitating comparisons of inferred behaviour. Since all investigations involve research designs these considerations apply to archaeology undertaken in the context of cultural resource management as well as pure research. Indeed, while a vast amount of archaeological investigations are being carried out in cultural resource management, it appears that the bulk of significant methodological and substantive findings are still obtained in university/museum research, particularly by research students. Consequently it would be highly advantageous to find ways in which to make the results of artefact analyses undertaken by consulting archaeology relevant beyond resource management, to make the results useful to scientific investigations, and to integrate the results of pure and applied research. Most importantly, we emphasise the need for analyses, whether CRM or pure research, to be undertaken within the framework of a sophisticated research design.

One of the curious aspects of attitudes towards stone artefacts is the view that the ability to identify and comment on artefacts is in some sense a 'core'skill obtained by virtually all archaeological graduates, and possessed by all archaeological consultants. This attitude reveals a lack of appreciation for the specialised nature of artefact analysis generally acknowledged for sub-disciplines such as physical anthropology, geoarchaeology, zooarchaeology or rock art studies. While many archaeology graduates have been trained using hand-picked 'classic'specimens illustrative of ideal flake and

implement characteristics, this will not equip them to examine the full range of varied forms that are found in the archaeological record. In reality, it is an expert task to accurately identify artefacts made on heterogeneous or ani-isotropic rocks, that have undergone massive taphonomic alteration, that occur within a matrix of naturally fragmented rock, that are of small size, and that exhibit unusual or poorly formed characteristics. Expertise that will allow such materials to be analysed must come about through specialized university training and/or extended supervised experience in recording archaeological material. We are not making this argument in an attempt to argue in favour of a small and exclusive set of archaeologists analysing stone artefacts. Since there are uncounted millions of stone artefacts in Australia, and so little known about the prehistoric production and use of such artefacts, it is desirable to encourage a large number of researchers to participate in the labour of research into past technology. But it is also essential to maximise the quality of observation and documentation of artefact assemblages.

In conclusion, these points are reflections of the themes that we have discussed throughout the paper. An over-riding concern is the need to encourage the development of research designs that have explicit theoretical orientations, clearly articulate the connection between methodology and theoretical objective, and frame the questions in terms of prehistoric behaviour. By recommending that researchers abandon the use of fixed methods and match their question to relevant measurements, this will necessitate a creative attitude to analysis.

One aspect of this might be to develop ways of maximizing the information that is obtained during the analysis. For instance this might be achieved by focusing examination on human activities involved in the production of all components of the preserved assemblage, without presupposing that information resides only in 'end-products'. Such an approach would result in the description of the overall production system and is likely to highlight variation rather than central tendency when comparing assemblages and examining chronological changes. It follows that it may be profitable to focus on exploring sources of variation in the record rather than impose a single explanation and to examine variation at an assemblage or regional rather than pan-continental level.

Our concern throughout has been for the establishment of analytical systems that enhance the quality of data produced. To this end it has become necessary to evaluate the robustness of principles used to infer properties of past behavioural systems. We have mentioned the need to re-examine the principles that underlay inferences of symbolism, usewear and residue studies, and typological schemes used to describe Australian stone artefacts. In the production of research designs aiming to test broad behavioural models it will be vital to integrate stone with other categories of archaeological material, and inferences of stoneworking with other forms of human activity. In this position paper we have argued that concerns over these issues should form the basis for a research agenda in coming years. What is important in refining research into Australian stone artefacts is that we create research frameworks that facilitate testing theoretical models and it is to that end that we can reflect on recent approaches to the analysis of artefacts in Sahul.

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'Cave men'honoured: Conferring of honorary Doctor of Science degrees on McCarthy and Tindale by the Australian National University, 18 April 1980. Left to right: F.D. McCarthy, D.J. Mulvaney, N.B. Tindale. Photo: ANU Photography. Courtesy of John Mulvaney