10

Artefacts on Aru: Evaluating the Technological Sequences

Peter Hiscock

School of Archaeology and Anthropology, The Australian National University, Canberra, ACT, Australia

Introduction

Cultural sequences from excavations at the two cave sites, Liang Lemdubu and Liang Nabulei Lisa, provide fundamental information about not only ancient cultural activities in this landscape, but also about the environmental history of the region and the nature of human exploitation in the changing ecosystems. In this context, the human use of lithic artefacts, which involved exploitation of rock resources and chronological changes in the procurement and processing of those resources, tells us about the human responses to changing environments. Although these excavations were small and exploratory in nature, their location in different parts of the landscape provides an opportunity to develop initial models of resource exploitation. In this way, the analysis of stone procurement and technology presented here compliments the analysis of vertebrate and invertebrate fauna discussed in Chapters 7 and 9 (this volume).

Chronological Framework

Although the interpretations of Liang Lemdubu and Liang Nabulei Lisa presented in this chapter are consistent with the analyses contained in other chapters in this volume, the particular needs of the lithic investigations have required a somewhat different treatment of chronological evidence. In particular, the emphasis on calculating rates of artefact accumulation required the use of both age estimates expressed in calendar years and the estimation of the antiquity of specific points in the deposits.

Calendrical dates were obtained where required by calibration carried out in appropriate ways. All radiocarbon values were calibrated using CALIB 3.0.3. Procedures for carrying out these calibrations can be summarized as follows: non-marine samples were processed using CALIB's bidecadal atmospheric/inferred atmospheric curve; and, marine samples used CALIB's composite marine and terrestrial carbon curve and the Australian standard ocean reservoir correction was applied. No southern hemisphere correction was applied in any of the calibration calculations.

The estimation of antiquity for specific depths in each deposit was accomplished using age-depth curves. Inferences about the relationship of depth below the current surface of the deposit and samples for which absolute age-estimates have been obtained permitted estimates of the antiquity of sediments at any point in the deposit by reference to their depth. Readers should note two points about these analyses. Firstly, the age-depth relationships were developed statistically using regression statistics, the correlation coefficients being a measure of the predictive value of the inferred relationships. This is an incalculably better approach than impressionistic, non-statistical approaches to identifying age-depth relationships. Secondly, these age-depth relationships are employed only to obtain robust estimates of the age of the boundaries of analytical units. Subsequent uses of these estimated ages do not express variations in deposition rates, or artefact accumulation rates, with the analytical units, but nor do they assume that deposition was constant throughout the sequence. Hence there is no contradiction in employing these age-depth relationships as an heuristic device for the expression of discard rates, while acknowledging that sedimentation rates varied or even ceased at some points during the formation of the deposits.

Liang Lemdubu chronology

A data set consisting of 13 samples, each with a calendrical age estimate and average depth, were employed to construct an age-depth relationship for Liang Lemdubu. For the relationship between age and depth within these data points the Spearman's rho is 0.861 ($p<0.0005$), indicating a positive relationship that is highly unlikely to result from chance. The nature of this relationship was defined using further regression analyses (see Fig. 10.1).

Figure 10.1 Liang Lemdubu: age-depth curves, examining all levels of the deposit

A simple linear regression, forced through origin, provides a strong correlation. This linear regression line can be defined as:

1) *Depth = 0.0049032376 * Age*

where Depth is centimetres below surface (0) and Age is years before 0. Such an equation gives an r^2 value of 0.789 (N=13), indicating that much of the variation in age estimates is explicable in terms of depth of the sample. Being a linear estimate, each five centimetre spit is calculated as representing the same duration (Fig. 10.1, Model 1). In this equation each spit represents approximately 1020 years.

Simple non-linear fitted lines using all data points do not provide estimates of the relationship between age and depth that are as good as the linear model. For instance, non-linear regression (of the form $y=a+bx^2$) can be defined by the equation:

2) *Depth = -0.00000022563473 * Age* ^{2}

where again Depth is centimetres below surface (0) and Age is years before 0.

This equation gives an r^2 value of 0.726 (N=13), and represents a trend to decreased sedimentation rates in the Holocene (Fig. 10.1, Model 2). A single outlier has reduced the calculated coefficient for this model.

In both equations 1 and 2 the charcoal sample OZC777 from Spit 26 constitutes a radical outlier, having a standardized residual value of almost three (i.e. being three standard deviations from the predicted y value). This sample is the lowest charcoal sample dated, and the only one from deep in the deposit. It has yielded a very different age estimate than all other dated materials, and may well have been contaminated. Since this datum point is atypical of the overall age-depth trend there is reason to explore the effect on regression analyses of excluding the sample.

Excluding OZC777 from the simple non-linear $y=a+bx^2$ model gives a dramatically changed depiction of the age-depth relationship, yielding a regression equation:

3) $Depth = -0.00000021298028 * Age^{2}$

This line of best fit can be seen as an improvement on the previous as the r^2 value has risen to 0.915 (N=12), revealing an impressive capacity to predict depth from age (Fig. 10.1, Model 3). The strength of this coefficient leads me to disregard sample OZC777 from considerations of age estimation in this site, and that the non-linear model given in equation 3 provides the best estimate of the relationship between age and depth in the Lemdubu deposit, when all parts of the deposit are incorporated in a single model. Using this model it is possible to estimate the sedimentation rates during different periods in the formation of the deposit (Table 10.1). These estimates indicate that sedimentation was an order of magnitude higher at the base of the sequence than at the top. Consequently, the levels representing Pleistocene times contain far higher chronological resolution than levels that accumulated during the Holocene.

Table 10.1 Liang Lemdubu: calculated sedimentation rates using model 3

ESTIMATED AGE (USING EQUATION 3)	ESTIMATED SEDIMENTATION RATE (CM/1000 YEARS)
0–10,000	2.12
10,000–15,000	5.30
15,000–20,000	7.42
20,000–25,000	9.54

While model 3 is the best description of age-depth relationships for the deposit as a whole it implies uninterrupted sedimentation throughout the Holocene at a low rate. While this is possible, the radiometric age-estimates that have been obtained do not compel such a presumption to be accepted. For instance, no radiometric sample has yielded an age-estimate between 9000 BP and 2000 BP, and it is possible that sedimentation may have slowed or ceased in that intervening period. Given the possibility that Holocene sedimentation rates may have departed significantly from those implied by model 3, I consider it safest to treat the top five spits as a single unit of Holocene age of low temporal resolution, within which chronological subdivisions and age-depth relationships cannot be precisely defined.

If only the inferred Pleistocene levels of the deposit are considered, involving spits 6 and below, an additional age-depth relationship can be defined. For the Pleistocene portion of the deposit alone, a simple linear regression yields a powerful description of the relationship between age-estimate and depth (again OZC777 is excluded for reasons discussed earlier). This linear regression line can be defined as:

4) $Depth = 34.712072 + (0.0064504317 * Age)$

This equation gives an r^2 value of 0.9267 (N=10), indicating that much of the variation in age estimates is explicable in terms of depth of the sample. Figure 10.2 shows the regression line for this equation. As a linear estimate each five centimetre spit is calculated as representing the same duration (Fig. 10.2). In this equation each spit represents approximately 770 years. The result is an estimate of age for lower levels of the deposit broadly similar to those provided by model 1. Since model 4 does not take into account the reduced sedimentation rates apparently occurring in the Holocene level of the site, as model 3 had, I take it to be a more reliable indication of age-depth relationships for the Pleistocene levels. Consequently, model 4 has been used to estimate ages for Spits 6 and below, while Spits 1–5 have been inferred to represent the last 9–10,000 years.

These age-depth estimates were used to develop a chronological analysis based on the artefactual sequence divided into four zones, labelled I at the top through to IV at the base. Table 10.2 lists the spits attributed to each analytical unit, and the estimated age range of those zones. The rationale for the divisions is based on a combination of dating and stratigraphic considerations.

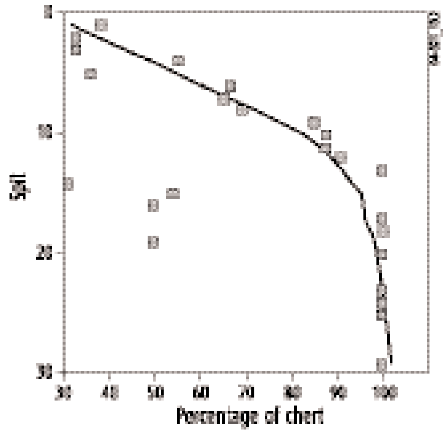

Figure 10.2 Liang Lemdubu: long-term trend in raw material composition as revealed by a Lowess curve fitted to 80% of data points

Zone I represents Spits 1–4, comprising Layers 1 and 2, and is Holocene in age on the basis of radiometric dating and the analysis of archaeo-fauna (see Chapter 9, this volume). Spit 5 is considered to be of uncertain chronological attribution, perhaps being a mixed level, and was excluded from statistical analyses of zones. Faunal evidence suggests that this zone represents a rainforest environment with no grassland areas close to the site (see Chapter 9, this volume).

Zone II contains Spits 6–11, which represents sediments laid down in Layer 3, primarily during the terminal Pleistocene. This zone represents a transitional environment, with the decline of grassland patches.

Zone III consists of a small number of spits (12-16) that are estimated to date from approximately 18,000 to 14,000 BP. These spits lay stratigraphically above the burial that is found in Zone IV. The faunal suite recovered from this zone indicates the existence of extensive tracts of open savannah.

Zone IV comprises those parts of the deposit in and below Spit 17. This combination of spits was selected because the inferred burial pit reported by Bulbeck (Chapter 12, this volume) is likely to have been dug from the surface of the deposit when it was represented by the sediments in Spit 17. Consequently, although the fill of the pit was not differentiated from the *in situ* sediments during excavations, both the pit fill and the pre-existing sediments are combined in this single analytical unit, which therefore dates to an age greater than approximately 18,000 years. The faunal suite recovered from this zone, like that of Zone III, is indicative of extensive tracts of open savannah.

Table 10.2 Liang Lemdubu: analytical divisions of the sequence

ZONE	SPITS (YEARS BP)	APPROXIMATE AGES	DURATION (YEARS)
I	1–5	0–9255	9255
II	6–11	9255–13,910	4655
III	12–16	13,910–17,785	3875
IV	17–9	17,785–28,580	10,795

Nabulei Lisa chronology

The chronology of the Nabulei Lisa sequence has been discussed in Chapter 7 and is used here for interpretation of the lithic sequence. The lithic interpretation centres on the differentiation of two analytical zones as a device for analysis. The rationale and chronology for two zones at Nabulei Lisa can be outlined as follows (see Table 10.3).

Zone I covered Spits 1–29, representing Layers 1–3 and the upper portion of Layer 4 (see Chapter 7, this volume). Radiometric examinations suggest this zone represents the last 10–12,000 years. The faunal assemblage from these levels has been interpreted as indicating the onset of extensive closed rainforest, the loss of grassland habitats, and the subsequent establishment of tidal conditions (see Chapter 7, for full details).

Zone II consisted of Spits 30–38, all of which were removed from Layer 4. Dating of spits from this zone indicates a terminal Pleistocene antiquity, of approximately 16,500–12,000 BP. Faunal assemblages in this zone show high relative abundance of *M. agilis* and the presence of taxa such as *Dorcopsis*, and probably reveal the presence of open grasslands in the vicinity of the site.

Table 10.3 Liang Nabulei Lisa: analytical divisions of the sequence

ZONE	SPITS (YEARS BP)	APPROXIMATE AGES
I	1–29	0–11–12,000
II	30–38	12,000–16,500

Comparison of chronological frameworks

These analytical divisions imposed on each site facilitate comparison between the assemblages. At a broad level Zones I at each site are contemporary, as are the Zone II assemblages, though there is no analogue at Nabulei Lisa for the material represented in Zones III and IV at Lemdubu. However, comparisons of these analytical units can only be made at a general level in recognition of the imprecision of current dating, and that the long time spans represented in each zone mean that the assemblages are 'time-averaged' samples of artefacts discarded during a number of occupational events — a point long recognized in archaeological and palaeontological literature (e.g. Bailey 1983; Behrensmeyer 1982, 1984; Behrensmeyer and Schindel 1983; Flessa et al. 1993; Fursich and Aberhan 1990; Potts 1986). Short-term strategies and variations in foraging and technological activities may not be discernible at the chronological resolution available in these analytical zones, and the following discussions concentrate on pronounced temporal trends in stone-working technology apparent at the two sites.

Table 10.4 Comparison of the Lemdubu and Nabulei Lisa chronology

APPROXIMATE AGES (YEARS BP)	PALAEOCLIMATE	LEMDUBU	NABULEI LISA
<12,000	Entire Holocene	Zone I (Spits 1–4)	Zone I (Spits 1–29)
ca. 12,000–ca. 14–16,000	Terminal Pleistocene	Zone II (Spits 6–11)	Zone II (Spits 30–38)
ca. 14,000–18,000	Final stage of LGM	Zone III (Spits 12–16)	N/A
>18,000	Earlier stage of OIS2	Zone IV (Spits 17–29)	N/A

Key Issues in Artefact Analysis

Regional and chronological comparisons are often said to drive artefact analyses, but in itself such comparisons do not generate the standard analytical frameworks so often applied to archaeological assemblages in Island Southeast Asia. In reality, those typological frameworks derive from an essentialist perspective on variation combined with an interest in the ideas of the artisan (see Hiscock in press, for an extended critique). Such typological perspectives, often with a French aetiology, have been widely applied despite the key notions being increasingly challenged. One effect of the persistence of typological analyses is that many assemblages have been described only in terms of those retouched flakes and cores thought to have been 'tools'. This approach is incapable of describing technology in those localities and regions where prehistoric strategies did not focus on the production of such items, a point that Australian researchers have repeatedly noted. What was immediately apparent from a cursory inspection of these two Aru assemblages is the infrequency of retouched flakes and cores, a characteristic that lends itself to a non-typological technological study using the materialist perspective outlined by Hiscock (in press). Within that framework the key issues to be examined include the analytical method and the chronological resolution available.

Analytic methods

Central to the investigation of the Aru assemblages is the measurement of characteristics about each specimen. The attribute analysis provides information about the range of technological activities evidenced in the assemblage, the contribution of taphonomic processes to the formation of the material, the economic context of the site, and the antiquity of human use of the site. Like many attribute analyses undertaken in archaeology the approach employed here involves measuring a number of interval variables to describe the size and shape of flakes, and a number of nominal variables to describe the treatment to the core (or retouched flake) prior to the production of the flake. The variables used in this study are defined in Table 10.5, and with the exceptions noted these definitions are consistent with those provided by Hiscock (1986a). One way to employ such measurements is as a quantified image of the various actions and products represented in an assemblage, in which the frequency of meaningful characteristics is measured. Applied to the two Aru assemblages, the attribute analysis can characterize the technology represented to describe the reduction system: the frequency of manufacturing patterns (Hiscock 1993:65).

Table 10.5 List of variables measured in the attribute analysis of stone artefacts

NOMINAL VARIABLES	DEFINITION
Amount of cortex	Amount of cortex on the dorsal face, measured in three categories
Artefact characteristics	Presence or absence of: an external initiation for the fracture, a bulb of force, a fracture termination, a platform, or negative scars
Colour	Dominant colour on the standard rock-color chart scale
Crazing	Presence of surface crazing
Crenated	Presence of crenated fractures
Flake termination	Form of the fracture termination on a flake, using HoHo committee terminology (feather, hinge, step, and outrepasse)
Fracture Initiation	The nature of fracture initiation: either Hertzian or bending initiations
Fragment (Breakage)	The portion of a flake represented by the specimen, using the categories discussed by Hiscock (2002)
Overhang removal	Presence of small scars on the dorsal face indicating the removal of platform overhang
Length	Distance from fracture initiation to fracture termination
Platform surface	The condition of the platform surface: cortex, single scar, multiple scars or unknown
Platform thickness	Distance from ventral to dorsal faces, across the platform surface
Platform width	Distance across the platform surface from one lateral margin to the other
Potlidding	Presence of negative or positive potlid scars
Raw material	Category of rock on which the artefact was made (silicified limestone, chert or other)
Retouch	Presence of retouch scars on a flake
Thickness	Distance from ventral to dorsal face, at intersection of length and width
Type	Category of artefact (flake, core or flaked piece), as defined by Hiscock (in press)
Weathering	Category of weathering (Fresh, light Patination, Patination, Heavily Weathered) after Hiscock (1985)
Weight	Weight of the specimens in grams
Width	Distance from one lateral margin to the other, half way along the length

Lithics at Liang Lemdubu

The archaeological sequence from Liang Lemdubu is the longest yet recovered from the Aru Islands. Since stone artefacts are known from most levels of this site it represents an opportunity to characterize the lithic assemblage through time.

Artefact identification

In a site such as Lemdubu, where small numbers of chert and limestone artefacts exist within a deposit containing large quantities of naturally fractured chert and limestone fragments, the issue of accurate artefact identification is paramount. The question of how to differentiate natural from human conchoidal fractures has posed great difficulties for archaeological interpretations. In the archaeological literature, one focus has been on examining situations in which natural mechanisms were available and could conceivably have created fractures. One of the classic studies, by Alfred Barnes (1939), suggested that it might be possible to distinguish natural from human flakes by looking at the angle between the platform and the dorsal face. The notion was that humans controlled fracture by keeping the angle low, whereas natural mechanisms could not regularly duplicate that pattern. So, Barnes concluded, if 75% or more of flakes had acute angles the material could be considered to have been produced by humans. This principle was derived through a study of material in glacial areas. More recently, the range of contexts in which natural hertzian fractures occur, and therefore the diversity of fracture forms, has been recognized as too great to be dealt with using a simple principle like Barnes'. For example, Bryan and Schnurrenberger (1985) discuss the variation in natural mechanisms that can cause fracture. They point out that while fracture produced by static loading in high energy environments (such as during glacial transport) often produces obtuse platform angles, dynamic loading in other environmental situations often produces acute platform angles. For this reason, they argue that the interpretation of fractured rocks as artefacts should be made with regard to their context: 'it must be demonstrated that the type of alteration exhibited by the specimens is anomalous in their reconstructed geomorphic context' (Bryan and Schnurrenberger 1985:139).

In Lemdubu 527 specimens were accepted as having adequate morphological features to indicate unambiguously that they were anomalous within the cave context, and are explicable only as the result of human knapping. Within the site there are no obvious natural mechanisms capable of inducing mechanical fractures, apart from rare roof fall events. Evidence from the deposit is consistent with the rarity of fracture mechanisms: crushing is rare on debris recovered from the sieves; and multiple, step terminated fractures are also rare. The material recovered from the sieves was divided into two groups: non-artefactual fragments (those with no morphological evidence for manufacture, including heat shattered rocks), and artefacts.

The objects identified as artefacts at Lemdubu conform to typical archaeological patterns in similar cave contexts. The assemblage comprises conchoidal flakes with acute platform angles and dorsal scar arrangements that are typically highly patterned. Specimens were only accepted as artefacts if they possessed diagnostic features indicating controlled blows producing conchoidal fracture. The characteristics deemed important in this context were:

1) a platform to which the blow was applied (85% of artefacts displayed this attribute);
2) signs of an external initiation to the fracture surface, such as a ringcrack or cone of force (91% of artefacts);
3) a bulb of force on the ventral surface of a flake (72% of artefacts);
4) a termination to the conchoidal fracture plane (91% of artefacts); and
5) one or more negative scars (92% of artefacts).

These characteristics easily distinguished flaked specimens from the rounded and weathered gravel in which they were lodged. The frequency of these features varied between the raw material, and the percentage of complete specimens identified as artefacts with each feature is summarised in Table 10.6. Many specimens have all, or almost all, of the characteristics. Of 394 complete flakes of chert and limestone, 279 (70.1%) have all five features, a further 103 (26.1%) have four features, and 16 (4.1%) have three features. The reliability of the identification of the specimens as artefactual is enhanced by the presence of multiple characteristics on most of the objects.

Table 10.6 Liang Lemdubu: proportions of characteristics in complete flakes by material

RAW	CHARACTERISTICS PRESENT AS PERCENTAGES OF SAMPLE					
MATERIAL	EXTERNAL INITIATION	PLATFORM	BULB OF FORCE	TERMINATION	NEGATIVE SCARS	N
Chert	302	286	253	300	293	302
	(100%)	(94.7%)	(83.8%)	(99.3%)	(97.0%)	
Limestone	92	83	54	91	79	92
	(100%)	(90.2%)	(58.7%)	(98.9%)	(85.9%)	
Total	394	369	307	391	372	394
	(100%)	(93.7%)	(77.9%)	(99.2%)	(94.7%)	

Raw materials and material acquisition

The 527 artefactual specimens recognized were classified into three raw material categories: chert, limestone, and 'other'. The limestone was a rough-textured, grey rock consistent with an unaltered or partly silicified dolomitic limestone. Cherts were rough-textured cryptocrystalline silica — white, grey and yellow in colour — and consistent with the form of chert that can be obtained in limestone and dolomitic landscapes. 'Other' is a catch-all category for rocks not described in the categories listed above: primarily fine-grained siliceous sedimentary rocks other than chert.

Of the 527 objects recorded 75% was chert, 24.1% was limestone and 0.9% was other materials. In the following sections statistics are only calculated for chert and limestone since only they constitute adequate samples. The excavators did not locate the source(s) of these materials, but it is likely that they were available in the immediate vicinity of the site. Intriguingly, there is a distinct temporal trend in the proportions of raw materials, a pattern that can be expressed in terms of the percentage of chert per spit through the archaeological sequence (see Table 10.7). Expressed by zone, the relative abundance of either chert or limestone is sufficiently different that they can have little chance of arising randomly (Table 10.8).

Figure 10.2 represents the trend in a visually digestible manner, with a Lowess curve fitted to 80% of data points. Two observations can be made about these data. Firstly, the overall trend as represented by the smoothed trend line (i.e. the Lowess curve), is that chert is the primary raw material in the lower half of the sequence, but the proportion of chert declines as it is replaced by limestone, until at the surface chert artefacts constitutes only about one third of the assemblage. A second pattern is an exception to the general trend, with four spits containing half the proportion of chert that would be predicted by the smoothed curve of the general trend (Spits 19, 16, 15, and 14). All four spits fall in Zone III, as defined earlier, dating approximately to the latter stage of the last glacial maximum (LGM). These spits represent outliers which may reflect a period in which material procurement may have been different to that which occurred earlier in the LGM or during the terminal Pleistocene/early Holocene. However, the importance of these proportional changes in raw materials in Zone III is unclear in view of the small numbers of artefacts involved. For instance, it is possible that one or two knapping events involving limestone rather than chert could be responsible for these exceptions to the long-term trend. However, it is also plausible that these dramatic departures from the long-term trend represent some shift in raw material procurement

Table 10.7 Liang Lemdubu: vertical changes in artefact abundance by raw material

SPIT	CHERT	LIMESTONE	OTHER	TOTAL	%CHERT
1	5	8	0	13	38.5
2	2	4	0	6	33.3
3	3	6	0	9	33.3
4	5	4	0	9	55.5
5	4	7	0	11	36.4
6	12	6	0	18	66.7
7	48	24	1	73	65.8
8	45	19	1	65	69.2
9	74	13	0	87	85.1
10	123	17	0	140	87.9
11	28	2	2	32	87.5
12	10	0	1	11	90.9
13	1	0	0	1	100.0
14	4	9	0	13	30.8
15	6	5	0	11	54.6
16	2	2	0	4	50
17	8	0	0	8	100
18	5	0	0	5	100
19	1	1	0	2	50
20	1	0	0	1	100
21	0	0	0	0	
22	0	0	0	0	
23	1	0	0	1	100
24	4	0	0	4	100
25	2	0	0	2	100
26	0	0	0	0	
27	0	0	0	0	
28	0	0	0	0	
29	1	0	0	1	100
Total	395	127	5	527	75.0
	(%)	(75.0%)	(24.1%)	(0.9%)	

Table 10.8 Liang Lemdubu: comparison of raw material abundance by Zone (Zone IV excluded because of zero cells)

ZONE	CHERT	LIMESTONE	TOTAL
I	15	22	37
II	330	81	411
III	23	16	39
Total	368	119	487

χ^2 = 35.369, d.f. = 2, $p < 0.001$

strategies during the LGM. Complicating any such interpretation is the question of whether artefacts were made at Lemdubu or simply transported here, in which case procurement took place at some other point in the landscape. I return to this issue later.

With these observations it is possible to characterize the use of raw material in each of the four zones (Table 10.9). The base of the archaeological sequence represents a period in which only chert was being procured for artefact manufacture. This may be interpreted as a highly selective but regular strategy for tool production in place during the early portion of Oxygen Isotope Stage 2 (OIS2); perhaps linked to a comparatively mobile or wide ranging foraging strategy capable of obtaining chert from a variety of localities.

During the later portion of the LGM, represented by Zone III, adjoining spits contain very different raw material proportions, a pattern which may well reveal different patterns of movement/foraging/procurement. In contrast to the preceding period, these differences in Zone III might reveal the existence of variable settlement systems or strategy switching during the harshest part of the LGM. An obvious explanation for these variable raw material compositions is the existence of embedded procurement within mobile foraging economies, that have changed spatial emphasis through time.

The terminal Pleistocene and Holocene, represented by Zones II and I contain a progressive transition from tool production strategies, emphasising the procurement and use of chert — perhaps obtained at some distance from Lemdubu — to strategies focussing on the flaking of limestone. In the absence of more specific information about raw material source distributions the most plausible hypothesis is that in the last 10–12,000 years there was a reduction in the radius of foraging and/or reduction in accessibility of chert sources, with a concomitant switch to the use of local material. Alternatively, or additionally, reduction in the reliance on stone artefacts may be related to a decline in the use of stone artefacts, and a switch from using relatively expensive material (chert) to a locally abundant and relatively inexpensive material (limestone).

Table 10.9 Liang Lemdubu: summary of changes in raw material by zone

ZONE	SPITS	RAW MATERIAL COMPOSITION
I	1–4	Limestone is the most common material on which flakes are made
II	6–11	Chert is consistently the dominant material being employed, but during Zone II it displays a progressive reduction in the level of dominance
III	12–16	Spit contents are radically varied, either containing all or almost all artefacts made on chert, or else having relatively little chert (<55%)
IV	17–29	With the exception of one artefact, in Spit 19, chert is the only raw material used for artefact manufacture

Trends in density

Chronological changes in artefact abundance are observable in the Lemdubu excavation. Figure 10.3 plots raw artefact counts by spit, and because spits are a uniform volume these plots effectively display vertical changes in artefact density within the deposit. If no taphonomic processes can be invoked to explain this pattern these density changes can be interpreted as a clear chronological trend in artefact accumulation. A pronounced unimodal curve is displayed in Figure 10.3, revealing low quantities of artefacts accumulating both early and late in the occupational sequence, separated by a period of comparatively high levels of artefact loss. The most

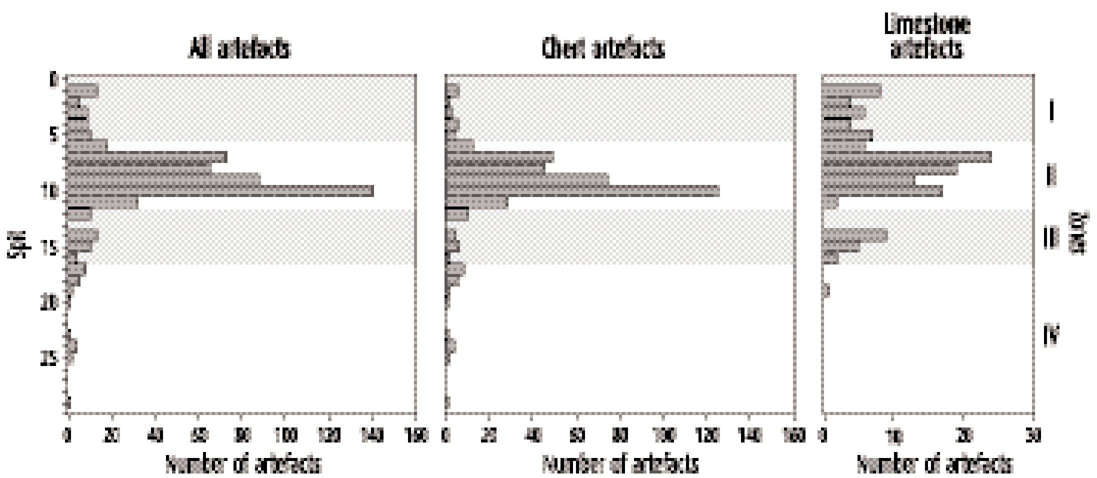

Figure 10.3 Liang Lemdubu: vertical changes in artefact numbers

pronounced rates of artefact accumulation occur in Spits 6–12: the late Pleistocene levels designated 'Zone II'. This chronological trend is apparent in both chert and limestone specimens, although more pronounced in the chert component of the assemblage.

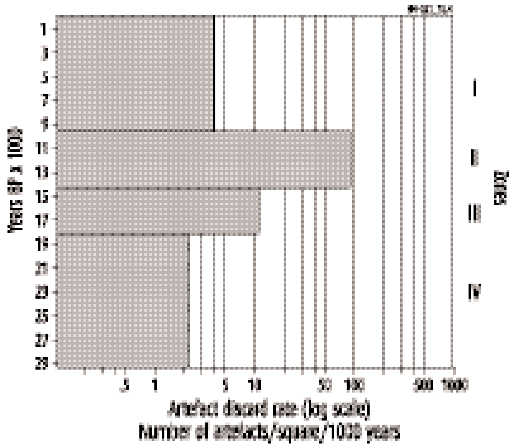

Figure 10.4 Liang Lemdubu: estimated discard rate by analytical zone

By re-expressing artefact numbers per square metre in terms of the duration of each zone, using the chronological estimates discussed above, it is possible to construct an image of chronological changes in the artefact accumulation rates in this portion of Lemdubu (see Fig. 10.4). These calculations indicate that during the terminal Pleistocene, represented by Zone II, artefact discard was approximately an order of magnitude higher than at any other period during human occupation of the locality. During the occupational sequence discard rates were extremely low prior to 20–18,000 BP; increased substantially during the latter part of LGM; increased substantially again immediately following the LGM; and decreased to a low level during the Holocene.

Interpreting this directional long-term trend is difficult for several reasons. For instance, this sequence derives from only one square metre (Test Pit C) and may reveal occupational patterns in only one part of the site. If preferred discard locations within the cave varied through time the changing accumulation rate in this test pit might reflect different discard behaviour rather than an overall shift in the level of artefact discard in the site. Without excavation and analysis of test pits from other parts of Liang Lemdubu this possibility cannot be excluded.

Another factor constraining interpretation is the complex issue of the extent to which variation in artefact numbers reflects variation in the intensity of occupation or change in the nature of cave use. Changes in the rate with which artefacts have accumulated may be signalling temporal variations in the frequency or nature of knapping, rather than changes in the level of all activities that took place during an occupation. This possibility was examined by looking at the degree of covariation between artefacts and faunal material. Weight of artefacts per spit or zone was used as the measure of artefact abundance and compared to selected categories of faunal material drawn from the data recorded by Aplin (Chapter 9, this volume). The relationship between the abundance of artefacts and faunal remains was examined using Spearman's correlations for the 24 spits containing artefacts. The results are listed in Table 10.10. The most noteworthy result in this table is the extremely poor relationship between the weights of artefacts and bones ($r = 0.145$, $p = 0.499$, $n = 24$; $r_S = -0.063$, $p = 0.768$, $n = 24$). Some spits with less than 10 artefacts have less than 200g of bone, while in other spits with similar artefact numbers there is more than five kilograms of bone. Table 10.10 also shows the coefficients for the relationship between artefacts and sub-groups of the faunal assemblage. These were calculated because at least a proportion of the bone is likely to derive from non-archaeological sources, and these sub-groupings are considered to be dominated by archaeological fauna. All bivariate comparisons reveal negligible covariation between artefact weights and the abundance of any of the categories of faunal material.

Table 10.10 Liang Lemdubu: correlations between weight of stone artefacts (g) and the quantity of bone using 24 spits

	WEIGHT OF ALL BONE	WEIGHT OF MAMMAL	WEIGHT OF THYLOGALE/PETROGALE	WEIGHT OF M.AGILIS	WEIGHT OF PHALANGER
Spearman's rank correlation	−0.063	−0.060	0.178	0.067	−0.008
(p value)	(0.768)	(0.781)	(0.405)	(0.756)	(0.971)

The reason for this non-correspondence of bone and stone is obvious in the visual comparison given in Figure 10.5, which expresses change by zone. Spits from the lower levels of the sequence, representing Zone IV, contain very few artefacts but generally have large quantities of bones. The earliest phase of occupation was one in which very large quantities of bone were deposited without much evidence of artefact use or discard. During later occupation, represented by Zones I–III, artefact discard is apparently more balanced with the quantity of fauna that was processed. The intriguing result of this analysis is a change in the relationship of artefacts and fauna at the end of Zone IV and the start of Zone III. In Zone IV there are very few artefacts at all, and large quantities of bone that vary independently of the artefacts. In Zones I to III artefacts are not only far more abundant and bones less abundant but artefacts and bone appears to covary by spit in a far stronger way (r = 0.668, p = 0.005, n = 16; rs = 0.438, p = 0.09, n = 16). This alteration in the relationship of bone and artefact discard is distinct and may well mark either a change in the function of the cave or a change in the discard patterns within the cave. In either case the final stage of the LGM marks an alteration in human behaviour at Liang Lemdubu.

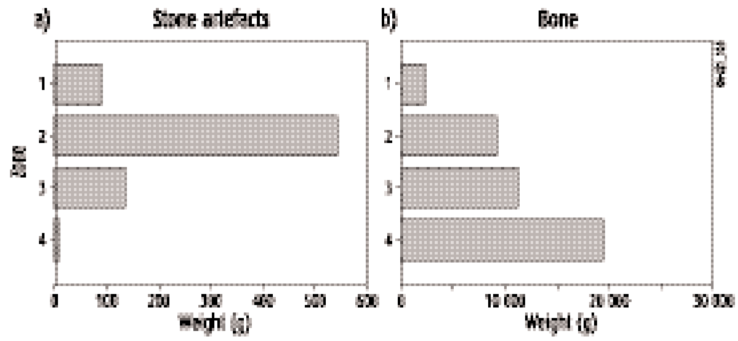

Figure 10.5 Liang Lemdubu: graphical comparison of temporal trends in the weight of a) stone artefacts and b) bone by analytical zone

Taphonomic processes

Changes in abundance of archaeological material should always be interpreted in light of a study of taphonomic processes. Stone artefacts are not immune to the sorts of taphonomic processes that effect other classes of archaeological material (Hiscock 1985). In the Australasian region two processes are frequently documented from limestone caves and rockshelters: shattering of stone through exposure to heat, and weathering of stone in seasonally wet deposits (see Hiscock 1988). Both of these processes are frequent in the Lemdubu assemblage, and need to be examined in some detail.

Artefact fragmentation

Fragmentation of rocks in this assemblage is likely to have occurred for a number of reasons, including exposure to fire, the knapping process itself, and post-depositional mechanical damage. Of the 518 flake fragments recognized, 23% were broken (Table 10.11). One consequence of this fragmentation is that the actual number of flakes represented may be less than a simple count of the fragments. As a result, calculations of artefact abundance are necessary.

Table 10.11 Liang Lemdubu: flake breakage by raw material

	COMPLETE*	PROXIMAL	MEDIAL	DISTAL	LCS	TOTAL
Chert	302	27	5	25	31	390
Limestone	92	6	0	10	16	124
Other	4	0	0	0	0	4
Total	398	33	5	35	47	518

* One specimen was encrusted and material could not be determined. It was excluded from this table

A simple estimate of the original number of flakes in this assemblage is provided in Table 10.12. This is achieved by counting only those flake fragments with platforms, since this is one indication of the number of blows represented by flake fragments in the collection. This kind of procedure is widely advocated in the literature (see Andrefsky 1998). In this estimation complete flakes, proximal fragments, and longitudinal cone-split fragments (LCS) have been employed to estimate the number of flakes that originally existed.

Table 10.12 Liang Lemdubu: flake breakage by raw material

	COMPLETE	PROXIMAL	LCS	ESTIMATED FLAKING EVENTS	%
Chert	302	27	31	360	75.3
Limestone	92	6	16	114	23.9
Other	4	0	0	4	0.8
Total	398	33	37	478	

A more sophisticated estimate of minimum numbers of flakes (MNF) can be obtained using Hiscock's (2002) procedure involving the equation MNF = C + T + L, where C is the number of complete flakes, T is the largest category of transverse fragments excluding medial fragments (i.e. the greater of the number of proximal fragments or distal fragments), and L is a count of longitudinal fragments. For chert this MNF value is 350 (= 302 + 27 + 21) or 74% of the assemblage, for limestone the calculated MNF value is 117 (= 92 + 10 + 15) or 25% of the assemblage, and for other materials it is 4 or 1% of the assemblage. Hence, the total MNF value for the assemblage (calculated from $MNF_{chert} + MNF_{limestone} + MNF_{other}$) is 471.

Of course, this estimate is a minimum one. In addition to the cores and flake fragments there were eight flaked pieces that must have derived from shattered cores and/or flakes. Furthermore, it is possible that some artefacts were heat shattered to such an extent that the fragments can no longer be recognized, and are not represented by artefactual fragments. Hence the minimum estimate of 459 may well represent up to 500 artefacts.

One thing that is obvious from these counts is the low intensity of artefact use, and perhaps occupation throughout the archaeological sequence. Over a period of perhaps 29,000 years, even 500 artefacts per square metre represents only 17 artefacts/1000 years/square metre. Given that many of these artefacts are very small (see below) it is likely that many are production debris that represent minimal activity beyond maintaining a few tools. As a very rough indication of the level of activities that may be involved here, Hayden (1979:166) estimated that at Walukaritji and Ngarulurutja, two sites in the Western Desert, the debris created by tool production and maintenance was 6.7 artefacts/person/week and 28–57 artefacts/person/week respectively. Acknowledging the difference in environmental context and tool form, this kind of ethnographic measure suggests that the artefactual debris may only reflect a few people visiting the site for a day or two every few years. These calculations should not be taken literally, as many factors including different site functions may make a recent Australian analogue inappropriate, but they can be used to reinforce the impression of this site as the location of occasional occupation by small groups.

Fire

Approximately one in eight artefacts (11.4%) display evidence of heat damage in the form of crenation, potlid scars, or surface crazing. Table 10.13 records the proportions of these categories of heat damage by raw material category. There appear to be differences in the frequency of thermal damage between raw materials, with chert having a far higher rate than limestone. Non-random differences between chert and limestone are confirmed by chi-squared statistics (Table 10.14), even when Zone II alone is examined to remove the effects of any chronological change (Table 10.15). These differences probably reflect the resilience of each material to heat. Consequently, any attempt to measure chronological changes in the abundance of heat damage will need to examine each rock type separately.

Table 10.13 Liang Lemdubu: thermal damage by raw material

	% CHERT (N=395)	% LIMESTONE (N=127)	% OTHER (N=5)	% TOTAL (N=527)
Crenation	4.8	3.9	20.0	4.7
Potlid	9.6	3.9	0	8.2
Crazing	1.0	1.6	0	1.1
Total damage*	13.4	4.8	20.0	11.4

* Total is not a column sum because some specimens have more than one kind of damage

Table 10.14 Liang Lemdubu: thermal damage by raw material

	CHERT	LIMESTONE	TOTAL
Unheated	342	120	462
Heated	53	6	59
Total	395	126	521

χ^2 = 6.291, d.f. = 1, p = 0.012, V = 0.117

Table 10.15 Liang Lemdubu: thermal damage by raw material for Zone II

	CHERT	LIMESTONE	TOTAL
Unheated	287	77	364
Heated	39	3	42
Total	326	80	406

χ^2 = 3.828, d.f. = 1, p = 0.05, V = 0.107

Temporal changes in thermal damage to chert flakes are described by the data listed in Table 10.16. Upper portions of the artefactual sequence, represented by Zones I and II, have roughly 13% of artefacts thermally damaged, whereas the lower Zones III and IV have more than 20% of specimens damaged. It is tempting to interpret this vertical change in the relative abundance of thermal damage as an indication that heat sources, such as fires, may have been more frequent or intense during the earlier parts of the Lemdubu sequence. However, such a conclusion is unwarranted, since the abundance of heat damage is likely to reflect a number of other factors in addition to heat sources. For instance, the rate of thermal shattering is likely to be related to sedimentation rates, since the length of time artefacts are exposed on or near the ground surface will be positively related to the probability of damage being sustained (see Hiscock 1985). Sedimentation rates in Lemdubu were higher in Zones III and II than earlier or later in the sequence, a pattern that parallels far higher accumulation rates for heat shattered specimens in Zones II and III (Spearman's r = 0.8, N=4). The conjunction of sedimentation and heating rates is the opposite of what would be predicted if thermal damage was proportional to the stability of the cave surface, possibly indicating that exposure of artefacts to heat sources was greatest during the LGM and terminal Pleistocene (see Fig. 10.6). However, the abundance of heat affected artefacts in the Lemdubu sequence is probably caused by variations in sample size. Impressively strong correlations exist between

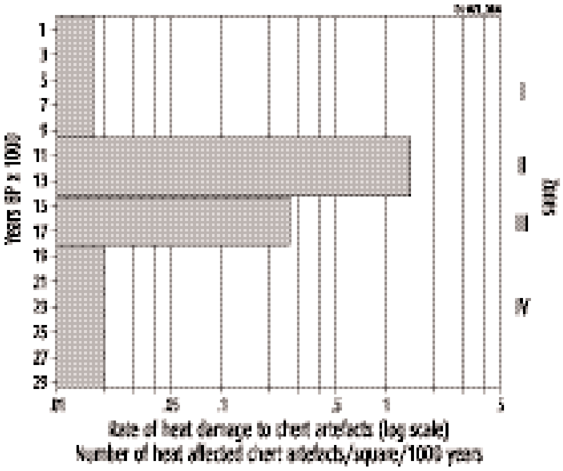

Figure 10.6 Liang Lemdubu: calculated accumulation rates for thermally affected chert artefacts by zone

the number of chert artefacts per spit and the number of artefacts with crenations (r = 0.95), with potlid scars (r = 0.88), and with crazing (r = 0.71). All of these correlations are significant at the p = 0.001 level. These statistics are best interpreted as indicating that the numbers of heat shattered fragments vary in response to changing artefact abundance; and perhaps when artefacts are more frequent they are more often exposed to heat sources, even when the abundance and nature of heat sources remains unchanged. Consequently, it is not possible to interpret heat shattering in Lemdubu as revealing temporal differences in site use. Regardless of this conclusion, the changing artefact density described above demands explanation.

Table 10.16 Liang Lemdubu: thermal damage by zone for chert flakes

ZONE	CRAZING	CRENATION	POTLIDDING	TOTAL THERMALLY DAMAGED*	% FLAKES DAMAGED	TOTAL ARTEFACTS
I	0	2	0	2	13.3	15
II	3	12	33	41	12.4	330
III	0	3	5	8	21.6	37
IV	1	2	0	2	22.2	9
Total	4	19	38	53	13.6	391
	(1.1%)	(4.8%)	(9.6%)			

* Total is not the sum of crazing, crenation and potlidding because some specimens have more than one kind of damage

Weathering

One characteristic of the Lemdubu chert artefacts that is immediately obvious is that they vary in colour. More interestingly, the colours change systematically through the deposit. These changes were quantified by recording the colour of each artefact using the Rock-color Chart distributed by the Geological Society of America. Table 10.17 presents the percentage of chert artefacts in each of 22 colour categories represented in the assemblage. Common colours include white (N9), light grey (N7-8), medium grey (N5), pinkish grey (5YR 8/1), light brownish grey (5YR 6/1), and pale yellowish brown (10YR 6/2). Some of these colour classes probably reflect the colours of chert being knapped, but the changes in the frequency of each colour class through the deposit are also likely to reflect alteration of the colour through processes such as weathering. This can be examined by characterising the colour frequencies for each zone.

Changes in the colour of chert artefacts at different depths in the deposit were quantified by zone. Interpreting these changes is complicated by the variation in sample sizes between the zones. This is shown by the strong Pearson's correlation between number of colour categories and number of chert artefacts per zone (r = 0.94, r2 = 0.87, p = 0.07), and a similarly strong Spearman's rank coefficient (r_S = 1.0, p < 0.0001). Zones I, III, and IV have a small range of colours compared to Zone II, and while this pattern may have other causes it is consistent with their low sample sizes.

Table 10.17 Liang Lemdubu: colours of chert artefacts (N=395)

		CHROMA (SATURATION)											
		HUE 5YR				HUE 10YR			HUE 5Y				N
		/1	/2	/4	/6	/2	/4	/6	/1	/2	/4	/6	/0
Value (Lightness)	9/												11.6
	8/	12.4		0.8		2.0		0.3	2.5				10.1
	7/		0.5				1.3						9.6
	6/	17.5		2.0		6.1			1.5		0.3		6.1
	5/		1.5				0.3						6.8
	4/	2.3											3.5
	3/												0.5

However, the differences in the frequency of colours between zones is not easily explained in this way. Trends from pinkish greys, brownish greys, and yellowish browns towards whites and greys, and from darker to lighter, can be observed from the surface to the base of the deposit. These trends are illustrated in Figure 10.7, which graphically depicts an increase in greys/whites and of lighter shades with increasing depth.

These vertical trends in the colour of chert artefacts through the sequence display a relationship with the erosion and weathering of the chert. The measurement of weathering here follows the approach developed by Hiscock (1985) in his description of the dolomitic chert artefacts from the small limestone rockshelter at Colless Creek in northern Australia. Although weathering is probably a continuous process four categories were distinguished as a means of quantifying the changes in the Lemdubu chert artefacts:

1) fresh — in which the fracture surfaces of the chert are hard, lustrous, and the same as the interior of the artefact;
2) light patination — where the surface appears to have a dull film, and may be mottled, some areas having the appearance of fresh chert and others displaying a patina;
3) patinated — where the texture of the surface has become dull and rough. Broken specimens reveal that while the weathering is not confined to the surface it need not occur throughout the entire artefact; and
4) heavily weathered — where the artefact is porous, and has become crumbly and powdery. Broken artefacts show that this degree of weathering occurs uniformly throughout the entire artefact.

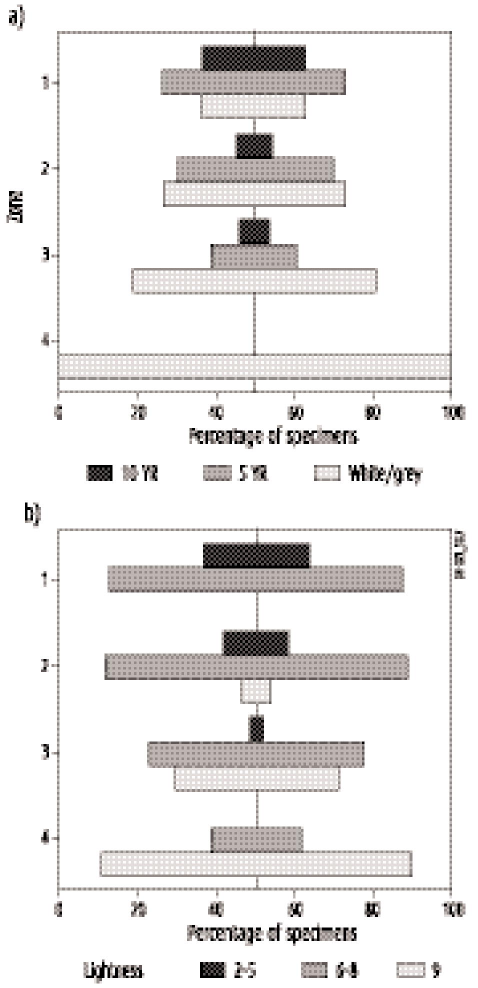

Figure 10.7 Liang Lemdubu: changes to the colour of chert artefacts in a) hue and chroma, and b) value (i.e. lightness)

Using these categories it is possible to quantify the relationship between aspects of colour and the extent of weathering. Table 10.18 shows that fresh chert is dominated by darker values, heavily weathered chert specimens are never dark and are often extremely light, with intermediate weathering categories being dominated by values of intermediate lightness. On the basis of this pattern it is likely that variation in colour in the Lemdubu assemblage is largely a consequence of different levels of weathering. Consequently, the vertical changes in chert colour within the deposit probably reflect changes in the levels of artefact weathering quantified in Table 10.19.

Variations through the deposit in the relative frequencies of these weathering categories appear to be independent of the frequency of heat damage. Table 10.20 documents this for chert flakes in Zone II, revealing that differences in the frequency of heat damage between the three weathering classes frequently represented in that zone may simply be due to chance. The independence of weathering and heat damage is not surprising in Lemdubu since it has already been demonstrated that there are no chronological changes in heating frequency that cannot be explained in terms of sample size. The chronological changes in weathering classes are clearly patterned in a different way.

Table 10.18 Liang Lemdubu: percentage of chert specimens in each weathering category by lightness category

LIGHTNESS	FRESH	LIGHT PATINATION	PATINATION	HEAVILY WEATHERED
9/	0	0.7	3.4	41.7
6–8/	36.3	75.7	83.6	58.3
2–5/	63.7	24.6	13.0	0

Table 10.19 Liang Lemdubu: relative abundance of weathering categories on chert artefacts

SPIT	LIGHT FRESH	PATINATION	HEAVILY PATINATED	TOTAL WEATHERED	NUMBER
1	3	1	1	0	5
2	1	1	0	0	2
3	0	3	0	0	3
4	3	1	1	0	5
5	0	0	4	0	4
6	3	6	3	0	12
7	1	20	21	6	48
8	0	28	13	4	45
9	0	52	19	3	74
10	0	25	61	37	123
11	0	1	16	11	28
12	0	0	6	4	10
13	0	0	0	1	1
14	0	0	1	3	4
15	0	0	0	6	6
16	0	0	0	2	2
17	0	0	2	6	8
18	0	0	1	4	5
19	0	0	0	1	1
20	0	0	0	1	1
21	0	0	0	0	0
22	0	0	0	0	0
23	0	0	0	1	1
24	0	0	0	4	4
25	0	0	0	2	2
26	0	0	0	0	0
27	0	0	0	0	0
28	0	0	0	0	0
29	0	0	0	1	1
Overall	11	138	149	97	395
Assemblage	(2.8%)	(34.9%)	(37.7%)	(24.6%)	

Table 10.20 Liang Lemdubu: relationship between heat damage and weathering categories for chert flakes in Zone II

	HEAT DAMAGE		TOTAL
	ABSENT	PRESENT	
Light patination	111	19	130
Patination	115	16	131
Heavily weathered	57	4	61
Total	283	39	322

χ^2 = 2.535, d.f. = 2, p = 0.282, V = 0.089

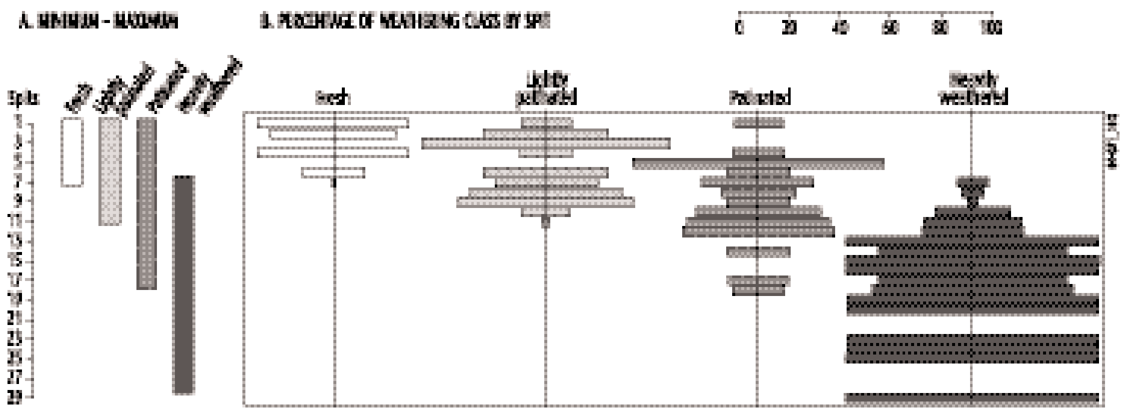

Figure 10.8 Liang Lemdubu: changes in weathering through the sequence

As shown in Figure 10.8, the proportion of artefacts in each weathering class varies vertically in a manner consistent with increased intensity of weathering at greater depth in the deposit. Departures from smooth battleship curves are directly related to spits with only one, two or three artefacts. Fresh chert artefacts extend down only six spits. Lightly patinated artefacts do not become common until Spit 6 but extend down only to Spit 11. Patinated artefacts are numerically dominant in Spits 10–12, although they extend down to Spit 18. Heavily weathered artefacts are not common until Spit 13, but below that point in the deposit almost all artefacts are highly altered by weathering. In the lower spits all chert artefacts are heavily weathered.

Several inferences can be drawn from these data on the distribution of weathering categories within the deposit:

1) the patterns are consistent with a decay of chert over time, with all chert artefacts being deposited in a fresh state and becoming progressively more weathered as they lay buried in the deposit. Hence the longer the artefacts have lain buried in the deposit, the more altered they are;
2) the rate of chert weathering can be broadly established by reference to the radiometric dates available for the cave. For instance, no artefacts remained in a fresh state for as long as 8000 years, and after 16–18,000 years have elapsed all artefacts had been altered to a point where they were patinated or heavily weathered; and
3) the absence of fresh or lightly patinated artefacts from the lower levels of the deposit should be interpreted as evidence that the deposit has not been homogenised by vertical movement of objects, and that the four zones defined earlier are a useful representation of chronologically different assemblages. Zone I is characterized by frequent fresh artefacts, Zone II by many lightly patinated and patinated artefacts, Zone III by patinated and heavily weathered specimens, and Zone IV contains only heavily weathered artefacts. These weathering patterns provide independent evidence of chronological differences between the artefacts in these analytical zones, thereby validating the interpretation of inter-zonal differences as a chronological sequence. Assemblage changes through time can therefore by recognized in the Lemdubu material.

Technological Interpretations

Artefact classes

A consistent pattern throughout the Liang Lemdubu sequence is the absence of cores. The artefact assemblage is dominated by flakes — only a few of which are retouched (see below) — and a few ‘flaked pieces’ (fragmentary specimens with negative scars unable to be classified as either flakes or cores). The relationship between artefact type and raw material is listed in Table 10.21. Based on these data it can be emphasised that cores are too infrequent to account for the flakes and flake fragments. The likely explanation for this pattern is one of three mechanisms, working individually or in combination:

1) flakes may have been made elsewhere and transported to this locality without cores;
2) cores might have been preferentially removed from the site; and
3) flakes may have been produced by knapping retouched flakes rather than cores.

These models will be considered in light of more detailed information about flake sizes.

Table 10.21 Liang Lemdubu: counts of artefacts by raw material

	FLAKES	FLAKED PIECES	TOTAL	(%)
Chert	390	5	395	(75.0)
Limestone	124	3	127	(24.1)
Other	5	0	5	(0.9)
Total	519	8	527	(100)
(%)	(98.5)	(1.5)	(100)	

Artefact sizes and shapes

The characteristics of these artefacts can be evaluated using a number of standard measures. Complete flakes have been used to indicate the characteristics of flaking in this assemblage. Descriptive statistics for flake size and shape are provided in Table 10.22. Variation between raw chert and limestone is apparent in these data, with the platforms of chert flakes being distinctly smaller than those of limestone flakes. However, the size and shape of chert and limestone flakes are remarkably similar in other traits. Taking flakes of all materials it is clear that the assemblage is dominated by small, squat flakes.

Table 10.22 Liang Lemdubu: descriptive statistics for the size and shape of complete flakes by raw material

VARIABLES	ALL MATERIALS	CHERT	LIMESTONE	DIFFERENCE BETWEEN CHERT AND LIMESTONE	IS THIS DIFFERENCE DUE TO CHANCE?
Length	14.1±7.3 (N=400)	14.2±7.5 (N=303)	13.7±5.8 (N=92)	t = 0.69 p = 0.485	Very likely
Width	14.5±7.2 (N=400)	14.1±7.1 (N=303)	15.7±7.4 (N=92)	t = -1.85 p = 0.065	Fairly unlikely
Thickness	3.3±2.3 (N=399)	3.2±2.3 (N=302)	3.4±1.8 (N=92)	t = 0.83 p = 0.406	Very likely
Platform width	9.1±8.1 (N=341)	8.3±5.8 (N=259)	11.4±5.9 (N=78)	t = -4.14 p = 0.001	Extremely unlikely
Platform thickness	2.4±2.0 (N=338)	2.1±1.9 (N=256)	3.2±2.1 (N=78)	t = -4.33 p = 0.001	Extremely unlikely
Elongation	1.0±0.4 (N=400)	1.1±0.4 (N=303)	0.9±0.4 (N=92)	t = 2.41 p = 0.017	Very unlikely
Area (mm^2)	241.9±258.5 (N=400)	238.5±255.9 (N=304)	242.5±218.9 (N=92)	t = -0.11 p = 0.913	Extremely likely
Weight (g)	1.5±3.5 (N=399)	1.5±3.6 (N=302)	1.4±2.1 (N=92)	t = 0.32 p = 0.748	Extremely likely

These patterns of flake size are not, of themselves, diagnostic of either particular forms of technology or of particular stages in a reduction process. However, the following statements are useful in typifying the bulk of the assemblage:

1) these generally small flakes are unlikely to have derived from early-stage reduction, including decortication. This inference is supported by the rarity of decortication flakes (see below);
2) reduction involves production of regular flakes but does not reveal frequent production of elongate flakes (sometimes called 'blades'); and
3) the majority of flakes are likely to have been removed from either large retouched flakes and/or small cores.

Change through time in these characteristics of flake size can be observed in the data presented in Table 10.23. The primary trend is a progressive increase in flake dimensions, especially flake width and platform width and thickness. The composite effect of increases in these dimensions is the progressive and marked increase in flake weight through time. The increase in width through time is more pronounced than the increase in flake length, and consequently the frequency of elongate flakes declines through time. For example, the percentage of complete chert flakes with a length more than twice their width was highest in the terminal Pleistocene (16.8% in Zone III) and declined to less than one per cent in Zones I–II. This decline in the relative abundance of elongate flakes represents subtle shifts in flake production and need not be construed as indicating a change in the overall technological strategy. However, it does demonstrate that there is no evidence from this site for Holocene blade technologies.

Table 10.23 Liang Lemdubu: descriptive statistics for the size and shape of complete chert flakes

VARIABLES		ZONE I (N=11)	ZONE II (N=257)	ZONE III	ZONE IV (N=14)
Length	Mean±Std.	15.6±7.4	14.2±7.6	14.1±6.4	13.7±7.7
	median (IQR)	12.6 (13.3)	12.2 (8.6)	12.6 (8.3)	13.7 (11.5)
Width	Mean±Std.	19.0±14.3	14.1±6.7	13.1±7.6	13.3±6.2
	median (IQR)	15.7 (8.5)	12.8 (9.1)	12.0 (7.9)	11.8 (10.1)
Thickness	Mean±Std.	3.9±4.2	3.1±2.1	4.0±4.3	3.4±2.1
	median (IQR)	3.0 (3.2)	2.5 (2.2)	2.9 (2.5)	3.0 (3.2)
Platform width	Mean±Std.	14.2±17.8	8.0±4.9	10.5±5.9	6.5±5.3
	median (IQR)	8.2 (6.1)	6.8 (6.0)	7.7 (10.2)	5.1 (3.3)
Platform thickness	Mean±Std.	4.8±6.9	2.1±1.5	2.6±1.5	1.4±0.8
	median (IQR)	2.0 (2.8)	1.6 (1.7)	2.5 (2.6)	1.3 (0.7)
Elongation	Mean±Std.	0.9±0.3	1.1±0.4	1.2±0.6	1.0±0.4
	median (IQR)	0.9 (0.6)	1.0 (0.5)	1.1 (1.0)	0.8 (0.7)
Area (mm^2)	Mean±Std.	373.8±475.8	238.3±250.5	215.2±223.6	208.7±167.4
	median (IQR)	231.6 (310.6)	156.1 (225.1)	152.1 (153.6)	159.1 (330.1)
Weight (g)	Mean±Std.	4.6±11.8	1.4±2.8	1.7±4.3	0.8±0.8
	median (IQR)	0.6 (1.6)	0.4 (1.3)	0.4 (1.0)	0.3 (1.6)

The location of knapping

The absence of cores and extensively retouched flakes, indeed, the rarity of any retouched flakes, perhaps suggests that either knapping was carried out on this part of the site and cores/retouched flakes have been preferentially removed, or that the flakes were made elsewhere and transported to this locality without the items from which they are struck. One test of these alternative models involves examining the sizes of flakes. During knapping large quantities of small flakes are produced for each larger flake, and these small flakes are left behind in the sediments at or near the spot where knapping took place. A larger number of archaeologists have concluded, on the basis of experiments, that small flakes will be produced at a far higher rate than large flakes during knapping (e.g. Amick and Mauldin 1989; Kluskens 1995; Newcomer 1971; Schick 1986). Consequently, in an intact knapping floor we would expect very small flakes to be more numerous than large ones by an order of magnitude or more. Where an artefact assemblage contains large flakes but does not contain small ones this may indicate that knapping was done elsewhere and flakes carried in to the site. In contrast, an assemblage containing a high proportion of small flakes may indicate that knapping was done at this locality and cores/retouched flakes carried away. These alternatives can be evaluated by inspecting flake size at Lemdubu for all time periods simultaneously to give a long-term image of behaviour at the site. What emerges is an intriguing pattern.

Artefacts in Lemdubu are generally small, and some are very small (see Table 10.24). For example, complete flakes have percussion lengths ranging from 2.7mm to 45.4mm, and widths ranging from 1.9mm to 58.2mm. At first glance these statistics suggest the presence of small flakes, a pattern that might indicate *in situ* knapping. However, a more detailed examination of these size data indicates that very small flakes — less than 5–6mm — are extremely rare. Three-quarters of the flakes are longer and wider than 8.5mm. Only two per cent of flakes have a length less than five millimetres, while five per cent of specimens have a length less than six millimetres. Similarly, only two per cent of complete flakes have widths less than five millimetres; 4.3% of specimens are less than six millimetres in width.

Table 10.24 Liang Lemdubu: descriptive statistics for complete flakes (in mm)

	MINIMUM	MAXIMUM	MEAN± STD.DEV.	MEDIUM (IQR)	LOWER QUARTILE	UPPER QUARTILE	N
Length	2.7	45.4	14.2±7.4	12.3 (8.7)	8.7	17.4	302
Width	1.9	58.2	14.1±7.2	12.6 (8.8)	8.9	17.7	302

Since artefacts greater than two millimetres would have been retained in the sieves the rarity of specimens between two millimetres and 5–6mm is curious. This rarity of flakes less than 5–6mm in length or width is illustrated graphically in Figure 10.9, which shows the frequency of complete flakes in size classes above two millimetres for both length and width. In this figure the grey band represents those size classes that *could* be retrieved using the two millimetres sieve mesh that was employed during excavation of Lemdubu, but which were rarely found. This pattern suggests that knapping was not frequently carried out at this locality. This conclusion is even more strongly evidenced by an examination of the similarity in this pattern for both flake width and length.

A scatter plot of chert flake sizes is illustrated in Figure 10.10, which plots lengths and widths for complete chert flakes from all levels. Although the two millimetres sieve mesh in conjunction with the careful wet sieving and sorting procedures employed, were capable of recovering specimens 2–6mm in both dimensions, no such specimens were recovered. The greyed block in Figure 10.10 illustrates the size of specimens that could have been recovered, but below the dimensions of specimens actually retrieved. Not a single chert flake with both a length and width of 2–5mm was obtained. An identical pattern is found when limestone flakes

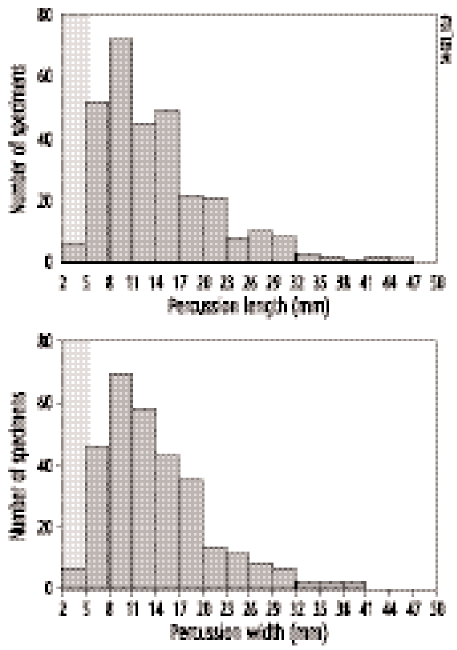

Figure 10.9 Liang Lemdubu: distribution of the frequency of complete flakes in size classes above 2mm. Grey portion represents those size classes that could be retrieved using the sieve mesh but which were rarely recovered

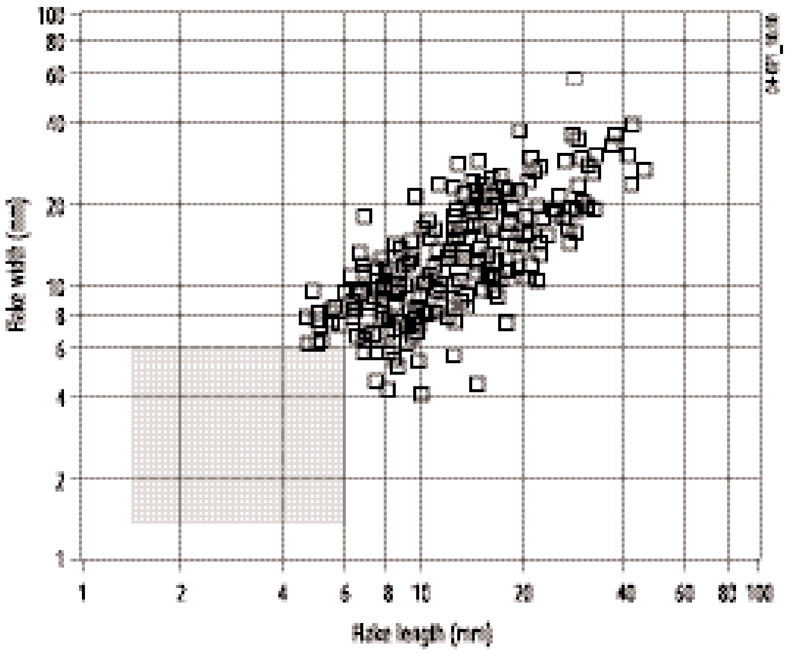

Figure 10.10 Liang Lemdubu: scatter plot of length (log scale) and width (log scale) for complete chert flakes. Grey portion represents those size classes that could be retrieved using the sieve mesh but which were rarely recovered

are plotted in the same manner, revealing that this pattern cannot be explained merely in terms of the mechanics of knapping the chert material.

The absence of flakes 2–5mm in either length or width cannot be explained by invoking erosional processes capable of removing rocks of that size, since the 2mm sieve retained large amounts of gravel of that size. Furthermore, the faunal analysis demonstrates an abundance of light bone fragments only a few millimetres long. It is therefore necessary to hypothesise that small flakes were never deposited in this area. Hence it can be concluded that at least in this portion of Lemdubu, people brought in flakes they manufactured elsewhere, used and lightly retouched them, and discarded those retouched flakes and the small resharpening flakes they removed. Flaking, including extensive retouching of flakes, may have happened elsewhere within the cave but appears always to have been rare in the vicinity of Test Pit C.

Because the data used in Figures 10.9 and 10.10 consist of all chert flakes recovered from the excavation, from all spits, this pattern can be viewed as being a consistent treatment/process throughout the history of occupation. Given the chronological shifts in raw material proportions and the likelihood that at least some of this material is available near the site, this constant tool provisioning strategy may indicate short term visitation by highly mobile foragers. If such a pattern has persisted despite changes in climate, rock procurement and diet it probably indicates that the interior location of this shelter has meant that it remained on the periphery of foraging ranges throughout the late Pleistocene and early Holocene. This model would account for the inferred high mobility, flake-based tool transport strategy, low tool discard rates, and minimal dietary debris. If this model explicates the artefact assemblage, what remains is to describe the patterns that were involved in retouching the flakes brought into the site. This can be accomplished by examining the small flakes removed during retouching as well as the retouched flakes themselves.

Platform characteristics

Platform characteristics are often some of the most revealing characteristics of flakes, reflecting the preparation of platform surfaces and core faces. For instance, Table 10.25 lists observations of platform surfaces on chert flakes from Lemdubu. The pattern is broadly consistent in all levels of the site, with conchoidal platforms dominating at all times. Most of these flakes are consistent with specimens removed from retouched flakes by blows to the ventral surface, although a few may have been removed from cores. The largest flakes in the assemblage, including the retouched ones (see below) have probably been struck from cores, although as argued above, this was probably done at another locality. While the absence of platforms with multiple scars in Zone IV and the presence of cortical platforms in Zone II only may represent different technical patterns of knapping, it is more likely that those variations merely represent differences in sample size. Consequently, these data are interpreted as indicating that platforms with multiple scars or cortex remain at similar relative frequencies throughout the sequence. The source of flakes with cortical platforms could be small cores but there is no need to propose such an explanation since the weight (1.8±2.3 vs 1.2±2.6, t=0.726, d.f.=328, p=0.468), length (15.3±4.8 vs 13.8±7.2, t=0.745, d.f.=326, p=0.457), and platform thickness (2.2±1.4 vs 2.1±1.6, t=0.166, d.f.=259, p=0.868) of flakes with cortical and other platform surfaces are not statistically different. In other words, flakes with cortical platforms have the same dimensions as other flakes — being on average 14–15mm long and about two millimetres thick at the platform — and could have been removed either from large retouched flakes or from small cores. In view of the absence of cores and the presence of large retouched flakes (see below) it is perhaps likely that almost all the flakes in the assemblage were struck from the dorsal face of retouched flakes, but that some were struck from the margin or ventral face of retouched flakes.

Table 10.25 Liang Lemdubu: summary of platform surface characteristics on chert flakes

ZONE	CONCHOIDAL	CORTEX	MULTIPLE SCARS	TOTAL	PERCENTAGE CONCHOIDAL
I	9	0	1	10	90
II	224	13	23	260	87
III	22	0	3	25	88
IV	8	0	0	8	100
TOTAL	263	13	27	303	87

A small but persistent proportion of unretouched flakes have other evidence of preparation. More than one in 10 artefacts display overhang removal. In Zone II the frequency of this feature varies between materials, being higher on chert flakes (13.2%) than on limestone flakes (7.5%). However, this difference is not statistically significant, as documented in Table 10.26, (=1.460, d.f.=1, p=0.227, V=0.069), and hence is not strong evidence that knappers treated these two materials differently. Nevertheless, chronological change in the frequency of overhang removal is best measured using chert flakes alone, as shown in Table 10.27. Data presented in this table indicates an extremely similar frequency of overhang removal in Zones II–IV, with a slight and statistically insignificant decline in Zone I. This reinforces the image of a consistent technological pattern throughout the archaeological sequence.

Table 10.26 Liang Lemdubu: frequency of overhang removal by raw material for Zone II

	NONE	OVERHANG REMOVAL	TOTAL
Chert	283	43	326
Limestone	74	6	80
TOTAL	357	49	406

χ^2 = 1.460, d.f. = 1, p = 0.227, V = 0.069

Table 10.27 Liang Lemdubu: frequency of overhang removal on chert flakes by zone

ZONE	NONE	OVERHANG REMOVAL	TOTAL	%OVERHANG REMOVAL
I	14	1	15	6.7
II	283	43	326	13.2
III	19	3	22	13.6
IV	20	3	23	13.0
Total	336	50	386	13.0

χ^2 = 0.551, d.f. = 3, p = 0.907, V = 0.38

Flake retouching

Only four retouched flakes were recovered from Test Pit C at Lemdubu. Of the four retouched flakes three are made on chert and one on limestone. As calculated in Table 10.28, the relative frequency of retouching is similar on both chert and limestone flakes, and is extremely rare on either material at an assemblage wide level. However, two of the four retouched flakes were obtained from Spit 15, which had only 11 artefacts, and hence the relative frequency of retouching for that spit alone is high. This evidence suggest consistent, low level accumulation of retouched flakes, but at variable rates.

Table 10.28 Liang Lemdubu: the frequency and location of retouched flakes

	UNRETOUCHED	RETOUCHED	% FLAKES RETOUCHED	SPITS CONTAINING RETOUCHED FLAKES
Chert (N=390)	387	3	0.8	7, 10, 15
Limestone (N=124)	123	1	0.8	15
Other (N=4)	4	0	0	
Total (N=518)	514	4	0.8	

Table 10.29 summarizes information about retouched flakes at Lemdubu. The following points are noted about these specimens:

1) the specimen from Spit 7 is technically retouched but has only one small retouch scar;
2) the specimen from Spit 10 had three burin spalls removing the platform — all scars abruptly terminated and originated from the same direction. The longest scar was 16.4mm in length;
3) the chert specimen in Spit 15 possessed a continuous series of retouch scars onto the ventral face at the distal end and right lateral margin. The left margin also had a continuous set of scars, but this time on the dorsal face. Scars were up to 8.1mm in length but most scars were 2–3mm long. The majority of scars were abruptly terminated; and
4) the limestone specimen from Spit 15 has retouch onto the dorsal face at the distal end. All visible retouch scars are less than five millimetres long. However, as this specimen is both heavily heat shattered and weathered the description of the retouch is limited.

Table10.29 Liang Lemdubu: summary of information about retouched flakes

	RAW MATERIAL	FRAGMENT	LENGTH (MM)	WIDTH (MM)	WEIGHT (G)	DESCRIPTION	MAX. SCAR LENGTH (MM)
Spit 7 (#594)	Chert	Complete	7.86	10.32	0.2	Irregular	5.0
Spit 10 (#210)	Chert	Complete	27.98	36.50	9.8	Burinate	16.4
Spit 15 (#95)	Limestone	Distal	22.02	30.01	3.9	Irregular	5.0
Spit 15 (#96)	Chert	Complete	29.86	29.62	18.2	Irregular	8.1
Statistics			21.9±10.0	26.6±11.3	8.1±7.9		

Discussion of technology at Liang Lemdubu

This analysis has demonstrated minimal changes in flake dimensions, shape and reduction characteristics through the Liang Lemdubu archaeological sequence. In conjunction with evidence of size classes these features have been interpreted as a relatively unchanging tool provisioning strategy, that may reflect short-term visitation to this site on the periphery of foraging ranges by highly mobile foragers.

Knapping at Liang Nabulei Lisa

Although the Liang Nabulei Lisa sequence complements the one from Liang Lemdubu by providing greater chronological resolution of Holocene change, the description of technological change during that period is limited by the small number of artefacts that were recovered from the test pit. As listed in Table 10.30, only 42 stone artefacts were identified from the site. Approximately one third of these artefacts were made from chert, while nearly two thirds were made from limestone. As at Lemdubu, most of the artefacts were small flakes.

Table 10.30 Liang Nabulei Lisa: frequency of artefact types by raw material

	CHERT	LIMESTONE	TOTAL
Flake	15 (93.8%)	25 (96.2%)	40 (95.2%)
Core	1 (6.3%)	0	1 (2.4%)
Flaked Piece	0	1 (3.8%)	1 (2.4%)
Total	16 (38.1%)	26 (61.9%)	42

Using the estimated antiquity for Zone I (Spits 1–29) and Zone II (Spits 30–38), as given above, Table 10.31 provides estimates for artefact discard in Nabulei Lisa. These data reveal a marked decline in artefact discard during the Holocene (Zone I) compared to the terminal Pleistocene (Zone II). This trend becomes exaggerated in the latter part of the sequence, with no stone artefacts being recovered from the uppermost six spits. While this final decline may be explicable in terms of radical techno-economic change, including the advent of agriculture and ceramic and metal tools, it may also be understood as part of a longer term trend.

Table 10.31 Liang Nabulei Lisa: analytical divisions of the sequence

ZONE	SPITS	ELAPSED YEARS (CAL BP)	NUMBER OF ARTEFACTS	ESTIMATED DISCARD RATE (#/1000 YEARS)
I	1-29	12,000	20	1.7
II	30-38	4500	22	4.9
All	1-38	16,500	42	2.6

Patterns in changing raw material usage are sufficiently strong in the Nabulei Lisa chronological sequence that they are apparent despite the small assemblage size. Table 10.32 lists the frequency of chert and limestone artefacts by spit. The pattern that exists is as follows: no stone artefacts at all were recovered from the upper six spits; limestone is the main material on which artefacts are made in Spits 7–29; and chert is the dominant artefactual material in Spit 30 and below (see Table 10.33). The shift in raw material emphasis at about Spit 30 in the deposit is dramatic, with the pattern of raw material abundance between Spits 7–29 and 30–38 being significantly different (= 15.155, d.f. = 1, $p < 0.001$). Hence, it is argued that the change from a chert dominated assemblage to a limestone dominated one in Spits 29–30 is extremely unlikely to be randomly produced, and is best explained as an alteration in the procurement of material about 12,000 years ago. As discussed below, this trend is broadly similar with that inferred from Lemdubu.

Another point of similarity with the Lemdubu assemblage is the rate of weathering of chert artefacts. Applying the same weathering classification as was employed earlier to the 14 chert artefacts retrieved from Nabulei Lisa below Spit 30 produced the following result: two (14.3%) were classified as fresh; nine (64.3%) as lightly patinated; and three (21.4%) as patinated. No heavily weathered artefacts were recovered. These weathering patterns at Nabulei Lisa are consistent with the artefact assemblage being largely *in situ*, with specimens in Spits 30–38 having levels of weathering congruent with a Pleistocene age. A similar pattern is found in Spits 6–9 at Lemdubu,

Table 10.32 Liang Nabulei Lisa: changes in raw material through the sequence

SPIT	CHERT	LIMESTONE	TOTAL	% CHERT
1	0	0	0	–
2	0	0	0	–
3	0	0	0	–
4	0	0	0	–
5	0	0	0	–
6	0	0	0	–
7	1	1	2	50
8	0	1	1	0
9	0	1	1	0
10	0	2	2	0
11	0	0	0	–
12	0	1	1	0
13	0	0	0	–
14	0	1	1	0
15	0	0	0	–
16	0	1	1	0
17	0	0	0	–
18	0	0	0	–
19	0	0	0	–
20	0	0	0	–
21	0	1	1	0
22	0	2	2	0
23	0	1	1	0
24	0	1	1	0
25	0	2	2	0
26	0	2	2	0
27	0	0	0	–
28	0	1	1	0
29	0	1	1	0
30	1	1	2	50
31	3	1	4	75
32	3	1	4	75
33	2	0	2	100
34	3	3	6	50
35	2	0	2	100
36	0	0	0	–
37	1	0	1	100
38	0	1	1	0
Total	16	26	42	75.0
(Percentage)	(38.1%)	(61.9%)		

Table 10.33 Liang Nabulei Lisa: raw material frequencies by groups of spits

SPITS	CHERT	LIMESTONE	TOTAL	% CHERT
1–6	0	0	0	–
7–29	1	19	20	5.0
>29	15	7	22	68.2
Total	16	26	42	38.1

levels that are also inferred to date to the terminal Pleistocene and early Holocene. This broad similarity in weathering within the two chert assemblages, despite the micro-environmental differences at the two sites, supports the use of these weathering classes as a rough indication of assemblage antiquity.

Artefact sizes are typically small at Nabulei Lisa and limestone flakes are often slightly larger than chert ones (Table 10.34). Although the samples are small, significance tests reveal that the differences are unlikely to be randomly produced. Minor technological differences between the knapping of the two materials might be responsible for the different sizes and shapes of flakes on each. For instance, the transportation and retouching of slightly smaller chert flakes would perhaps be sufficient to explain the size contrasts between artefacts made from the two materials. Such size differences may reflect a contrast between local and non-local sources, although in the absence of further geological information that possibility is speculative.

Table 10.34 Liang Nabulei Lisa: descriptive statistics for the size and shape of complete flakes by raw material

VARIABLES	CHERT	LIMESTONE	DIFFERENCE BETWEEN CHERT AND LIMESTONE	IS THIS DIFFERENCE DUE TO CHANCE?
Length	16.7±6.8 (N= 12)	22.7±7.9 (N= 19)	t = -2.19 p = 0.036	Fairly unlikely
Width	17.1±5.3 (N= 12)	27.4±14.5 (N= 19)	t = -2.83 p = 0.009	Very unlikely
Thickness	3.1±1.6 (N= 12)	5.4±2.5 (N= 19)	t = -2.85 p = 0.008	Very unlikely
Platform width	9.6±4.2 (N = 12)	16.1±10.0 (N= 19)	t = -2.50 p = 0.019	Very unlikely
Platform thickness	2.2±1.3 (N= 12)	3.3±3.3 (N= 19)	t = -1.16 p = 0.257	Fairly likely
Elongation	0.9±0.3 (N= 12)	0.9±0.3 (N= 19)	t = 0.591 p = 0.559	Very likely
Area (mm^2)	308.9±180.3 (N= 12)	695.9±545.8 (N= 19)	t = -2.85 p = 0.009	Very unlikely
Weight (g)	1.5±1.2 (N= 12)	6.9±8.3 (N= 19)	t = -2.84 p = 0.010	Very unlikely

Artefacts on Aru

It must be acknowledged that archaeological exploration of the Aru Islands is in its pioneering stage and consequently our ability to comprehend the patterns observed at Liang Lemdubu and Liang Nabulei Lisa is limited by two factors. First is the excavation of only one small area in each site. This recovery strategy is justified in terms of the exploratory nature of the project, but has the consequence of yielding very small artefact sample sizes and preventing any understanding of spatial patterns of artefact manufacture and discard within the shelters. A second factor inhibiting more detailed models is the lack of contextual environmental data with which economic and technological statements could be framed. The most obvious need is for information about the abundance, size, shape and distance of the sources of rock that were procured and transported to each site. Without these data our ability to identify and explain spatial and chronological variations in human behaviour remains imperfect.

However, in view of the exploratory nature of investigations on Aru, the archaeological data is surprisingly highly patterned. Despite their different landscape positions the two archaeological sites discussed in this paper display distinctly similar assemblages of stone artefacts, and by inference similar knapping technologies, throughout the Stone Age occupation of the region. These similarities offer us baseline descriptions of the uniformity and change in stone assemblages on Aru.

The chronological trends identified at Lemdubu and Nabulei Lisa are summarized in Table 10.35. At both sites there was a noticeable reduction in the rate of artefact discard during the Holocene, a pattern hypothesized to reflect the reduction of open and patchy vegetation systems, and a shift in the economic focus of foraging groups. At Lemdubu, which has the benefit of a longer archaeological sequence, the evidence points to increasing occupation and tool using activity in the terminal Pleistocene. At both sites the reduction in artefact discard is broadly coincident with a switch from chert dominated assemblages to limestone dominated ones, revealing that changes in the intensity of knapping and tool use were linked to alterations in the procurement and transportation of stone materials, and by implication forager landuse and/or mobility. Furthermore, the similarities in the archaeological assemblages indicate that a relatively uniform technological strategy may have been in place at both sites and throughout much of the late Pleistocene and early Holocene. As shown in Table 10.36 the size of chert flakes is extremely similar between the two sites, while limestone flakes are larger at Nabulei Lisa than at Lemdubu. This pattern may reflect difference in the form, availability, or cost of raw materials at each site, but what is remarkable is the strong concurrence of archaeological assemblages and chronological trends at both sites.

Table 10.35 Liang Lemdubu and Liang Nabulei Lisa: comparison of chert and limestone complete flakes (mean±std.)

	RELATIVE DISCARD RATES		DOMINANT RAW MATERIAL	
	LEMDUBU	NABULEI LISA	LEMDUBU	NABULEI LISA
Zone I	Low (3–4/1kyr)	Low (<2/1kyr)	Limestone	Limestone
Zone II	High (80/1kyr)	Medium (5/1kyr)	Chert	Chert
Zone III	Medium (10+/1kyr)	–	Varied	–
Zone IV	Low (2–3/1kyr)	–	Chert	–

Table 10.36 Liang Lemdubu and Liang Nabulei Lisa: comparison of chert and limestone complete flakes (mean±std.)

	CHERT		LIMESTONE	
	LEMDUBU ZONE I (N = 11)	NABULEI LISA (N = 12)	LEMDUBU ZONE I (N = 14)	NABULEI LISA (N = 19)
Length	15.6±7.4	16.7±6.8	14.8±8.6	22.7±7.9
Width	19.0±14.3	17.1±5.3	15.7±8.9	27.4±14.5
Area (mm^2)	373.8±475.8	308.9±180.3	279.7±333.2	695.9±545.8

The broad correspondence in the raw material usage, pattern of knapping and tool production, and changes in artefact density and raw material procurement between the two sites described here, suggests that many of the patterns identified may be regional in scale rather than site-specific. This is intriguing because in many areas of both mainland and Island Southeast Asia depictions of archaeological trends have often focused on changes in technology and assemblage composition, with assertions that change was substantial. Such a pattern is not in evidence in the sites on the Aru Islands. For instance, over the last 30,000 years on Aru there is no sign of the Hoabhinian pattern involving large flaked cobbles, and no evidence for the advent of different technologies emphasizing blade production. Instead, the archaeological observations document transportation and knapping of small retouched flakes and cores, even when changes to foraging range stimulate an alteration in raw material procurement patterns. In some ways this technology is similar to that reported from comparable limestone landscapes in Australia (see Hiscock 1988), but broad similarity in assemblages across the lowlands of Northern Sahul cannot be interpreted as a reflection of cultural affinity, and is better viewed as representing broadly similar technological and foraging strategies responding to similar stone resources. The data offered in this chapter offers a baseline description of the nature of, and chronological changes in stone artefacts on Aru, together with intriguing hints of technological adjustments in an ecologically dynamic landscape. The detailed understanding of those adjustments awaits future researchers.

Acknowledgements

To Erica Lindgren, who assisted with much of the analysis and data entry, many thanks. Thanks also to Sue O'Connor and Ken Aplin for helpful discussions on the material presented here. The analysis of both assemblages was carried out at the School of Archaeology and Anthropology, The Australian National University, Canberra.

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