THE CORE OF THE MATTER:

CORE REDUCTION IN PREHISTORIC EAST TIMOR

HELEN SELIMIOTIS

A Dissertation Submitted to the Australian National University in
Fulfilment of the Requirements for the Degree of Master of Philosophy by Research

School of Archaeology and Anthropology
2006
DECLARATION

Bui Ceri Uato was excavated by Ian Glover as part of his doctoral dissertation (Glover, 1972), subsequently published in Archaeology in Eastern Timor, 1966-67 (Glover, 1986). Excavation details and archaeological contents at Bui Ceri Uato are referenced to these studies.

This dissertation represents my own work and contains no material which has been accepted for the award of any other degree or graduate diploma in any university. To the best of my knowledge and belief the dissertation contains no material previously published or written by any other person except when reference is made in the text of the dissertation.

Helen Selimiotis

March, 2006
ACKNOWLEDGEMENTS

I would like to thank the Australian Museum for access to the Bui Ceri Uato cultural material collection and permission to radiocarbon date marine shellfish and charcoal samples. Ulrike Troitzsch at the Department of Earth and Marine Sciences, Australian National University (ANU), conducted the shell recrystallization analysis. The samples were radiocarbon dated by Abaz Alimanovic at the Radiocarbon Dating Laboratory at the ANU, with a grant obtained by Centre for Archaeological Research.

Nuno Vasco Oliveira (Archaeology and Natural History, RSPAS, at the Australian National University) provided photographs of Bui Ceri Uato and immediately surrounding areas as I was unable to access the site.

Thanks to David McGregor, Kathy Callen, Liz Walters and Sue Fraser of the School of Archaeology and Anthropology at the Australian National University. Their combined technical and administrative support was unfailing.

I thank my supervisors Sue O'Connor, Peter Hiscock and Matthew Spriggs for their advice, support and encouragement. Sue was always available for discussion and read first drafts of the entire thesis. Special thanks for her perseverance. Peter inspired yet another lithics student, provided a guide through basic statistics and was deeply influential in thinking about ways of investigating human behavioural responses from lithic technology. Matthew provided valuable radiocarbon dating advice and was a careful editor, improving the written quality of the thesis substantially.

Thank you to the East Timorese people, especially those of Tequino1nata village. My experience in your country left a lasting impression and I hope to be back again.

To David Mollica, Michael Jon Slack and Patrick Andrew Faulkner, thanks for reading drafts, helping out with software and generally preventing me from going terribly batty. Michael made a useful suggestion regarding figures in the thesis.

Edward Austin Clarke has seen this thesis through to the end, provided all sorts of computer assistance and edited drafts. He and his wife Ali have been
generous of their time and home, and welcomed me on many occasions. Many thanks Ed, your support has been invaluable.

Thanks to Arch, Peter and Nina for their continuous support and encouragement. A warm welcome to Christian. Finally, I thank Chris and Mandel Selimiotis. Without the support of the folks this study would not have been possible. I hope that their patience has been rewarded with the completion of this thesis.
ABSTRACT

The aims of the present study are to assess temporal changes in the extent/length of reduction of cores as well as levels of human occupation at Bui Ceri Uato shelter, East Timor. These temporal trends form the basis of interpretations of human behaviour, mobility and settlement in the prehistory of East Timor.

The extent/length of core reduction was assessed by recording morphological attributes such as core size, rotation and flake scars. Indices of levels of human occupation recorded included sedimentation rate, flaked stone artefact discard rates and the frequency of occurrence of cores with thermal damage. These indices were calculated based on radiocarbon dating determinations of marine shellfish collected from the excavation. Glover (1986) was unable to date satisfactorily the cultural contents of the site, which means that the construction of a chronological sequence by the present study is of added importance.

Radiocarbon dates from marine shell established initial human occupation of Bui Ceri Uato to the Pleistocene (26,520 ± 340 ANU-11738, provisionally calibrated to 30,660-29,200 BP, Gillespie pers. com. 2006). This was followed by extremely sporadic occupation of the shelter (or even its abandonment) until the terminal Pleistocene (13,191-12,886 cal. BP ANU-11878, and 13,059-12,789 cal. BP ANU-11877), coinciding with the arid and cold conditions of the Last Glacial Maximum. An explanation for these low levels of human occupation of Bui Ceri Uato during the LGM may be that humans largely focussed on coastal resources to supplement the paucity of large endemic fauna available in East Timor.

The core technology responded strongly to raw material quality, whereby cores of ‘good’ quality chert were further reduced than those of lesser grades. Temporal trends in the extent/length of reduction of cores at the site were subtle and, on the whole, not statistically significant at the 5% level of probability. The most parsimonious interpretation of this result is that there is no change in the extent/length of reduction of cores at Bui Ceri Uato. This outcome may be symptomatic of human subsistence or settlement being unresponsive in lithic
assemblages whereby it is actually technological constraints (in this case chert quality) that strongly influence the nature of lithic assemblages. However, two factors likely contributed to the subtly of observed temporal trends in the extent/length of core reduction. The first is the arbitrary and inter-mixed nature of subgroups, the unit of analysis of the cultural contents of the excavation adopted by the present study, which likely played a role in diluting temporal changes to core morphology. The second is our limited understanding of the relationship of the technological sensitivity/responsiveness of the morphological indicators of core reduction adopted in this study (size, platforms and flake scars) with progressive stages of core reduction. For these reasons, this study was not wholly reliant on statistical significance outcomes in comparing the morphology of cores between subgroups. With due consideration, the approach adopted was that the perceived temporal trends in the extent/length of core reduction were not random but reflected real changes in stone knapping over time.

The directionality of change in the extent/length of core reduction was observed in combination with other site features such as levels of human occupation of the shelter. Relatively high levels of human occupation of Bui Ceri Uato were observed at the terminal Pleistocene (12,990-10,383 cal. BP) and peaked during the early Holocene (10,383-9,022 cal. BP). Similar trends were observed in core reduction, which increased at the terminal Pleistocene and peaked in the early Holocene. This is indicative of relatively higher pressure for stone resources at the terminal Pleistocene/early Holocene and may suggest that people were not replenishing stone resources from the Bobonaro Scaly Clays as frequently as before. Synchronous trends of high levels of human occupation associated with high levels of pressure for flaked stone were interpreted as indicative of prolonged or more sedentary occupation of the shelter, perhaps by hunter-gatherers attracted to a nearby spring. Relatively high levels of occupation at the site coincide with ameliorated climatic conditions and may signify human recolonisation of the Baucau Plateau with rising sea levels, which would have decreased the vertical distance to the coastline for people to access coastal resources.

A subtle decline in core reduction occurred in levels spanning the majority of the Holocene (younger than 9,022 cal. BP). This corresponded with a decline in levels of human occupation to levels slightly above that observed in
the initial Pleistocene phase of occupation. These trends were interpreted as sporadic use of Bui Ceri Uato in this broad period which is inclusive of the onset of agriculture in the mid-late Holocene.

This study contributes to an understanding of cave use in East Timor spanning the transition from hunter-gatherers to agriculturalists, as well as inferring aspects of human behaviour from a lithic assemblage which could be described as morphologically amorphous. It illustrates the potential of the combination of technologically-oriented approaches to lithic analysis, taphonomic considerations and site contextual information in providing a powerful framework to investigate human behaviour, mobility and settlement.
CONTENTS

Declaration................................................................. ii
Acknowledgements....................................................... iii
Abstract........................................................................ v
Table of Contents........................................................ viii
List of Tables.............................................................. xv
List of Figures.............................................................. xx

Chapter 1 - Introduction............................................... 1
  Bui Ceri Uato and East Timor Prehistory......................... 5
    Subsistence/settlement changes.................................. 5
  Flaked stone artefacts............................................... 7
    Stone knapping and core reduction............................. 11
    The lithic system.................................................. 12
  Research aims....................................................... 15
    Bui Ceri Uato cores.............................................. 16
  Research agenda.................................................... 18
    Aims........................................................................ 19
      Sedimentation and flaked stone discard rates............... 19
      Taphonomic impacts............................................ 20
  Thesis structure................................................... 22

Chapter 2 – Archaeological Research and Palaeoenvironmental
Conditions................................................................ 25
  Background history of research.................................. 26
    Bühler................................................................. 27
      Excavations...................................................... 28
    Bühler’s views on the antiquity of human occupation in
    Timor............................................................... 29
  Verhoeven............................................................ 30
  Almeida, Mendes Correa and Cinatti............................. 31
    Excavation and archaeological finds.......................... 31
Portuguese views on the antiquity of human occupation in East Timor ................................................... 32
Glover’s research in East Timor ........................................... 33
Glover’s research ........................................... 34
Cultural trends ........................................... 35
   Endemic species ........................................... 35
   Introduced species ........................................... 37
Human settlement, subsistence and population changes ................................................... 39
   An evaluation of human subsistence, settlement and population changes ................. 40
The East Timor Archaeological Project (ETAP) ........................................... 41
   Matja Kuru 1, Matja Kuru 2 and Telupunu ........................................... 43
   Lene Hara ........................................... 43
   Background to lithic research in East Timor ........................................... 45
Regional considerations ........................................... 46
   Palaeoenvironment ........................................... 48
   Conclusion ........................................... 54

Chapter 3 – Bui Ceri Uato ................................................... 55
Bui Ceri Uato ........................................... 56
   The setting ........................................... 61
      Marine terrace zone ........................................... 61
      Tectonic uplift ........................................... 64
   Stone materials ........................................... 65
   Contemporary human use of Bui Ceri Uato ........................................... 71
   The excavation ........................................... 72
   The stratigraphy ........................................... 78
   Horizons ........................................... 80
   Levels of recording of excavated squares ........................................... 81
   Spit thickness ........................................... 82
   Horizon delineations and stratigraphy ........................................... 83
      Distinct layers of accumulation ........................................... 85
      Natural soil layers ........................................... 86
Initiation phase of flake formation........................................ 122
Termination phase of flake formation.................................... 124
Stone knapping variables................................................... 125
  Stone material considerations........................................ 125
    Raw stone material........................................ 126
    Heat-treatment........................................ 127
    Physical characteristics..................................... 133
Application of Force: Pressure and percussion techniques........ 135
Core surface topography.................................................... 137
Inertia................................................................. 142
Core attributes and attribute states..................................... 144

Chapter 6 – Dating Determinations and relative levels of human occupation....................................................... 146
Dating determinations.................................................. 147
  Recrystallization....................................................... 149
  Overall chronology................................................... 150
  Inversions............................................................... 152
    Horizons VI with Horizon VII................................ 152
    Horizon I with Horizon II................................... 153
Dating determinations and the cultural sequence.................. 154
Sedimentation rates: Age/depth curve................................ 155
  Trends in sedimentation rates: levels of human occupation... 156
Subgroups: the unit of analysis......................................... 157
  Subgroups and flaked stone discard.......................... 160
    Trends in flaked stone artefact discard rates.......... 160
Levels of human occupation, the palaeoenvironment and the cultural sequence................................................. 164
Conclusion........................................................................ 166

Chapter 7 – Taphonomic impacts........................................ 169
Provenance........................................................................ 170
  Identification.......................................................... 170
  Distribution of cores.................................................. 171
<table>
<thead>
<tr>
<th>Chapter 8 – Technological variables influencing core reduction</th>
<th>209</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sampling considerations ..................................................</td>
<td>209</td>
</tr>
<tr>
<td>Stone materials ..................................................................</td>
<td>209</td>
</tr>
<tr>
<td>Taphonomically impacted cores ..........................................</td>
<td>210</td>
</tr>
<tr>
<td>Indicators of the extent of core reduction ..........................</td>
<td>211</td>
</tr>
<tr>
<td>Size ...............................................................................</td>
<td>211</td>
</tr>
<tr>
<td>Rotation .............................................................................</td>
<td>211</td>
</tr>
<tr>
<td>Flake scars .......................................................................</td>
<td>212</td>
</tr>
<tr>
<td>Sensitivity/responsiveness with core reduction ....................</td>
<td>215</td>
</tr>
<tr>
<td>Chert quality .....................................................................</td>
<td>215</td>
</tr>
<tr>
<td>Chert quality and core reduction .......................................</td>
<td>217</td>
</tr>
<tr>
<td>Grades of quality chert quality and core size .....................</td>
<td>218</td>
</tr>
<tr>
<td>Grades of quality chert quality and core rotation ................</td>
<td>224</td>
</tr>
<tr>
<td>Grades of quality chert quality and flake scars ..................</td>
<td>227</td>
</tr>
<tr>
<td>Heat-treatment ...............................................................</td>
<td>230</td>
</tr>
<tr>
<td>Heat-treatment and core reduction ......................................</td>
<td>231</td>
</tr>
<tr>
<td>Heat-treatment and core size ............................................</td>
<td>232</td>
</tr>
<tr>
<td>Heat-treatment and core rotation .......................................</td>
<td>236</td>
</tr>
<tr>
<td>Heat-treatment and flake scars .........................................</td>
<td>237</td>
</tr>
<tr>
<td>Heat-treatment and core reduction ......................................</td>
<td>241</td>
</tr>
<tr>
<td>Conclusion .........................................................................</td>
<td>242</td>
</tr>
</tbody>
</table>
Chapter 9 - Temporal trends ..................................................... 243
Subgroups ............................................................................. 243
Subgroups and the detection of temporal changes ................. 244
Temporal trends in chert quality ............................................ 245
Temporal trends in core reduction ........................................... 247
Temporal trends in core size .................................................... 247
The problem of interpretation ................................................. 248
Temporal trends in the extent of core reduction on the basis of
size ...................................................................................... 248
Temporal trends in core rotation ............................................. 254
Temporal trends in flake scars ................................................. 256
Temporal trends in core reduction ........................................... 262
Core reduction and chert quality ............................................ 264
The frequency of heat-treated cores ....................................... 265
Conclusion .......................................................................... 268

Chapter 10 - Synthesis and Conclusion ..................................... 270
Core reduction ....................................................................... 272
The comparatively earlier Pleistocene .................................... 272
The terminal Pleistocene ......................................................... 273
The early Holocene ................................................................ 273
The Holocene ....................................................................... 274
Synthesis: changing occupation at Bui Ceri Uato ................. 276
Conclusion .......................................................................... 282

References ............................................................................ 285

Appendix
Appendix A - Attributes and attribute states ......................... 320
Appendix B - Stratigraphic details: stratigraphic differences across the
shelter .................................................................................... 353
Appendix C - Evidence of post-depositional movement .......... 358
Appendix D - Radiocarbon dates with delta carbon concentrations 365
Appendix E - Radiocarbon determinations and cal. years BP .... 367

xiii
Appendix F - Recrystallization ................................................................. 368
Appendix G - Age/depth calculations ..................................................... 370
Appendix H - Subgroup sedimentation and flaked stone artefact discard calculations ................................................................. 371
Appendix I - Cores identified by the present study contrasted with Glover's (1986) lithic classification at Bui Ceri Uato ......................................................... 372
Appendix J - Cores originally classed in flake categories in Glover (1986) and provisionally allocated an identification number by the present study, Bui Ceri Uato ........................................................................ 373
List of Tables

Table 3.1 Table 3.1 Bui Ceri Uato, squares and associated spit and horizon ranges.................. ................................................................. 74
Table 3.2 The stratigraphy, horizon delineations and spit boundaries drawn in section for each excavated square at Bui Ceri Uato.......................... 82
Table 3.3 Horizons and soil layers, Bui Ceri Uato................................... 84
Table 3.4 Horizon depths below surface in Squares N7E2, N6E2, N5E2 and N6W1, N6E0, N6E1, Bui Ceri Uato........................................... 90
Table 3.5 Glover’s estimated chronology at Bui Ceri Uato and cultural changes.................................................................................................. 97
Table 3.6 The estimated chronological framework suggested by Glover (1986), numbers of flaked stone artefacts, pottery sherds and Minimum Number of Individual fauna, Bui Ceri Uato........................................... 98
Table 6.1 Subgroups and core artefacts, Bui Ceri Uato............................ 158
Table 7.1 Distribution of cores by spit, Bui Ceri Uato............................ 172
Table 7.2 Distribution of cores by horizon, Bui Ceri Uato....................... 172
Table 7.3 Core raw stone material types, Bui Ceri Uato.......................... 175
Table 7.4 Cores with thermal fractures, Bui Ceri Uato.......................... 175
Table 7.5 Spatial concentration of cores with thermal fractures, Bui Ceri Uato........................................... 177
Table 7.6 Cores with taphonomically affected characteristics, Bui Ceri Uato........................................................................................................ 180
Table 7.7 Descriptive statistics comparing weight, length and number of platforms between cores with and without these respective characteristics taphonomically affected, Bui Ceri Uato........................................... 182
Table 7.8 $t$-test results comparing the difference in weight, length and number of platforms between cores with and without taphonomic impacts to these respective characteristics, Bui Ceri Uato........................................... 182
Table 7.9 Amount of non-flaked surface area on cores with and without taphonomic impacts to estimates of non-flaked surface area, Bui Ceri Uato........................................... 183
Table 7.10 Chi-square statistics comparing differences in the amount of non-flaked surface area between cores with and without taphonomic impacts to this characteristic, Bui Ceri Uato........................................... 183
Table 7.11 Amount of cortex on cores with and without taphonomic impacts to estimates of the amount of cortex, Bui Ceri Uato.......................... 183
Table 7.12 Chi-square statistics for differences in the proportion of cores with varying amounts of cortex with and without cortex taphonomically removed, Bui Ceri Uato................................................................. 183
Table 7.13 Core raw stone materials and thermal fractures, Bui Ceri Uato.. 184
Table 7.14 Descriptive statistics of the size of cores with and without thermal fractures, Bui Ceri Uato........................................................................ 192
Table 7.15 t-tests comparing the size of cores with and without thermal fractures, Bui Ceri Uato................................................................. 192
Table 7.16 Descriptive statistics of the shape of cores with and without thermal fractures, Bui Ceri Uato........................................................................ 202
Table 7.17 t-tests comparing the shape of cores with and without thermal fractures, Bui Ceri Uato........................................................................ 202
Table 7.18 The frequency of occurrence of cores with thermal damage (# per m$^3$ per 1,000 years) and subgroups, Bui Ceri Uato................................................................. 205
Table 8.1 Taphonomically affected morphological recordings and excluded analyses, Bui Ceri Uato cores........................................................................ 210
Table 8.2 Trends in core morphology indicative of further reduction............ 214
Table 8.3 Homogeneity, Bui Ceri Uato cores............................................. 216
Table 8.4 Texture of flake scar surfaces, Bui Ceri Uato cores...................... 217
Table 8.5 Macroscopically visible cracks, Bui Ceri Uato cores................... 217
Table 8.6 Grade of chert, Bui Ceri Uato cores.......................................... 217
Table 8.7 Size of ‘good’, ‘medium’ and ‘poor’ grade chert cores, Bui Ceri Uato........................................................................ 223
Table 8.8 t-test results comparing differences in size between cores of ‘good’, ‘medium’ and ‘poor’ grade chert, Bui Ceri Uato.............................. 223
Table 8.9 Number of platforms and flake scar directions on ‘good’, ‘medium’ and ‘poor’ quality chert cores, Bui Ceri Uato................................................................. 226
Table 8.10 t-test results comparing the number of platforms and flake scar directions between cores of ‘good’, ‘medium’ and ‘poor’ grade chert, Bui Ceri Uato........................................................................ 226
Table 8.11 The total number of flake scars on ‘good’, ‘medium’ and ‘poor’ grade chert cores, Bui Ceri Uato........................................................................ 229
Table 8.12 t-test results comparing the number of flake scars between cores of ‘good’, ‘medium’ and ‘poor’ grade chert, Bui Ceri Uato ........................................ 229
Table 8.13 Percentage of non-flaked surface area and ‘good’, ‘medium’ and ‘poor’ grade of cores, Bui Ceri Uato ........................................ 229
Table 8.14 Chi-square statistics for differences in the percentage of non-flaked surface area between cores of ‘good’, ‘medium’ and ‘poor’ grade chert, Bui Ceri Uato ........................................ 229
Table 8.15 Amount of cortex on cores of ‘good’ and ‘medium’ grade chert, Bui Ceri Uato ........................................ 229
Table 8.16 Chi-square statistics for differences in the proportion of cores with varying amounts of cortex in ‘good’ and ‘medium’ grade chert, Bui Ceri Uato ........................................ 230
Table 8.17 Amount of cortex on cores of ‘poor’ grade chert, Bui Ceri Uato ........................................ 230
Table 8.18 The number/proportion of heat-treated cores and grades of chert, Bui Ceri Uato ........................................ 231
Table 8.19 Chi-square statistics for differences in the proportion of heat-treated cores of ‘good’, ‘medium’, and ‘poor’ grade chert, Bui Ceri Uato ........................................ 231
Table 8.20 Indicators of size and heat-treatment, Bui Ceri Uato cores ........................................ 235
Table 8.21 t-test results comparing differences in size between heat-treated and non-heat-treated cores, Bui Ceri Uato ........................................ 235
Table 8.22 Number of platforms and flake scar directions on heat-treated and non-heat-treated cores, Bui Ceri Uato ........................................ 237
Table 8.23 t-test results comparing the number of platforms and flake scar directions between heat-treated and non-heat-treated cores, Bui Ceri Uato ........................................ 237
Table 8.24 Total number of flake scars on heat-treated and non-heat-treated cores, Bui Ceri Uato ........................................ 239
Table 8.25 t-test results comparing the total number of flake scars between heat-treated and non-heat-treated cores, Bui Ceri Uato ........................................ 239
Table 8.26 Percentage of non-flaked surface area on heat-treated and non-heat-treated cores, Bui Ceri Uato ........................................ 240
Table 8.27 Chi-square statistics for differences in the percentage of non-flaked surface area between heat-treated and non-heat-treated cores, Bui Ceri Uato ........................................ 240
Table 8.28 Amount of cortex on heat-treated and non-heat-treated cores, Bui Ceri Uato ................................................................. 240
Table 8.29 Chi-square statistics for differences in the amount of cortex between heat-treated and non-heat-treated cores, Bui Ceri Uato ............................................ 240
Table 9.1 Subgroups and chert cores, Bui Ceri Uato .................................................. 244
Table 9.2 Homogeneity and subgroups, Bui Ceri Uato cores ........................................ 246
Table 9.3 Chi-square statistics comparing homogeneity between subgroups, Bui Ceri Uato cores .............................................................................................................. 246
Table 9.4 Texture of flake scar surfaces and subgroups, Bui Ceri Uato cores ................................. 246
Table 9.5 Chi-square statistics comparing the texture of flake scar surfaces between subgroups, Bui Ceri Uato cores ................................................................. 246
Table 9.6 Grade of quality chert and subgroups, Bui Ceri Uato ........................................ 247
Table 9.7 Chi-square statistics comparing the grades of quality chert between subgroups, Bui Ceri Uato cores ................................................................................. 247
Table 9.8 Size of ‘good’ grade quality chert cores in each subgroup, Bui Ceri Uato .................... 253
Table 9.9 t-test results comparing differences in size between cores in each subgroup, Bui Ceri Uato ........................................................................................................... 253
Table 9.10 Number of platforms, flake scar directions, and subgroups, Bui Ceri Uato cores ................................................................. 256
Table 9.11 t-test results comparing the number of platforms and flake scar directions between cores in each subgroup, Bui Ceri Uato ...................................................... 256
Table 9.12 Total number of flake scars on cores in each subgroup, Bui Ceri Uato .................... 260
Table 9.13 t-test results comparing the total number of flake scars on cores in each subgroup, Bui Ceri Uato ........................................................................................................... 260
Table 9.14 Percentage of non-flaked surface area and cores in each subgroup, Bui Ceri Uato ................................................................. 261
Table 9.15 Chi-square statistics for differences in the percentage of non-flaked surface area between cores in each subgroup, Bui Ceri Uato ...................................................... 261
Table 9.16 Amount of cortex on cores in each subgroup, Bui Ceri Uato ........................................ 261
Table 9.17 Chi-square statistics for differences in the proportion of cores in each subgroup with varying amounts of cortex, Bui Ceri Uato ................................................................. 261
Table 9.18 Ratio of the length of the longest complete flake scar (from platform 1) over core length, Bui Ceri Uato ................................................. 262
Table 9.19 t-test results comparing the ratio of the length of the longest complete flake scar from platform 1 over core length between cores in each subgroup, Bui Ceri Uato .............................................................................. 262
Table 9.20 Heat-treated cores and subgroups, Bui Ceri Uato .................. 267
Table 9.21 Chi-square statistics the proportion of heat-treated chert cores between subgroups, Bui Ceri Uato ................................................. 267
Table 9.22 Rates of occurrence of heat-treated chert cores ..................... 267
List of Figures

Figure 1.1 Location of East Timor in Island Southeast Asia ..................... 3
Figure 1.2 East Timor and the location of Bui Ceri Uato .......................... 4
Figure 1.3 Bui Ceri Uato and the Bobonaro Scaly Clays .......................... 4
Figure 1.4 Dwellings in a village settlement located near the Baucau Plateau, East Timor ................................................................. 7
Figure 1.5 ‘Scrapers’ from Bui Ceri Uato, East Timor ......................... 8
Figure 1.6 Utilised flakes from Bui Ceri Uato, East Timor ....................... 9
Figure 1.7 ‘Tanged points’ from Uai Bobo 1, East Timor ....................... 9
Figure 1.8 Core artefacts from Bui Ceri Uato ........................................ 17
Figure 2.1 Place names and archaeological sites investigated by Bühler, Verhoeven, Almeida, Mendes Correa and Cinatti in Timor ....................... 27
Figure 2.2 The location of Glover’s main excavations in East Timor ... 35
Figure 2.3 Glover’s main sites and those excavated by the ETAP .......... 42
Figure 2.4 The location of drilled cores in Island Southeast Asia .............. 51
Figure 2.5 Sea levels in Southeast Asia at 20 metres below present day level .................................................................................... 52
Figure 2.6 Sea levels in Southeast Asia at 50 metres below present day level .................................................................................... 52
Figure 2.7 Sea levels in Southeast Asia at 75 metres below present day level .................................................................................... 53
Figure 2.8 Sea levels in Southeast Asia at 120 metres below present day level .................................................................................... 53
Figure 3.1 Bui Ceri Uato and the Baucau Plateau, East Timor .................. 57
Figure 3.2 Bui Ceri Uato and reef terraces on the Baucau Plateau, East Timor .................................................................................... 58
Figure 3.3 Bui Ceri Uato, northern area of the shelter ............................ 59
Figure 3.4 Bui Ceri Uato, southern area of the shelter ............................ 59
Figure 3.5 Bui Ceri Uato, southern area of the shelter ............................ 60
Figure 3.6 View from Bui Ceri Uato, East Timor ..................................... 60
Figure 3.7 Bui Ceri Uato and the Marine Terrace Zone .......................... 63
Figure 3.8 Dense vegetation surrounding a freshwater spring on the Baucau Plateau ................................................................................. 64
Figure 6.2 Flaked stone artefact discard rate (# per m$^3$ per 100 years) according to subgroups, Bui Ceri Uato .......................................................... 163
Figure 6.3 Core artefact discard rate (m$^3$ per 100 years) according to subgroups, Bui Ceri Uato ......................................................................... 163
Figure 6.4 Core:Flake ratio (standardised by m$^3$ per 100 years) according to subgroups, Bui Ceri Uato ............................................................ 164
Figure 7.1 Cores of (a) silicified limestone (4381, V) and (b) a volcanic material (4380, V), Bui Ceri Uato ............................................................. 174
Figure 7.2 Cores of obsidian, Bui Ceri Uato ............................................................. 174
Figure 7.3 Weight of cores with and without taphonomic impacts to mass. 180
Figure 7.4 Length of cores with and without taphonomic impacts to length 181
Figure 7.5 Number of platforms with and without taphonomic impacts to platform counts ................................................................. 181
Figure 7.6 Crazing and weight, Bui Ceri Uato cores ................................................................. 186
Figure 7.7 Crazing and length, Bui Ceri Uato cores ................................................................. 187
Figure 7.8 Crazing and volume, Bui Ceri Uato cores ................................................................. 187
Figure 7.9 Crazing and surface area, Bui Ceri Uato cores ................................................................. 188
Figure 7.10 Crazing and surface area to weight ratio, Bui Ceri Uato cores ................................................................. 188
Figure 7.11 Pot lid scars and length, Bui Ceri Uato cores ................................................................. 189
Figure 7.12 Pot lid scars and volume, Bui Ceri Uato cores ................................................................. 189
Figure 7.13 Pot lid scars and surface area, Bui Ceri Uato cores ................................................................. 189
Figure 7.14 Convoluted surfaces and length, Bui Ceri Uato cores ................................................................. 190
Figure 7.15 Convoluted surfaces and volume, Bui Ceri Uato cores ................................................................. 190
Figure 7.16 Convoluted surfaces and surface area, Bui Ceri Uato cores ................................................................. 191
Figure 7.17 Crazing and parallel index at midpoint, Bui Ceri Uato cores ................................................................. 194
Figure 7.18 Crazing and parallel index at endpoint, Bui Ceri Uato cores ................................................................. 195
Figure 7.19 Crazing and relative thickness index, Bui Ceri Uato cores ................................................................. 195
Figure 7.20 Crazing and longitudinal thinness index at midpoint, Bui Ceri Uato cores ................................................................. 196
Figure 7.21 Crazing and longitudinal thinness index at endpoint, Bui Ceri Uato cores ................................................................. 196
Figure 7.22 Pot lid scars and parallel index at midpoint, Bui Ceri Uato cores ................................................................. 197
Figure 7.23 Pot lid scars and parallel index at endpoint, Bui Ceri Uato cores......................................................................................................................... 197
Figure 7.24 Pot lid scars and relative thickness index, Bui Ceri Uato cores. 198
Figure 7.25 Pot lid scars and longitudinal thinness index at midpoint, Bui Ceri Uato cores........................................................................................................... 198
Figure 7.26 Pot lid scars and longitudinal thinness index at endpoint, Bui Ceri Uato cores........................................................................................................... 199
Figure 7.27 Convoluted surfaces and parallel index at midpoint, Bui Ceri Uato cores........................................................................................................... 199
Figure 7.28 Convoluted surfaces and parallel index at endpoint, Bui Ceri Uato cores........................................................................................................... 200
Figure 7.29 Convoluted surfaces and relative thickness index, Bui Ceri Uato cores........................................................................................................... 200
Figure 7.30 Convoluted surfaces and longitudinal thinness index at midpoint, Bui Ceri Uato cores........................................................................................................... 201
Figure 7.31 Convoluted surfaces and longitudinal thinness index at endpoint, Bui Ceri Uato cores........................................................................................................... 201
Figure 7.32 Frequency of occurrence of cores with thermal damage and sedimentation (log scale; number of cores/m³/1,000 years; m³ of deposit/1,000 years), Bui Ceri Uato ............................................................................................................................................ 206
Figure 8.1 Core reduction with (a) no rotations and (b) two rotations........ 212
Figure 8.2 The relationship between flake scar count and the percentage of non-flaked surface area (a) Three small flake scars and a correspondingly large non-flaked surface area (b) Three large flake scars and a correspondingly larger area of non-flaked surface........................................................................................................... 214
Figure 8.3 Weight and grades of chert quality, Bui Ceri Uato cores........... 221
Figure 8.4 Length and grades of chert quality, Bui Ceri Uato cores........... 221
Figure 8.5 Volume and grades of chert quality, Bui Ceri Uato cores........... 222
Figure 8.6 Surface area and grades of chert quality, Bui Ceri Uato cores....222
Figure 8.7 Surface area to weight ratio and grades of chert quality, Bui Ceri Uato cores........................................................................................................... 223
Figure 8.8 Number of platforms and grades of chert quality, Bui Ceri Uato cores........................................................................................................... 225
Figure 8.9 Number of flake scar directions and grades of chert quality, Bui Ceri Uato cores......................................................................................... 226
Figure 8.10 The total number of flake scars and grades of chert, Bui Ceri Uato cores......................................................................................... 228
Figure 8.11 Weight and heat-treatment, Bui Ceri Uato cores.......................................................................................... 233
Figure 8.12 Length and heat-treatment, Bui Ceri Uato cores.......................................................................................... 233
Figure 8.13 Volume and heat-treatment, Bui Ceri Uato cores.......................................................................................... 234
Figure 8.14 Surface area and heat-treatment, Bui Ceri Uato cores..................................................................................... 234
Figure 8.15 Surface area to weight ratio and heat-treatment, Bui Ceri Uato cores......................................................................................... 235
Figure 8.16 Number of platforms and heat-treatment, Bui Ceri Uato cores......................................................................................... 236
Figure 8.17 Number of flake scar directions and heat-treatment, Bui Ceri Uato cores......................................................................................... 237
Figure 8.18 The total number of flake scars and heat-treatment, Bui Ceri Uato cores......................................................................................... 239
Figure 9.1 Weight and subgroups, Bui Ceri Uato cores......................................................................................... 250
Figure 9.2 Length and subgroups, Bui Ceri Uato cores......................................................................................... 251
Figure 9.3 Volume and subgroups, Bui Ceri Uato cores......................................................................................... 251
Figure 9.4 Surface area and subgroups, Bui Ceri Uato cores......................................................................................... 252
Figure 9.5 Surface area to weight ratio and subgroups, Bui Ceri Uato cores......................................................................................... 252
Figure 9.6 Number of platforms and subgroups, Bui Ceri Uato cores......................................................................................... 255
Figure 9.7 Number of flake scar directions and subgroups, Bui Ceri Uato cores......................................................................................... 255
Figure 9.8 Total number of flake scars and subgroups, Bui Ceri Uato cores......................................................................................... 260
Figure 9.9 Length of the longest complete flake scar over core length ratio and subgroups, Bui Ceri Uato......................................................................................... 262
Figure 9.10 Frequency of occurrence of (heat-treated) chert cores in subgroups, Bui Ceri Uato......................................................................................... 267
CHAPTER 1

INTRODUCTION

A number of studies suggest that associated with higher sedentism (i.e. lower residential mobility; Binford, 1980; see also Kelly, 1992) or with higher intensities of human occupation at a site, are attempts to conserve or maximise stone material in knapping activities (e.g. Hiscock, 1994: 285-286, 1996, 2003: 72; Holdaway, 2000; Shiner et al, 2005). This may be indicated by highly reduced lithic assemblages with an emphasis on local stone (Hiscock, 1994: 285-286). Other indications of economising behaviour in lithic assemblages may include intensive reduction of cores (Hayden et al, 1996: 39; Holdaway, 2000; Munday, 1977; Roth and Dibble, 1998; Shen, 2001: 134-135), relatively high frequencies of retouched flakes (Hiscock, 2003), relatively more frequent use of bipolar knapping (Hiscock 1996), and extensive use of heat-treatment (Hiscock, 1993: 75). Such strategies serve to prolong reduction, thereby extending the exploitation of stone material in knapping activities and reducing the stone procurement costs incurred by more sedentary groups.

On the other hand, in an overview of archaeological sites in North America, Parry and Kelly (1987) describe multidirectional cores in terms of an expedient/informal core technology which became more common when populations became more sedentary. They suggest that this informal core technology was actually wasteful of stone material in knapping activities and that people amassed and stored raw stone materials at sites in sufficient quantities to avoid any limitations that may have otherwise been created by raw material
shortage. This stockpiling strategy of provisioning places provided the constant availability of raw materials and effectively eliminated the effect of absolute distance from raw material source in reduction strategies (Johnson, 1987: 203). In this way, provisioning of places should be marked by less extensive reduction and a lower occurrence of reworked flakes (Kuhn, 2004: 433).

The present study explores these issues of core reduction at Bui Ceri Uato, East Timor (Figures 1.1 and 1.2). Bui Ceri Uato is located a minimal direct distance of 8 km from an abundant source of naturally occurring chert nodules, Bobonaro Scaly Clays (Figure 1.3). This ready supply of stone material suitable for knapping occurs immediately on descent off the limestone Baucau Plateau on which Bui Ceri Uato is located. In fact, arriving onto the Baucau limestone plateau overland would necessitate travelling through the Bobonaro Scaly Clays. This means that the opportunity to obtain chert nodules for knapping activities once off the limestone Baucau Plateau is immediately available. As distance to lithic source is controlled, temporal trends in the extent/length of reduction of cores at Bui Ceri Uato may be explained by changes in levels of mobility of human groups occupying the shelter and may be indicated by the intensity of human use/occupation of the site. Temporal trends in levels of human occupation as well as the extent/length of core reduction at Bui Ceri Uato will be discussed in the context of broader processes such as palaeoenvironmental conditions and human settlement/subsistence changes in the prehistory of East Timor.
Figure 1.1 Location of East Timor in Island Southeast Asia
Figure 1.2 East Timor and the location of Bui Ceri Uato

Figure 1.3 Bui Ceri Uato and the Bobonaro Scaly Clays (Adapted from Metzner, 1977: Figure 10, after Audley-Charles 1968: 42)
BUI CERI UATO AND EAST TIMOR PREHISTORY

One of four major cave/rockshelter sites excavated by Ian Glover in the 1960s, Bui Ceri Uato reveals major changes in human subsistence/settlement strategies in the prehistory of East Timor. This can be simply described in terms of a hunter-gatherer subsistence strategy in the Pleistocene and early Holocene, followed by the adoption of animal husbandry, some sort of agricultural practices and the establishment of village communities in the mid-to late Holocene. Technological replacement may also have occurred, with the introduction of metal to Timor just over 2,000 years ago and with the probable introduction/cultivation of bamboo sometime during the late Holocene. Chapter 2 of the present study provides a comprehensive outline of human subsistence/settlement changes in the prehistory of East Timor. Only a brief synthesis of these broader subsistence/settlement changes in East Timor prehistory is provided below.

SUBSISTENCE/SETTLEMENT CHANGES

Glover described a hunter-gatherer exploitation of East Timor's depauperate endemic fauna (giant and small murids, reptiles, birds and bats) extending from about 13,400 BP (1986: Table 1). From about 5,000 BP pottery, seemingly in tandem with a range of imported animals both wild (civet cat, cuscus, macaque, Rattus exulans, Rusa deer) and domesticated (pig, dog, Capra/Ovis, Bos), appeared. Glover (1986) interpreted the appearance of domesticated fauna in terms of marking the adoption of animal husbandry and, synonymous with ceramic technology, the adoption of some sort of agricultural practices. Other inferred changes include an overall increase in population size and the establishment of village settlements such as those seen on Timor today.
(Figure 1.4) (Glover, 1986). On the basis of information recorded by Glover (1986), the cultural contents of Bui Ceri Uato and sequence of material changes are provided in Chapter 3 of the present study. Glover (1986) also suggested that a decline in flaked stone artefact counts in upper layers of the excavated sites may mark the arrival of metal and/or the cultivation of bamboo within East Timor. Evidence of technological replacement at Bui Ceri Uato is examined further in Chapter 4.

Archaeological research in East Timor is still in a preliminary stage. The order of faunal succession remains unknown. Extinction of the giant murids occurred after these faunal introductions. Precise dating of and cause of extinction are unclear. As yet, there is no direct archaeological evidence of agricultural practices and, apart from the identification of a possible foxtail millet seed (*Setaria*, see Glover, 1986: Appendix 4), no plant staples have been found in an archaeological context. There is no convincing archaeological evidence of population increase and the timing of initial village communities in the prehistory of East Timor remains unknown. In essence, interrelationships between the adoption of animal husbandry, agricultural practices, the establishment of village communities and population increase remain speculative pending further archaeological research.

While aware of the extremely limited knowledge of the nature and timing of human subsistence, settlement and population changes, the present study concedes Glover’s (1986) model of developmental changes in the prehistory of East Timor as reasonable. For instance, broad changes thought of in terms of an initial colonisation by relatively small sized populations of hunter-gatherers, followed by (not necessarily in order) the adoption of animal husbandry, some
sort of agriculture, the establishment of village settlements and population increase are acceptable modelled developments and widely attested elsewhere in Island Southeast Asia (Bellwood, 1997a). Of interest to the present study, is how these inferred changes in human settlement/subsistence of East Timor may be reflected in its flaked stone technology.

Figure 1.4 Dwellings in a village settlement located near the Baucau Plateau, East Timor (Courtesy of Nuno Vasco Oliveira)

FLAKED STONE ARTEFACTS

Despite the suite of human subsistence, settlement and population changes inferred to have taken place, Glover (1986) noticed few distinct changes in the lithic technology of East Timor. The only major change observed was a decline in flaked stone artefact counts in upper layers in his excavated sites. This decline was explained by Glover (1986: 202-204) in terms of the technological replacement of flaked stone with metal and/or bamboo (e.g. Pope, 1989). He
described a decline in the 'popularity' (i.e. abundance) of flaked stone at about 3,000 BP (Glover, 1986: 203), stating that flaked stone was abandoned as an important tool-making material by 2,000 BP (Glover, 1986: 202). On this basis, he described the period between 3,000-2,000 BP as possibly marking the arrival and spread of metal and/or the introduction of/or cultivation of bamboo in East Timor (see Chapter 4 of the present study for further examination of this issue at Bui Ceri Uato).

Glover (1986) described the flaked stone artefacts in East Timor as generally amorphous in shape, with the most distinctive tools described as 'steep-edge hollow scrapers' (Figure 1.5) and 'unretouched flakes with traces of edge gloss' (Figure 1.6) (Glover, 1977a: 43). Apart from the addition of 'tanged points' (10 specimens at Uai Bobo 1; some of which are illustrated in Figure 1.7) which seemed to accompany the appearance of pottery and domesticated animals, Glover described a continuity in the lithic technology of East Timor (1986: 197, 1977a: 43, 1973: 60-61).

Figure 1.5 'Scrapers' from Bui Ceri Uato, East Timor
From top left through to bottom right, identification number and (Horizon); 2784 (IX); 2845 (IX); 2822 (IX); 6103 (II); 2958 (VIII); 3009 (VIII); 3003 (VIII); 3411 (VII); 3480 (VII); 3229 (VII); 3998 (VI); 3897 (VI); 4051 (VI). (From Glover, 1986: Fig.24)
Glover was of the belief that there were no substantial changes in the nature of human use of the excavated rockshelters (1986: 206) and that this may explain the apparent continuity in the flaked stone technology. He believed that the excavated shelters were always used only as temporary camps (even when village settlements existed in East Timor) and reflected mostly hunting and collecting aspects of daily life (Glover, 1986: 206-207, 1971: 174; see also
Gorecki, 1991, where on the basis of ethnoarchaeological evidence in New Guinea he showed that horticulturalists camping overnight at rockshelters on hunting trips were indistinguishable from hunter-gatherers in terms of their material remains). Glover proposed that simple cutting tools for food preparation and the manufacture/repair of hunting equipment were not likely to have been affected by changes to the subsistence economy (1986: 207). He argued that the same sorts of cutting tools would be needed for the same sorts of purposes and it is, therefore, unsurprising that a change in the basic mode of subsistence did not affect the activities carried out (or the stone technology) at the various rockshelters (Glover, 1971: 174).

This view of the function of flaked stone artefacts as primarily maintenance tools (Binford and Binford, 1966: 286-287) was also adopted by other researchers working in Island Southeast Asia and Melanesia as a means of explaining the amorphous morphology of flaked stone artefacts and chronological continuity in lithic traditions similarly observed in these respective agricultural regions (Presland, 1980 e.g. Hutterer, 1976: 225, 1977a: 51-57, 60, 1985: 13-14; White, 1971: 190-191, 1977: 22, 1984: 102). This functional approach to explain chronological uniformity in lithic assemblages also extended to researchers investigating hunter-gatherer prehistory in Australia (e.g. Peterson, 1971: 243). More recently, claims of chronological uniformity in lithic technology have been criticised on the basis that such analyses are usually formed solely on descriptions of artefact size and a general level of typological analysis and, thus, are inadequate in detecting change in lithic technology (Hiscock, 1984: 148; 1988: 269; 2003: 72; Hiscock and Attenbrow, 2005; Hiscock and Clarkson, 2000; Holdaway, 1995; see Holdaway and Stern, 2004:
275-315 for a historical overview of lithic developments in Australia). These critics propose that the methodologies of such typologically oriented studies claiming uniformity in lithic assemblages are likely to be deficient, rather than actually reflecting any real conservatism in the lithic technology.

It is likely that the paucity of distinctive types and the general amorphous nature of flaked stone artefacts in the East Timor assemblages were not amenable to the detection of change on the basis of a typologically oriented approach to lithic analysis such as that adopted in Glover (1986). The present study aims to investigate this issue of apparent continuity in East Timor lithic traditions by adopting a technological approach to lithic analysis, one that is based on an understanding of the mechanical process of stone knapping and core reduction and the system of organisation of lithic technology.

STONE KNAPPING AND CORE REDUCTION

Vital to any technological investigation of flaked stone artefacts is a clear understanding of the process of stone knapping or stone reduction. Knowledge of stone knapping can provide us with insights into the relationship between human choice and mechanical necessity. This relationship can be described in terms of the manufacturing techniques adopted in the reduction of stone (including heat-treatment) and levels of human necessity for flaked stone, with the mechanics of stone knapping and the intrinsic properties of the raw material being reduced. Chapter 5 of the present study outlines the process and considerations involved in stone knapping and core reduction. Technologically orientated analyses of flaked stone assemblages can provide insight to examine larger scale questions such as mobility of human groups and other strategies of land use, particularly when studied from the viewpoint of the organisation of lithic technology.
THE LITHIC SYSTEM

Flaked stone artefacts were manufactured in an ordered succession of actions by humans in the prehistoric past. Broadly, these comprise the procurement of suitable stone, stone knapping or reduction, flaked stone tool use (i.e. as tools), followed by discard. These processes form a basic framework for what can be regarded as a 'system' (Clarke, 1978) of organisation of lithic technology. This conceptualisation of a system of technological organisation allows archaeologists to analyse flaked stone artefact assemblages in terms of dynamic relationships of human behaviour in prehistory (Nelson, 1991) and goes beyond basic descriptions of stone artefacts (e.g. Andrefsky, 1994a; Bamforth, 1991; Carr, 1994; Cowan, 1999; Cundy, 1990; Hallos, 2004; Henry and Odell, 1989; Johnson and Morrow, 1987; Kelly, 1988; Kuhn, 1995, 2004; Law, 2003; Ricklis and Cox, 1993; Roebroeks et al, 1988; Shott, 1986, 1989a, 1989b). Within this framework, lithic assemblages can be viewed as patterned by the way the organisation of flaked stone technology is placed within the constraints of human settlement and subsistence strategies in prehistory. That is, flaked stone artefact assemblages can be seen to be a result of a dynamic set of human behavioural responses which interact with - and are conditioned by – human strategies of land use in the past.

Human capacity to reason and manipulate symbols is fundamental to investigations of human behavioural responses inferred from lithic assemblages (assuming on the basis of evolutionary and biological principles that these abilities extended to human beings in prehistory) (Trigger, 1991). The capacity to manipulate symbols “allows human beings to foresee, at least within limited degrees, the consequences of alternative courses of action” (Trigger, 1991: 555).
Reason, as the "the ability to make informed choices between perceived alternatives", permits individuals to "judge which of a number of alternative strategies may be either the most desirable, or the least undesirable, in terms of the goals they have set for themselves" (Trigger, 1991: 555). Such abilities outline a rationale to human behaviour and form the basis for archaeological endeavours to frame problems encountered by humans (and their responses) in the lithic system.

Flaked stone artefact assemblages can be regarded as an adaptive solution to a set of problems encountered by humans in prehistory. These can be defined, on the one hand, as the predictability of procuring suitable stone sources for lithic manufacture, the cost or effort of transporting stone for lithic manufacture and the predictability of successfully reducing stone to obtain flaked stone tools and, on the other, as the locations of human land use where the use of lithic technology was required. The predictability of procuring suitable stone sources for lithic manufacture is dependant largely on the familiarity of human groups with the surrounding region, and will vary depending on the mobility and settlement strategies adopted. It may also reflect the nature and rate of change in the environment, such as when environmental processes may alter the distribution and/or availability of suitable stone resources in the landscape (e.g. rising sea levels inundating coastal quarries). The cost or effort of transporting stone for lithic manufacture will vary depending on the distance, mode of transport, accessibility and availability of lithic resources to the human groups that require them. The predictability of successfully (however this may be defined) reducing stone to obtain flaked stone tools is, in part, dependant on the quality of the stone material being knapped, the level of experience and skill of
the knapper, and the strategy of reduction. These factors describe the nature of interactions between the lithic system and human settlement strategies.

Variables linking the organisation of flaked stone technology and human settlement strategies are: levels of mobility of human groups and human necessity and/or pressure for flaked stone. Along with the ‘cost’ or effort involved in procuring or making raw stone material available, these variables interact and have a role in determining the extent of reduction observed in lithic assemblages (Hiscock, 2003: 72; Jeske, 1989; Kuhn, 1991). The ‘cost’ or effort involved in making raw stone material available varies partly as a function of the natural distribution of stone resources in the landscape and the movement of human groups relative to the location of these stone resources (Kuhn, 1995: 124; see also Andrefsky, 1994a, 1994b; Bamforth, 1990; Holdaway, 2000; Rolland and Dibble, 1990: 484; Roth and Dibble, 1998). This can be illustrated by the distance between the location of flaked stone artefact sites and the source of raw stone material in the landscape (e.g. McNiven, 1993). In the case of large distances between flaked stone artefact sites and lithic resources, stone materials could be procured directly but with significant cost and with little or no direct reference to human settlement/subsistence activities. The higher the cost or effort involved in procuring stone sources, the greater the pressure experienced on the part of the knapper to reduce stone further in order to maximise the stone material in knapping activities (Jeske, 1989; Kuhn, 1995). In this way, lithic assemblages with highly reduced cores and/or high frequencies of retouched flakes may be indicative of pressure of availability of stone resources. This pressure could be explained by mobility of human groups distant from sources of lithic raw materials. An alternative explanation could involve social factors such
as territoriality and the ownership of resources restricting access to local stone (Bamforth, 1986; Jeske, 1989). If the cost or effort of obtaining suitable stone for knapping purposes is too great and/or if other materials such as metal and/or bamboo become relatively more available, then the abandonment of flaked stone technology in favour of these easier alternatives becomes more likely.

A combined understanding of the process of stone reduction and the system of organisation of lithic technology forms a powerful investigative framework with which to examine temporal change in lithic technology. Such a framework is based on an understanding of the constraints inherent to the technology and, thus, more sensitive to the detection of change than typological-based approaches. In turn, technological changes may be interpretable in terms of human behavioural responses within the lithic system and linked more broadly to human land use strategies.

RESEARCH AIMS

The present study aims to bring some light to bear on the issue of apparent chronological continuity in the flaked stone traditions of East Timor. This is approached from a technological-based understanding to lithic analysis, founded on an understanding of mechanical process of stone knapping and from the perspective of the organisation of flaked artefact manufacture. More specifically, the present study aims to investigate the level of technological response evident from the morphology of core artefacts at Bui Ceri Uato.
The Bui Ceri Uato excavation produced the most abundant flaked stone assemblage in East Timor known to date. Over 39,000 stone artefacts were recovered, 852 of which were identified by Glover as cores (1986: Tables 41 and 43). On the basis of a more technological definition of a core, however, the present study identified 395 cores in the Bui Ceri Uato assemblage (see Chapter 7). The shelter reflects the major changes in human subsistence practices in East Timor, whereby native fauna are replaced with imported fauna in ceramic-containing deposits (see Chapter 3). The abundance of lithic material in a cultural assemblage which reflects major subsistence changes warranted further investigation whereby one aspect of the lithic assemblage, the cores, were specifically targeted for analysis.

The vast majority of the core artefacts at Bui Ceri Uato are multi-platformed and heavily rotated (Figure 1.8). Glover did not observe any typological changes in core morphology over time (1986: Table 43). However, he did record a continuous decline in the average diameter of cores. Interestingly, this trend paralleled a sequential decline in the average mass of ‘waste flakes’ at the site (1986: Table 42, p. 100). Glover’s (1986) analysis of cores at Bui Ceri Uato and his conclusion are reviewed further in Chapter 4 of the present study.

The overwhelming majority of Bui Ceri Uato cores were manufactured from chert, which is found in abundance in the Bobonaro Scaly Clays immediately adjacent to the limestone Baucau Plateau (see Figure 1.3), on which Bui Ceri Uato is located. A minority of the cores were manufactured from obsidian, which Glover describes as occurring as small vesicular pebbles along the western edge of the Baucau Plateau (1986: 56). The present author was
unable to access this region of the Baucau Plateau and verify this obsidian source. However, on the basis of observations of a similar range of coloured cherts in the Bui Ceri Uato lithic assemblage with those found in the Bobonaro Scaly Clays, it is reasonable to suggest that the majority of the chert cores were procured locally from the Bobonaro Scaly Clays (pers. obs., see Chapter 3). Consequently, distance to raw stone materials as a variable factor in the lithic system can be essentially eliminated. Relative levels of accessibility to local Bobonaro chert may have changed as a result of changes in human land use (i.e. changes in human subsistence and settlement/social organisation) and is a factor that has explanatory potential for temporal changes in the extent/length of core reduction at the site.

Figure 1.8 Core artefacts from Bui Ceri Uato
From top left through to bottom right, identification number and (Horizon): 5625 (III); 5357 (III); 5625 (III); 5519 (III); 5378 (III); 5275 (III).
(Each square is equal to 1 cm)
RESEARCH AGENDA

A core depicts the latest series of flake scars at the point when knapping ceased or reduction was discontinued (see Figure 1.8). At this stage, the core is inferred to have been discarded by the knapper. Earlier stages of flaking may be completely eliminated from the face of the core as reduction continued (Dibble, 1995: 102). There is no reason to think, however, that all cores in a lithic assemblage were discarded at the exact same point in their potential use life (Dibble, 1995: 102). That is to say, individual cores may have undergone different degrees of reduction prior to being discarded. There may be a number of technical reasons why core reduction was discontinued including serious flaws in the material, inappropriate and/or unrecoverable flaking and platform surfaces, high platform angles, as well as the absolute size of the core itself (see Chapter 5). Overall, however, the degree to which cores in a lithic assemblage are reduced is a function of the human necessity for flaked stone (Dibble, 1995: 102). This, in turn, may be reflective of the availability of raw stone material (which is dependent on the mobility of human groups and the natural distribution of stone resources in the landscape) and the overall intensity of human occupation of a site (Dibble, 1995: 102; Kuhn, 1991; Rolland and Dibble, 1990).

Glover (1986) observed a sequential decline in core size at Bui Ceri Uato. On preliminary observation, this may be suggestive of a temporal trend toward greater core reduction. By undertaking a comprehensive analysis of the morphology of the cores, the present study aims to investigate this observed trend and evaluate the extent to which this may represent a temporal increase in the extent/length of core reduction. Based on the reasoning outlined in this chapter, temporal changes in the extent/length of core reduction may be regarded
as indicative of economising of stone material in knapping activities and of pressure experienced by humans occupying the shelter for flaked stone. This is, in turn, linked to stone procurement strategies and levels of mobility of human groups at the site.

A further indicator of human land use/mobility at Bui Ceri Uato, are levels of occupation at the shelter. This can be assessed independent of trends in core reduction. Assessing the direction of temporal trends in core reduction as well as levels of human occupation of the shelter provide a powerful analysis on which to base interpretations of the nature of human land use/mobility at Bui Ceri Uato in the distant past.

AIMS

The principal aims of the present study are to:

1. **Assess temporal trends in levels of human occupation**

Indices of levels of human occupation at Bui Ceri Uato are provided by sedimentation rates, flaked stone artefact discard rates and the frequency of occurrence of cores with taphonomic damage from uncontrolled exposure to heating/cooling.

*Sedimentation and flaked stone discard rates*

Glover (1986) was not able to obtain dates satisfactorily determining the age of the cultural contents at Bui Ceri Uato shelter. Instead, he relied on correlations with the nearby better-dated site of Lie Siri to suggest a chronological framework at the site (see Chapter 3). The present study seeks to redress this dating issue, with the aim of providing a radiocarbon dated marine shell sequence determining the age of cultural contents deposited at the shelter.
A dated chronological sequence allows sedimentation rates and flaked stone artefact discard rates to be calculated, which are indicators of levels of human occupation at Bui Ceri Uato. This reasoning is based on the assumption that human use of the site resulted in accelerated rates of weathering of the limestone walls in addition to deposition of sediments brought into the shelter (Farrand, 2001: 542, 546-547). Flaked stone artefact discard rates reflect knapping activities conducted at the site and, in this way, provide an indirect measure of levels of human use of the site. These indices of levels of human occupation are presented in Chapter 6 of the present study.

*Taphonomic impacts*

Taphonomic impacts to flaked stone artefacts (e.g. Hiscock, 1985) occur after reduction has taken place. That is, taphonomic impacts are those that occurred after knapping ceased and the core was discarded. One type of taphonomic impact to stone artefacts may result from direct or uneven exposure to heat (such as that caused from proximity to a campfire). Uncontrolled exposure to heat may produce thermal fractures on the stone artefacts e.g. crazing, pot lids, crenated fracture and what can be generally described as convoluted surfaces. Thermal fractures are described further in Chapter 5 and Appendix A of the present study.

The frequency of occurrence of cores with thermal damage may be indicative of temporal trends in relative levels of human use of fire/hearths at Bui Ceri Uato (e.g. Hiscock, 1984: 144-146; Hiscock and Hall, 1988a: 101). This, in turn, may provide one indication of relative levels of human use of the shelter. For instance, a higher frequency of cores with thermal damage indicates relatively higher levels of human induced impacts from campfires lit in the
shelter and, thus, may be indicative of relatively greater human use of Bui Ceri Uato. Taphonomic assessments of the cores are presented in Chapter 7 and include an overall assessment of levels of human occupation as illustrated by sedimentation rates, flaked stone artefact discard rates and frequencies of cores with thermal damage.

An added advantage of assessing taphonomic damage to the core artefacts is that it allows assessments of the extent/length of core reduction to be filtered of taphonomic bias. For instance, thermal damage may result in taphonomic bias in recordings of core morphology by underestimating core size (i.e. weight and length), affect the extent of core rotation (i.e. the number of platforms and flake scar directions) and flake scars (i.e. flake scar counts, flake scar area, the amount of cortex). Identifying morphological damage in this way allows cores with taphonomically-affected morphological recordings to be excluded from analyses involving these particular morphological attributes. Consequently, taphonomic biases are filtered from core reduction assessments.

2. Assess temporal trends in the extent/length of core reduction

Relative changes in the extent/length of cores at Bui Ceri Uato provide an indication of temporal trends in levels of pressure for stone resources experienced by humans occupying the shelter in prehistory. With the distance to lithic source (a minimal direct distance of 8 km from Bobonaro Scaly Clays) remaining constant, temporal changes in levels of pressure for flaked stone can be interpreted in terms of stone procurement strategies and the mobility of human groups occupying the shelter.

Morphological attributes recorded by the present study relevant to assessments of the length/extent of core reduction involve the raw stone material,
the quality of the stone material and heat-treatment (see Chapter 5 and Appendix A). Morphological indicators of the extent/length of core reduction include core size (e.g. weight, length, volume, surface area, surface area to weight ratio), rotation (indicated by the number of platforms and the number of flake scar directions) and flake scars (indicated by the number of flake scars, percentage of flake scar area as a proportion of the surface area of the core, and the amount of cortex) (Appendix A). Assessments of the extent/length of core reduction are presented in Chapters 8 and 9.

Temporal trends in levels of pressure for available stone resources and levels of human occupation of Bui Ceri Uato are discussed in the context of the modelled developmental changes in human subsistence/settlement organisation in East Timor (outlined in this chapter). A further consideration which is incorporated into the analysis is palaeoenvironmental changes in the region and fluctuations in World sea levels (see Chapter 2). It is possible that some of the trends evident on analysis of the cultural materials contained at Bui Ceri Uato may be informative of human responses to changes in past environments.

**THESIS STRUCTURE**

This thesis is divided into ten chapters.

Chapter Two provides a background history of archaeological research and previous investigations of the lithic technology of East Timor. Changes in palaeoenvironmental conditions in the Timor region and World sea levels are also outlined.
Contextual information on Bui Ceri Uato rockshelter including its environmental setting, excavation and cultural contents, is provided in Chapter Three.

A review of Glover's lithic analysis including flaked stone artefact density trends, cores is provided in Chapter Four, along with his interpretations of the nature of human use of Bui Ceri Uato shelter.

Chapter Five provides technical and mechanical information on the process of stone knapping and core reduction. This describes the technological approach to lithic analysis adopted.

Chapter Six presents the results of radiocarbon-dated marine shell and charcoal determinations from the site obtained by this study. For the first time, rates of sedimentation and flaked stone artefact discard are calculated and provide indicators of levels of human occupation at the shelter. Core subgroups are constructed in order to detect temporal changes in core reduction.

Chapter Seven explores the nature of taphonomic impacts on core morphology and assesses the frequency of occurrence of cores with thermal damage at Bui Ceri Uato. This is an indication of levels of fire/hearth use at the site and, thus, a further indication of levels of human occupation at the shelter.

Chapter Eight explores the nature of the core technology at Bui Ceri Uato in order to identify technological considerations that may influence the extent/length of core reduction. Inter-relationships between the extent/length of core reduction, chert quality and heat-treatment are investigated.

Chapter Nine investigates temporal trends in the extent/length of core reduction, the quality of chert and occurrence of heat-treatment. These trends provide an indication of pressure for flaked stone. Viewed from the perspective
of the organisation of lithic technology in procuring stone resources and of levels of human occupation at the shelter, relative trends in the mobility of human groups on the Baucau Plateau may be proposed.

Chapter Ten forms the discussion and conclusion. Temporal trends in levels of human occupation (indicated by sedimentation rates, flaked stone artefact discard rates and the frequency of cores with thermal damage) and relative levels of requirement for stone resources (indicated by the extent/length of core reduction) are discussed in terms of levels of human mobility at the site in the context of broad processes including palaeoenvironmental conditions and World sea level changes in the Pleistocene, and the transition to agriculture which is presumably associated with the establishment of village communities in the Holocene.
CHAPTER 2

ARCHAEOLOGICAL RESEARCH AND PALAEOENVIRONMENTAL CONDITIONS

This chapter provides necessary background information describing the archaeology of East Timor as well as an outline of the environmental conditions prevailing over the timespan of human occupation in the region.

The chapter is divided into three sections. The first section provides a background history of archaeological research in East Timor including findings made by Bühler, Verhoeven and anthropologists Almeida, Mendes Correa and Cinatti. This is followed by Ian Glover’s archaeological research, and relatively recent research undertaken by the East Timor Archaeological Project. This section concludes with a description of the status of lithic research in East Timor.

The second section provides a regional context for the archaeology of East Timor. Austronesian influences in the region are broadly outlined, followed briefly by recent research timing faunal species introductions to Timor and/or nearby islands. This way the cultural contents of Bui Ceri Uato shelter (see Chapter 3) can be understood in terms of broader changes in the prehistory of East Timor and the region.

The third section outlines palaeoenvironmental conditions in the East Timor region as well as broad changes in World sea levels. This is relevant because the
present study is interested in investigating whether human responses to palaeoenvironmental conditions may be reflected in the cultural materials at Bui Ceri Uato.

**BACKGROUND HISTORY OF RESEARCH**

There had been limited archaeological undertakings in East Timor prior to Glover’s (1972a, 1986) research conducted in the late 1960s. Previously known archaeological findings include those made by Alfred Bühler in the 1930s (Sarasin, 1936), Father Theodor Verhoeven in the 1950s (Verhoeven, 1959, 1964) and Portuguese anthropologists Almeida, Mendes Correa and Cinatti in the 1950s and 1960s (Almeida and Zbyszewski, 1967; Mendes Correa *et al*, 1953). The prehistorian W. J. A. Willems also undertook excavations at three locations in West Timor in 1939. However, there is very little information available on his work and it will not be discussed further by the present study (see Glover, 1972a: 350-351). These pioneers undertook the first excavations and established the presence of flaked stone tools on Timor.

The following paragraphs outline Bühler, Verhoeven, Almeida, Mendes Correa and Cinatti’s findings in Timor. Places and archaeological sites mentioned are illustrated in Figure 2.1.
BUHLER

In 1935, Bühler spent several months in Timor collecting ethnographic and archaeological material for the Basel Museum. He conducted eight excavations, deposits of which contained flaked stone and pottery (Glover, 1972b). The published report of Bühler’s excavations was written by the director of the Basel Museum (Sarasin, 1936) and is in German. The report (Sarasin, 1936) omits stratigraphic details, the method of excavation and the proportion of the archaeological contents that were retained. Only one excavation was reported in any detail; that of Abri 1 at Nikiniki in West Timor (Figure 2.1) (Glover, 1972b: 120).

The following information on Alfred Bühler’s excavations in Timor is derived from Glover (1971, 1972a: 323-350, 1972b).
Excavations

Bühler explored Su and Nikiniki in West Timor (then Dutch Timor) and Bagua (south of Laga) in East Timor (Figure 2.1) (Glover, 1972b: 120). Two excavations were made near Su and resulted in the recovery of some flakes but no pottery. In the first cave, a small excavation reached bedrock at 35 cm. A few flakes were found, but Bühler believed they were probably waste products from the manufacture of gun flints and strike-a-lights (both of which were still used by the local Timorese) and not prehistoric tools (Glover, 1972b: 121). In the second cave, a one metre by 15 cm long trench was dug to 75 cm and produced a few flakes (Glover, 1972b: 121).

Bühler excavated three rockshelters at Nikiniki, named Abri 1, 2 and 3 (Glover, 1972b: 122). Of these, only Abri 1 was reported in detail. The shelter was eight by seven metres, with the entrance partly blocked by a stone wall nearly two metres thick and 1.2 metres high. Such structures which feature along the front of many caves in East Timor may relate either to permanent human occupation or as a form of fortification (Glover, 1972b: 121). Two trenches one metre wide were dug just behind the stone wall and a small area was also excavated around a stalactite near the centre (Glover, 1972b: 121). The shelter was dug to 1.35 metres, at which point large boulders prevented further excavation (Glover, 1972b: 123). No stratigraphic changes were observed, but it was noted that limestone fragments increased in occurrence toward the base (Glover, 1972b: 122). Flaked stone artefacts occurred below 70 cm and pottery continued from the surface to the base of the trench (Glover, 1972b: 122-123). Remains of domesticated animals were found 75-
135 cm into the deposit and included bovid, horse, pig and dog. At Nikiniki 3, sheep or goat bone were found 70-80 cm below the surface. Bone of extinct giant rat Coryphomus bühlerei were recovered from the site and, in lower levels, shell and candlenut (Glover, 1972b: 123). Further details of flaked stone types and pottery at the Nikiniki sites are provided in Glover (1972b).

Bühler conducted an excavation at Baguia, 15 km south of Laga, in East Timor (Figure 2.1) (Glover, 1972b: 127). In this small shelter a 2-2.5 metre wide trench was dug from the back wall to the rubble wall along the front of the cave (Glover, 1972b: 127). Pottery continued to the base of the deposit, at a depth of two metres below the surface (Glover, 1972b: 128).

**Bühler’s views on the antiquity of human occupation in Timor**

Bühler did not believe that there was a deep antiquity of human occupation in Timor. This view was based on a number of observations, including: contemporary human uses of cave/rockshelters in Timor, historical accounts of flaked stone use, changes to sedimentation rates as a result of fences/walls commonly constructed in front of caves/rockshelters, the similarity of excavated finds with contemporary materials, as well as myths recounted by the Timorese of the timing of ancestral arrivals.

Bühler believed that the use of caves/rockshelters by hunting parties or in times of war/raids as well as their use as overnight shelters for travellers, led to modern flaked stone in the excavated deposits. On these grounds, he believed that the flaked stone observed in the excavated deposits were not prehistoric artefacts (Glover, 1972b: 121, 129).
He perceived that fences/walls commonly constructed along cave/rockshelter openings would have affected the patterning of soil deposition and sedimentation rates at these site types (Glover, 1972b: 121). He proposed that such changes could explain the extensive depth of cultural finds at the various cave/rockshelter sites.

Bühler acknowledged that materials such as pottery were identified by Timorese people as a product of their own culture, albeit no longer regularly made. He observed that the shellfish, candlenut and grinding stones found in deeper levels were materials still in use amongst the Timorese (Glover, 1972b: 129).

Finally, Bühler argued that Timorese ethnohistory portrayed only a recent history, whereby people arrived to the island only a few hundred years before the Portuguese appeared (see Glover, 1972b: 130).

On these grounds, Bühler described pottery and domesticated fauna in his excavated sites as representing the ‘neolithic’ and dating from immediately before the arrival of Europeans in south-east Asia (Glover, 1986: 7).

VERHOEVEN

Father Theodor Verhoeven’s archaeological findings in West Timor were published in Dutch (Verhoeven, 1959, 1964). Consequently, the following outline of Verhoeven’s work derives largely from Glover (1972a: 351-352).

In 1954, Verhoeven excavated two caves named Liang Leluat II and Liang Djenilu located in West Timor (Figure 2.1) (Glover, 1972a: 351). The Liang Djenil excavation was not described in Glover (1972a) and there is only brief information provided on the Liang Leluat II excavation. Both sites contained flaked stone artefacts. About 20 m² of Liang Leluat II was excavated to a depth ranging between
50-60 cm. No stratification was visible and there was no mention of pottery. Mandibles from the giant murid *Coryphomys Bühleri* were found (Hooijer, 1965).

Verhoeven also made discoveries of *Stegodon* bones in gravel deposits near Atambua, West Timor (Verhoeven, 1964) (Figure 2.1). According to Bednarik (2000: 16, 18), Verhoeven mentions the occurrence of surface stone tools in the vicinity of Atambua but does not suggest that there was a connection between these finds. This was followed up by Rhys Jones, who visited Atambua in 1993 and whose inspection revealed no stone artefacts. This led him to conclude that there was no primary association between the extinct fauna and the stone artefacts (O'Connor, 2002: 46).

**ALMEIDA, MENDES CORREA AND CINATTI**

The following outline of Portuguese anthropologists Antonio de Almeida, Mendes Correa and Ruy Cinatti’s archaeological findings in East Timor is derived from Almeida and Zbyszewski (1967) and Mendes Correa et al (1953). Other publications (but which are not discussed further by the present study) include Almeida (1967) where rock paintings are described, Cinatti (1963) written in Portuguese on the rock paintings at Ili Kere Kere (Figure 2.1) and Mendes Correa et al (1956, 1964) on observations of flaked stone artefacts (see Glover, 1972a: 25, 41, 44).

**Excavation and archaeological finds**

In 1953, Mendes Correa, Almeida and Cinatti surveyed and excavated at the salt lake of Gassi Issi, located about 5 km east of Laga in the district of Baucau on
the north east coast of East Timor (Figure 2.1) (Almeida and Zbyszewski, 1967: Plate 2, p.55; Mendes Correa et al, 1953). Shell middens and flaked stone artefacts were found (Almeida and Zbyszewski, 1967: 55; Mendes Correa et al, 1953: 52).

Flaked stone artefacts were also recorded at Maliana and Suai, in the central west and south coast of East Timor, respectively (Figure 2.1) (Almeida and Zbyszewski, 1967: 56).

In 1963 Almeida excavated Lene Hara cave, located at the eastern tip of the island (Figure 2.1). The excavation comprised two right angles trenches measuring two by one metres and dug to a depth of 80 cm (Almeida and Zbyszewski, 1967: 57). The excavated deposits contained ochre, coal remains (presumably charcoal) and marine mollusc shells. Flaked stone artefacts continued to the base. No pottery was found (Almeida and Zbyszewski, 1967: 64).

**Portuguese views on the antiquity of human occupation in East Timor**

In contrast with Bühler, the Portuguese anthropologists adopted the view of a greater antiquity of human occupation in East Timor (Almeida and Zbyszewski, 1967; Mendes Correa et al, 1953). This belief was based on observations of typological parallels with European lithic traditions, the weathered condition of flaked stone artefacts at Laga Lagoon and the composition of Lene Hara assemblage.

The Portuguese anthropologists linked flaked stone artefacts at Laga Lagoon to Mousterian and Levalloisian typological features. They described the artefacts in terms of three European technical traditions: Clactonian, Tayacian and Mousterian (Almeida and Zbyszewski, 1967: 56; Mendes Correa et al, 1953: 52; Mendes Correa
et al, 1956). In short, they attributed East Timor flaked stone artefacts to the Palaeolithic.

This perception of an antiquity of lithic artefact manufacture was further supported by the weathered or “somewhat rolled state or condition” (Mendes Correa et al, 1953: 52) of the flaked stone artefacts at Laga Lagoon. The anthropologists were aware of the implications of the weathered condition of the flaked stone artefacts. That is, that the flaked stone artefacts must have been manufactured by humans living in a very distant past, whereby the slow geological process of weathering had sufficient time to impact on the condition of the stone artefacts.

The lack of recognisably ‘neolithic’ type finds (i.e. pottery, polished axes or adzes, chisels, denticulated arrowheads, etc.) indicated to the Portuguese anthropologists that the contents at Lene Hara predated these changes. On this basis, they recognised that the contents of the site contained older deposits evident of earlier human occupation in East Timor (Almeida and Zbyszewski, 1967: 64).

GLOVER’S RESEARCH IN EAST TIMOR

Glover’s research in East Timor is reported in his doctorate dissertation *Excavations in Timor* (1972a) and published in *Archaeology in Eastern Timor, 1966-67* (1986) as well as a variety of other papers (1969, 1971, 1973: 60-61, 1977a, 1979). This body of research established the foundation for future archaeological investigations in East Timor and, on the whole, meant that previous archaeological endeavours (i.e. by Bühler, Verhoeven and the Portuguese anthropologists Almeida, Mendes Correa and Cinatti) could be largely disregarded from further
considerations. A brief outline of Glover’s research and excavation outcomes is provided.

Glover’s research

In the years 1966 and 1967, Ian Glover completed 10 months of fieldwork in East Timor (then Portuguese Timor). He undertook intensive archaeological reconnaissance and an extensive test pit excavation program which comprised a total of 12 rockshelters/cave sites at a number of locations (Glover, 1971: 164). These included: Baucau (four excavations on the eastern and south side of the Baucau Plateau, three on the western side of the plateau including the main excavations of Lie Siri and Bui Ceri Uato), Baguia (one excavation), as well as the area between Venilale and Ossu (four excavations including the main excavations of Uai Bobo 1 and Uai Bobo 2) (Figure 2.2).

The excavation of four cave/rockshelters, Lie Siri, Bui Ceri Uato, Uai Bobo 1 and Uai Bobo 2 (Figure 2.2), formed the key sites on which he based his construction of the prehistory of East Timor. As discussed in Chapter 3, Glover (1986) was unable to date the site which forms the basis of this study, Bui Ceri Uato. However, on the basis of correlation with faunal, pottery and plant materials recovered from the other three sites, he was able to establish a broad cultural sequence spanning approximately 14,000 years (Glover, 1986: Table 1). For instance, all sites showed the replacement (and subsequent apparent extinction) of fauna endemic to Timor (primarily small and large murids) with humanly introduced fauna (of both wild and domesticated species) in tandem with the appearance of
pottery and new plant species in the mid Holocene (Glover, 1973: 60). These cultural trends are outlined in further detail below.

Figure 2.2 The location of Glover's main excavations in East Timor
(Adapted from Glover, 1986: Fig.3b)

**Cultural trends**

**Endemic species**

The lower deposits of Lie Siri, Bui Ceri Uato, Uai Bobo 1 and Uai Bobo 2 were found to contain several species of bones of extinct native giant murids, small murids, bats, birds, reptiles and, at the near-coastal sites of Lie Siri and Bui Ceri Uato, fish and shellfish (Glover, 1977a: 43).

Glover considered large murids to be the principal source of human food in these lower levels (1986: 156). While some individuals may also have been eaten by humans, he believed that most of the small murids were likely to have been brought into the various deposits by owls or other predators (Glover, 1986: 156, 223). This suggestion was based on several observations:
1. Large murids were not found in the most recent levels, whereas some of the small murids continued (albeit in small numbers) to the surface;

2. Many of the large murid bones were broken to a greater extent than the small ones and a higher proportion showed signs of burning. This was noted during sorting, but not quantified;

3. There was an absence of any large land mammals as food in Timor prior to the introduction of various exotic animals; and

4. There was ethnographic evidence of large rats as food in areas of Melanesia, distinguished from small rats which were not so commonly eaten (Glover, 1986: 156).

Five small murid species were identified in the archaeological deposits. These included two species of Melomys (large and small), Rattus exulans and two other Rattus species (of which one is most probably Rattus rattus, but remained at the genus level of classification) (Glover, 1986: Appendix 2: 223). Rattus exulans was considered a relatively recent introduction to Timor (Glover, 1986: 197; see also Musser, 1981: 135-136).

Plant materials recovered in levels dating to before 5,000 BP included candlenut (Aleurites), hackberry (Celtis), betel nut (Areca) and pepper betel (Piper), the last two forming the ingredients of betel chewing, as well as a single pierced specimen of Jobs' tears (Coix) (Glover, 1977b: 18).

The faunal and plant materials in lower deposits indicate that from initial human occupation to some time in the mid Holocene, humans were dependent on naturally occurring food resources in East Timor (Glover, 1986: 212).
Introduced species

From about 5,000 BP, a range of exotic fauna, pottery and new plant species appeared in the excavated deposits.

A pig tooth was found in Uai Bobo 1 associated with a date of 5,520 ± 60 BP (ANU-187; Glover, 1986: 204). According to Glover (1971: 176), no dog bones appeared before 2,000-2,500 BP (cf. Veth et al, 2004; see ETAP outcomes outlined further below). Goat bones appeared in quantity at Uai Bobo 1 and 2 between 3,500-2,000 BP (Glover, 1971: 176). Cuscus also appears in the faunal sequence within the last 5,000 years (Glover, 1986: 196-197).

Glover (1986) established a generalised faunal sequence, whereby pig (Sus) seemingly coincided with the appearance of pottery. This was followed by dog (Canis), sheep/goat (Capra/Ovis), buffalo (Bos), civet cat (Paradoxurus hermaphroditus), cuscus (Phalanger), macaque monkey (Macaca), Rattus exulans and, in Portuguese times by cattle and deer (Cervus) (Glover, 1977a: 43; 1986: 197). On the basis of strong presumptive evidence, Glover suggested that these faunal species were brought - either directly or inadvertently - to Timor by humans (1986: 196). With the exception of the Pleistocene Stegodon reported by Verhoeven (1964), Glover’s (1986) excavations showed that the only truly native mammals on the island of Timor were murids and bats.

A number of new plant species were also found in the mid-Holocene. These included the Polynesian chestnut (Inocarpus), bamboo, bottlegourd (Lagenaria), one possible specimen of foxtail millet (Setaria) as well as coconut, various fruits and trees such as custard apple/soursop (Annona), mangosteen (Garcinia), Prunus, a
Curcurbitacea and Cocculus (a fish poison or medicine). Peanut (Arachis) and maize (Zea) occurred in the latest levels, the latter almost certainly introduced by the Portuguese in the 16th Century (Glover, 1977a: 43, 46; 1977b: 18). With the exception of one possible foxtail millet specimen and the recently introduced maize, there was no direct evidence of plant domestication or of staple vegetable foods in the excavated deposits. This means that there is a large gap in our knowledge of the total subsistence contributed by plants in the prehistory of East Timor.

Although there was no direct and/or satisfactory evidence of plant domestication, Glover believed a *prima facie* case could be argued that the introduction of domesticated fauna and pottery could be the result of the arrival or development of a way of life dependent on animal husbandry and plant cultivation (1986: 195-196). That is to say, that the trend from exclusively endemic fauna (i.e. large rats and bats) followed by the appearance of domesticated species (i.e. pig, Capra/Ovis, dog and bovid) associated with pottery, could mark the introduction of agriculture to East Timor (Glover, 1971: 175-176).

The large native murids (the previous principal terrestrial prey) showed a progressive depletion in species diversity after the introduction of exotic fauna and appear to have become extinct on Timor (Glover, 1986: 197). Glover suggested ecological changes brought about by the introduction of bush fallow agriculture and extensive burning and clearing of land, together with browsing and grazing animals, led to drastic vegetation changes which contributed to the demise of the native murids (1986: 197). However, as the genus Melomys thrives in urban areas in Melanesia, Glover suggested its extinction was unlikely to have been brought about
by human-induced ecological changes, but may be better explained by the introduction of the civet cat predator (*Paradoxurus hermaphroditus*) which may have additionally contributed toward the extinction of the large murids (Glover, 1986: 156). Stated simply, Glover speculated that the extinction of the giant murids resulted through hunting pressure (perhaps from both people as well as the introduced civet cat) and the wholesale clearance of forests for agriculture (1986: 212).

**Human settlement, subsistence and population changes**

For the period between about 14,000 to 5,000 BP, Glover described human occupation in Timor in terms of small isolated communities of hunter-gatherers exploiting large murids and possibly bats (1971: 177, 1977a: 59). Around 4,500-5,000 BP, he believed expanding agricultural populations from the west or north, possibly Austronesian speakers, brought Timor into a closer relationship with neighbouring islands with improved boat building and sailing techniques (1977a: 46, 59). They brought with them pigs, civet cats and pottery, with goats, dogs, cuscus and monkeys following soon after (1971: 177). Glover stated that the introduction of pottery and exotic animals reflected "the arrival in Timor of an immigrant people practising some form of agriculture and animal husbandry" (1986: 202) and speculated on "the growth of population, development of settled village communities, and craft specialisation that may have accompanied these archaeologically visible culture traits" (1986: 204). He opined that pottery would be of little value to nomadic hunter-gatherers, but has a value with more permanent settlement (1986: 207). Glover envisaged the appearance of pottery and introduced domesticated
animals in terms of the adoption of some form of food producing economy and that this was presumably associated with population increase and the development of village communities.

An evaluation of human subsistence, settlement and population changes

It seems reasonable to interpret the introduction of domestic animals (i.e. pig, sheep/goat) in terms of evidence of the adoption of animal husbandry practices. As yet, however, there is no direct archaeological evidence bearing on the development of agriculture in East Timor. For instance, there is no satisfactory archaeological evidence for plant cultivation, either in the particular form of agriculture that may have been present or the kinds of crops cultivated. The nature and timing of the transition toward greater control of food production in East Timor remains speculative. Glover was aware that his evidence for an economy based on agriculture depended entirely on the predictive value of traits such as animal husbandry, pottery and plant cultivation occurring synonymously (1986: 202).

Glover (1986) inferred that the use of ceramics, the adoption of animal husbandry and some sort of agricultural practices were associated with the establishment of village communities. As yet, there is no archaeological evidence establishing the timing of early village settlements. Little is known of the relationship between village settlements and the transition to more controlled food production in East Timor.

Nor is there direct archaeological evidence of population increase. While Glover interpreted an increase in the occurrence of secondary worked flaked stone artefacts in pottery-containing levels in terms of an increase in population associated
with the adoption of some form of food production (1986: 202, 207), this link between secondary worked flakes with population increase is theoretically unsound (as reviewed further in Chapter 4 of the present study). At this stage, only broad changes in the relative size of prehistoric human populations in East Timor may be reasonably suggested. This essentially involves initially small populations of colonising groups, followed by an increase in numbers as populations expanded over time. The rate and timing of population increase, however, remains unknown. Also speculative is the association between population increase and subsistence changes pending further archaeological investigations.

Knowledge of the modelled developmental changes in human subsistence, settlement and population size in East Timor is still preliminary. There is no direct archaeological evidence of the exact timing of the introduction/development of agricultural practices and/or of the initial establishment of village communities. Presumably these occurred some time in the Holocene but need not necessarily coincide. The relationship between population increase and the adoption of agricultural practices also remains speculative. Further archaeological research (such as that initiated by the East Timor Archaeological project) is required to investigate such complex developmental changes in the prehistory of East Timor.

THE EAST TIMOR ARCHAEOLOGICAL PROJECT (ETAP)

Following the 1975 Indonesian invasion of East Timor, there had been little archaeological investigation following on from Glover's 1966-1967 fieldwork. With the United Nations takeover and then Independence the opportunity to conduct
archaeological research in the country arose. In July 2000, the East Timor Archaeological Project (ETAP) commenced and preliminary results of the project have been published (O’Connor, 2002, 2003; O’Connor et al, 2002a, 2002b; O’Connor and Veth, 2005; Pannell and O’Connor, 2005; Spriggs et al, 2003, 2005; Szabó and O’Connor, 2004; Veth et al, 2004, 2005).

The ETAP 2001 excavations of Matja Kuru 1 and Matja Kura 2, Telupunu excavation in 2002, and Lene Hara cave in 2000 and 2002 (Figure 2.3) are outlined below. The ETAP also examined a number of middens (Tim 3, Tim 51, Tim 21, Tim 46, Tim 7 and Kusu; Figure 2.3) (see O’Connor, 2002; Veth et al, 2004: 220-221), but few flaked stone artefacts were recovered. For this reason, outcomes of the midden investigations will not be discussed.

Figure 2.3 Glover’s main sites and those excavated by the ETAP
(Adapted from Veth et al, 2004: Figure 13.3)
Matja Kuru 1, Matja Kura 2 and Telupunu

Matja Kuru 1 (Figure 2.3) produced a near basal shell date of 15,850 cal. BP. However, most of the deposit seemed to have accumulated between 6,000 to 4,550 cal. BP (Veth et al, 2004: 222). The excavators timed the introduction of *Rattus exulans* to levels dated to about 3,770 cal. BP (3,776 ± 40, NZA-17007) and pottery to levels dated to 3,800 cal. BP (3,840 ± 70 BP, ANU-11632) (Veth et al, 2004: 222).

Matja Kuru 2 (Figure 2.3) provided a near-basal date of 32,220 BP. The site seems to have been abandoned between 31,000 and 12,800-12,700 cal. BP, during the Last Glacial Maximum (LGM) (Veth et al, 2004: 223). The cave contained a dog burial, bone of which was directly AMS dated to 3,150-3,100 cal. BP (Veth et al, 2004: 223). This represents the only currently known date timing the introduction of dog to East Timor.

Telupunu (near Kusu in Figure 2.3) yielded a basal date of 16,450 cal. BP, but most of the cultural materials accumulated between 6,600 and 4,500 cal. BP (Veth et al, 2004: 223). A thin ceramic horizon dated to around 1,050 BP lay on top of a pre-ceramic deposit with sparse artefactual and faunal material extending 1.5 metres below the surface (Veth et al, 2004: 223).

**Lene Hara**

Lene Hara cave (Figure 2.3) was excavated over two seasons of fieldwork in 2000 and 2002 (O’Connor, 2002: 50; O’Connor et al, 2002a, 2002b; Veth et al, 2004). The site was targeted by the ETAP to allow comparisons with Almeida’s (Almeida and Zbyszewski, 1967) earlier findings.
In the first season, a one by one metre square was dug adjacent to Almeida’s trench, reaching 84 cm in depth (O’Connor et al, 2002b: 47). Deposits were wet-sieved through fine mesh (<2 mm) and excavated in 5 cm units, taking account of stratigraphic boundaries (O’Connor et al, 2002b: 47). Contrary to Almeida (who found no pottery, but more than likely did not screen the deposits), the ETAP excavation found that pottery mostly occurred in the top 25 cm of the deposit (O’Connor et al, 2002b: 47, Table 1). Flaked stone artefacts, marine shell and bone continued to bedrock (O’Connor et al, 2002b: 47). Marine shell was dominated throughout by rocky platform species. Fauna included fish, marine turtle, small murids, snakes, lizards and crabs (O’Connor et al, 2002b: 47). A giant rat femur was found and is probably Coryphomus bühleri (O’Connor et al, 2002b: 47).

Radiocarbon determinations of marine shell indicate Lene Hara was initially occupied by humans in the Pleistocene, between 35,000-30,000 BP (O’Connor et al, 2002b: Table 1). When first excavated, this was the first evidence of other than terminal Pleistocene human occupation on Timor.

In the second season of excavation in 2002, Lene Hara revealed pottery, marine and terrestrial fauna, shellfish and a human burial (Veth et al, 2004: 221). Pottery extended to about 60 cm from the surface, below which giant rat bones were recovered (Veth et al, 2004: 221). Artefacts included flaked stone artefacts, shell beads, flaked shell tools and two polished shell fish-hooks, the lowest of which was AMS dated to 9,741 ± 60 BP (NZA 17000; O’Connor and Veth, 2005: 251). The ETAP excavators observed that almost all the flaked stone artefacts at Lene Hara were manufactured from chert, ranging in colour from pale to dark red (O’Connor et
Further lithic observations made by the ETAP at Lene Hara are outlined below in describing the developmental history of lithic research in East Timor.

BACKGROUND TO LITHIC RESEARCH IN EAST TIMOR

The developmental history of lithic research in East Timor is described on the basis of lithic observations made by Bühler, Verhoeven, the Portuguese anthropologists (Almeida, Mendes Correa and Cinatti), Glover’s approach to lithic analysis and preliminary lithic observations made by the ETAP.

Bühler and Verhoeven recorded the presence of flaked stone in East Timor, the antiquity of which was later asserted by the Portuguese anthropologists (Almeida, Mendes Correa and Cinatti) on the basis of typological comparisons with European lithic traditions. In contrast, Glover (1972a) considered that such broad-scale geographical comparisons were inappropriate and felt that the typological descriptions of the flaked stone artefacts by the Portuguese researchers were unjustified.

Instead, Glover (1972a) undertook a metric based analysis of the flaked stone artefacts recovered from his East Timor excavations. He also applied descriptive statistical analysis, one of the first of its kind undertaken by Australian based archaeologists (Mulvaney, 1986: v). Furthermore, Glover undertook functional investigations by observing side scraper edge angles and microscopic edge polish on flakes (e.g. 1986: 208-209). These applications illustrate Glover’s (1972a) scientific approach to lithic analysis, which was very forward-thinking for its time. It was, however, limited by the fundamentally typologically-oriented framework which
predominated in the 1960s and 1970s, the period during which he conducted his research.

Three decades after Glover's important research in East Timor, the ETAP responded to theoretical advancements in lithic analysis. Undertaking a technological-based analysis of the lithic artefacts, the ETAP observed lithic economising trends at Lene Hara. This included reduced debitage mass, greater flake platform overhang removal and core rotation (Veth et al, 2004: 219). These preliminary observations at Lene Hara form the background to current lithic research in East Timor.

Aside from initial observations made by the ETAP, no studies have as yet examined East Timor's flaked stone artefacts since Glover's (1972a) research. The present study is the first to address this research gap, specifically focusing on the core technology at Bui Ceri Uato.

In the remainder of this chapter, regional archaeological considerations followed by palaeoenvironmental conditions in East Timor are outlined.

REGIONAL CONSIDERATIONS

It is not yet possible to evaluate clearly the extent to which independent change versus those accompanying more regional developments (in the form of expanding Austronesian populations across Island Southeast Asia and Melanesia) contributed to change(s) in the cultural assemblages of East Timor in the mid-Holocene. For instance, there is convincing archaeological, linguistic and genetic evidence linking Austronesian languages to the spread of horticulture/agriculture,

Certainly, the translocation of various faunal species to Timor is indicative of maritime exchange and inter-island networks some time in the Holocene. However, the timing of faunal introductions to East Timor remains unclear pending better chronological resolution and direct dating of bone material. More recently, direct AMS dates obtained by the ETAP time the arrival of dog to East Timor to 3,150-3,100 cal. BP (2,967 ± 58 BP, NZA-14382; Veth et al, 2004: 223), which seems to coincide with the timing of dingo in Australian assemblages between about 3,500-3,000 BP (Gollan, 1984). Research in nearby Sulawesi dates the arrival of deer to 2,810 ± 50 BP (OZE132) or between 3,140-2,800 BP calibrated at two sigma
(Bulbeck and Nasruddin, 2002: 85; Simons and Bulbeck, 2004: 170-171) and may also have been introduced to Timor about this time. Recent excavations at Lene Hara recorded cuscus bone in levels dated to about 9,000 BP (Aplin and O’Connor, pers. com. 2006). Direct dating of the bone is required to test this antiquity as there is the possibility that the bone material may have filtered downwards in the deposit. The small commensal *Rattus exulans* was likely an accidental introduction to Timor and spread across the Pacific with the Lapita culture, dating from about 3,300 to 2,900 BP in the archipelago between the Bismarcks and Samoa (Groves, 1984: 8; Matisoo-Smith, 1994; Matisoo-Smith and Allen, 2001; Matisoo-Smith *et al.*, 1997; Musser, 1981: 135-136; Spriggs, 1997). At Matja Kuru 1, levels with *Rattus exulans* were dated to 3,770 cal. BP (3,776 ± 40, NZA-17007), which may be indicative of the timing of its arrival to East Timor (Veth *et al.*, 2004: 222).

Further research is required to date the timing of wild and domesticated faunal species introductions to East Timor and the surrounding region. This would provide a better understanding of the nature of maritime exchange and local development in relation to broader changes, such as Austronesian agriculturist expansion in the region as well as palaeoenvironmental conditions.

**PALAEOENVIRONMENT**

Palaeoenvironmental conditions in East Timor differ strongly from those observed today. The present study is interested in how human responses to palaeoenvironmental conditions may be manifest in the material culture of Bui Ceri Uato. For instance, relative levels of human occupation of the shelter may be
responsive with palaeoenvironmental conditions and changes in World sea levels and is investigated in Chapters 6 and 7.

Knowledge of palaeoenvironmental conditions in East Timor is very limited and basically derives from drilled cores taken from the Timor Trough between Timor and Australia (Van Andel et al., 1967; Van der Kaars, 1989, 1991: 266-267; Yokoyama et al., 2001; Zaklinskaya, 1978) and the eastern Indonesian region (Barmawidjaja et al., 1993; Van der Kaars et al., 2000) (Figure 2.4). Given the limited specific palaeoenvironmental information on Timor, climate and vegetational changes in eastern Indonesia and New Guinea are integrated to provide a broad outline of palaeoenvironmental conditions in this general region (e.g. Bellwood, 1985: 16-37, 1987: 177-181, 1992: 61-65). Broad changes in World sea levels are also outlined (Figures 2.5, 2.6, 2.7 and 2.8).

Between 80,000 to 40,000 BP, sea levels oscillated between about 20 and 90 metres below present sea level (Chappell, 1982: Figure 1). At a sea level of 20 metres below present sea levels it is likely that no land bridges existed between the Malay Peninsula, Sumatra, Java and Borneo, although it is possible that the Malay Peninsula and Sumatra were connected by a largely freshwater estuary (Figure 2.5) (Voris, 2000: 1164). At 50 metres below present sea levels extensive land bridges connected the Malay Peninsula, Sumatra, Java and Borneo (Figure 2.6) (Voris, 2000: 1155). Within Wallacea, however, fluctuating Pleistocene sea levels would not have created any major land bridges (Bellwood, 1992: 64). While Timor and the island of Roti were joined together during periods of low sea level (Figures 2.7 and
2.8) (Van Andel et al, 1967: 745), human arrival to this larger Timor island landmass would have required water crossings.

Between 40,000 and 16,000 BP, distinctly cooler and dryer conditions prevailed (Van der Kaars et al, 2000; Van der Kaars and Dam, 1995: 71). The peak of the Last Glacial Maximum (LGM) between about 22,000-18,000 BP experienced an average annual temperature somewhere between 2-7°C Celsius lower than today, a major decrease in annual rainfall, a longer dry season, overall drier conditions and a lowering of World sea level by as much as 130 metres below the present level (see Figure 2.8 which shows land masses at 120 metres below present sea levels) (Barmawidjaja et al, 1993; Bellwood, 1985: 21, 1987: 180-181, 1992: 62; Dam and Wong, 1998; Heaney, 1991; Kershaw et al, 2002; Lambeck et al, 2002; Stuijts, 1993; Van der Kaars, 1991; Van der Kaars and Dam, 1995; Van der Kaars et al, 2000; Yokoyama et al, 2001). Reduced rainfall and lower temperatures changed vegetation patterns in the region from closed rainforest to more open vegetation such as dry forest, woodland and grassland (Heaney, 1991; Kershaw et al, 2002; Van der Kaars, 1989; Van der Kaars et al, 2000). Cores taken from the Timor shelf show grassland vegetation predominated between 38,000 and 12,000 BP (the maximum expansion of which occurred between 19,000 and 17,000 BP) with the contraction of coastal tropical lowland forest and eucalypt woodland (Van der Kaars, 1991: 267).

Between 18,000 to about 6,000 BP, sea levels rose extremely rapidly from minus 130 metres to the present level in response to temperature and rainfall increases, subsequently causing woodland and coastal tropical forest expansion (Chappell, 1982; Kershaw et al, 2002; Stuijts, 1993; Van der Kaars, 1991: 267; Van
der Kaars et al, 2000; Yokoyama et al, 2001). This provides only a very broad resolution of palaeoenvironmental changes in the Timor region and does not include relatively minor climatic fluctuations in the Holocene.

Figure 2.4 The location of drilled cores in Island Southeast Asia (Adapted from Barmawidjaja et al, 1993: Fig.1)
Figure 2.5 Sea levels in Southeast Asia at 20 metres below present day level
(Adapted from Voris, 2000: Figure 1g)

Figure 2.6 Sea levels in Southeast Asia at 50 metres below present day level
(Adapted from Voris, 2000: Figure 1d)
Figure 2.7 Sea levels in Southeast Asia at 75 metres below present day level
(Adapted from Voris, 2000: Figure 1c)

Figure 2.8 Sea levels in Southeast Asia at 120 metres below present day level
(Adapted from Voris, 2000: Figure 1a)
CONCLUSION

This background history of archaeological research in East Timor lithic outcomes provides a backdrop for the present study. Regional considerations such as mid-Holocene Austronesian influences, the introduction of exotic fauna and broader palaeoenvironmental conditions in the region along with fluctuations in World sea levels allow the present study to explore these wider impacts on humans occupying Bui Ceri Uato in prehistory, as investigated from the cultural contents of the shelter. Incidentally, the cultural contents of the excavated deposits of Bui Ceri Uato form the focus of the next chapter of the present study.
CHAPTER 3

BUI CERI UATO

Contextual information on Bui Ceri Uato rock shelter and its archaeological contents is provided on the basis of information recorded by the excavator (Glover, 1986: 90-126).

Chapter 3 is divided into four sections. In the first section, Bui Ceri Uato shelter is introduced including the environmental setting of the shelter, the natural distribution of stone materials (chert and obsidian) available in the surrounding landscape, and the nature of contemporary human uses of the shelter. This is followed by details of the excavation and the stratigraphy of the site. Further stratigraphic details are provided in Appendix B.

In the second section the integrity of horizon contents at Bui Ceri Uato is examined. This involves consideration of the level of recording of section drawings of excavated squares, spit thickness, correlations between horizons and stratigraphic contours, overlapping horizon depths, and the implications of combining spit contents across the entire expanse of the excavated deposits.

In the fourth section radiocarbon dating determinations of charcoal samples collected and submitted by Glover (1986) are discussed. The cultural sequence and cultural contents of the excavated deposits are described, further details of which are found in Appendix C, where evidence of post-depositional movement of modern artefacts (i.e. European), sherds and faunal material are examined. This provides a further assessment of the chronological integrity of the Bui Ceri Uato deposits.
BUI CERI UATO

Bui Ceri Uato is a limestone shelter situated on the western edge of the Baucau Plateau, an uplifting Pleistocene limestone reef, 175 metres above sea level (coordinates 126° 22' East, 8° 27' South) and approximately 11 km west of Baucau township on the north coast of East Timor (Figures 3.1 and 3.2) (Glover, 1986: 90). It is a long and shallow shelter, approximately 18 metres long, 6 metres wide, less than 3 metres high and facing in a northwesterly direction (Figures 3.3, 3.4 and 3.5) (dimensions are derived from Glover, 1986: Fig. 19a). The shelter is situated approximately 1.5 kilometres directly south of the present coastline and can be considered as a ‘near-coastal’ site (Figure 3.6). The site lies immediately inland of a natural freshwater spring (1986: 90), which was likely to have been an important attraction for humans occupying the shelter.
Figure 3.1 Bui Ceri Uato and the Baucau Plateau, East Timor
(Adapted from Glover, 1986: Fig.4)
Figure 3.2 Bui Ceri Uato and reef terraces on the Baucau Plateau, East Timor
(From Glover, 1986: Fig.5)
Figure 3.3 Bui Ceri Uato, northern area of the shelter
(Courtesy of Nuno Vasco Oliveira)

Figure 3.4 Bui Ceri Uato, southern area of the shelter
(Courtesy of Nuno Vasco Oliveira)
Figure 3.5 Bui Ceri Uato, southern area of the shelter
(Courtesy of Nuno Vasco Oliveira)

Figure 3.6 View from Bui Ceri Uato, East Timor
(Courtesy of Nuno Vasco Oliveira)
THE SETTING

Two studies particularly relevant to the environment of the Baucau region are Metzner (1977) on the marine terrace zone and Chappell and Veeh (1978) on rates of tectonic uplift on the north east coast of East Timor.

Marine Terrace zone

Metzner (1977) places the location of Bui Ceri Uato shelter within the physiographic unit of the Marine Terrace Zone (Figure 3.7). This is a peculiar morphology of the Baucau Plateau and consists of...

"a series of up to twelve upheaved Pleistocene marine terraces which rise abruptly from the sea in a step-like fashion...Up to twelve such terraces can be observed in the Baucau area. These terraces are correlated with successive shifts of the sea level due to uplift of Timor and to a lesser degree to the phases of glaciations in these latitudes (Audley-Charles 1968: 38)" (Metzner, 1977: 25).

Water seepages or natural springs occur at the base of these reef terraces and support dense vegetation as well as provide good gardening soils in their immediate vicinity (Figure 3.8). Unsurprisingly, ethnographic observations of contemporary Timorese communities record that areas close to natural springs were favoured locations for human settlement (McWilliam, 1989: 21; Cunningham, 1959: 159).

The significance of the Marine Terrace Zone is obvious at the town Baucau, East Timor's largest population concentration after Dili. Situated on the eastern escarpment of the Baucau Plateau, Baucau town has two major freshwater springs. These provide a constant water supply, allow intense cultivation of the terraces from the township down to the edge of the sea and establish the most productive agricultural zones in the region (Metzner, 1977: 25-26).
The proximity of Bui Ceri Uato to what continues to be an important water source on the Baucau Plateau as well as being located in a region of high agricultural potential, is significant in understanding the abundance of cultural materials at the site. Indeed, the high density of cultural materials suggest that Bui Ceri Uato may have been incorporated into a settlement situated in close proximity to the shelter (Veth et al, 2004: 221, 2005: 181). This localised environmental richness is further accentuated when contrasted with the dry, barren landscape and poor thin soils with high exposure to erosion that characterises much of the Baucau Plateau not directly watered by spring-fed irrigation.
Figure 3.7 Bui Ceri Uato and the Marine Terrace Zone
(Adapted from Metzner, 1977: Fig. 9)
Figure 3.8 Dense vegetation surrounding a freshwater spring on the Baucau Plateau (Courtesy of Nuno Vasco Oliveira)

**Tectonic uplift**

Chappell and Veeh (1978) calculated that reefs at Baucau underwent a fairly rapid rate of uplift of 0.5 metres per thousand years. It is uncertain how sea level oscillations and the rate of uplift may have interacted in relation to the position of Bui Ceri Uato shelter from the coastline. However, the profile of the north coast of East Timor drops off steeply (Figure 3.9). It could, therefore, be suggested that the coastline did not radically expand or contract with fluctuating sea levels but essentially remained in its present location. In this way, fluctuating sea levels and this rapid rate of uplift may only have affected the vertical distance humans had to negotiate to the coastline from Bui Ceri Uato.
STONE MATERIALS

The majority of flaked stone artefacts at Bui Ceri Uato comprise chert, which Glover (1986) refers to as ‘flint’. This is essentially a differential nomenclature rather than misidentification (see Luedtke 1992: 5-6; Mandeville, 1973: 177-178). A small proportion of the flaked stone comprise obsidian. Two passages in Glover (1986) are relevant in describing the chert and obsidian and their naturally occurring whereabouts in the surrounding landscape:

"The stone used for flaking comprised for the most part, fine, non-crystalline flint obtained from water-worn beach pebbles, and from flint nodules which can be found in the extensive clay deposits which are, in many places, adjacent to the Baucau reef plateau...The quality of flint does vary, but not enough to affect its flaking properties, and for the moment, no differentiation has been made between varieties of flint used for the manufacture of the stone tools. The only exception to this is obsidian, small quantities of which (<1%) occur throughout all the sites. The obsidian is found as small pebbles on the edges of the volcanic rock which underlie the limestone reef terraces on the western edge of the Baucau..."
Plateau. The quality is poor for the obsidian is vesicular and containing many flaws" (Glover, 1986: 56).

Secondly:

"The stone used was flint distinguishable by colour rather than by texture or flaking properties. Most common was a glossy, chocolate brown variety with black, dark grey and cream, slightly less common. My workmen could not ascribe the variously coloured flints to different sources; it was all found, they said, in nearby stream-beds and occasionally in the fields on the slopes of the Social River to the east. This agreed with my own impressions and, given the extremely widespread occurrence in that region of the Bobonaro scaly clay deposit containing large blocks of flint as well as other exotic rocks (Audley-Charles 1968: 116-117), there seemed to be no immediate prospect of identifying the particular source of any of the flint" (Glover, 1986: 132).

Chert raw material is found in abundance in the Bobonaro Scaly Clays located immediately adjacent to the limestone Baucau Plateau (Figures 3.10 and 3.11; Audley-Charles, 1965a, 1965b, 1968: 46-50).

During a brief exploratory visit to the Bobonaro Scaly Clay deposits in the Baucau-Laga region, the author observed an abundance of chert nodules of a wide variety of colours including red, brown, black, yellow and grey. Some of this variety is illustrated in Figures 3.12 and 3.13. While not quantitatively analysed, brown and red coloured cherts seemed to be more common than black chert. Black chert was observed to occur in more angular-shaped nodules less than about 15 cm in maximum diameter with white soft cortex (see Figure 3.12). The other coloured cherts were generally rounded in shape and ranged in size from small pebbles less than 2 cm in maximum diameter to boulders about one metre in diameter. Most commonly, however, chert nodule width, breadth and thickness dimensions ranged between 10-20 cm.

This range of coloured varieties of chert characteristic of the Bobonaro Scaly Clays correspond with the range of coloured cherts comprising the Bui Ceri Uato lithic assemblage, with specific attention focussed on the cores
Black chert cores feature white soft cortex such as that observed on black chert found in the Bobonaro Scaly Clays (see Figure 3.14). These observations suggest that the majority of the chert flaked stone artefacts at Bui Ceri Uato were procured from the chert nodules found in abundance immediately adjacent to the limestone Baucau Plateau.

Audley-Charles suggested that a large part of the Bobonaro Scaly Clays probably derived from submarine weathering of volcanic ash, an obvious source of which is about 50 km north of Timor at Aloe and Wetar in the volcanic Inner Arc (1968: 49). It is possible that the igneous origins of the obsidian described by Glover (1986: 56) as naturally occurring on the western edge of the Baucau Plateau may have geologically derived from this region. Unfortunately, unable to overcome logistical difficulties attempting to access this area, the author was not able to investigate this potential obsidian source. Ongoing research is investigating the source the obsidian found in East Timor assemblages (Ambrose et al, 2006).

Arriving onto the Baucau limestone plateau overland in any direction would necessitate travelling through Bobonaro Scaly Clays (see Figure 3.10). This means that the opportunity to obtain chert nodules for knapping activities is immediately available once descended off the limestone Baucau Plateau. Bui Ceri Uato is about 8 km from the closest Bobonaro Scaly Clays in a south-westerly direction, a distance of about 16 km directly south, and about 14 km to the east (see Figure 3.10).
Figure 3.10 Bui Ceri Uato and Bobonaro Scaly Clays: Geology of the region
(Adapted from Glover, 1986: Fig.3c. Originally from Metzner, 1977: Fig. 11)
Figure 3.11 Nodules of chert exposed in the profile of a monsoon river as it traverses through Bobonaro Scaly Clays, east of Laga

Figure 3.12 Chert nodules in the Bobonaro Scaly Clays: black and brown (Collected by the author and knapped to show fresh flaked surfaces) (Each square is equal to 1 cm)
Figure 3.13 Chert nodules in the Bobonaro Scaly Clays: red and brown
(Collected by the author and knapped to show fresh flaked surfaces)
(Each square is equal to 1 cm)

Figure 3.14 Bobonaro chert (collected by the author) and core artefacts from Bui Ceri Uato: black and red
(Core artefacts are arranged along the bottom row. From left to right, identification number and (Horizon): 4238 (V); 5455 (III); 6417 (I).
(Each square is equal to 1 cm)
CONTEMPORARY HUMAN USE OF BUI CERI UATO

During his time on the plateau, Glover (1986) noted evidence of contemporary human uses of Bui Ceri Uato. He observed that the shelter was used as a goat pen as well as a place to parch corn for storage. This was evident from the limestone rubble wall running along the length of the overhang, the thick layer of goat dung on the deposit surface and (at the south-western end of the shelter) a frame of wood and bamboo with underlying white ash where corn cobs were most likely dried over a slow fire (Figure 3.16) (Glover, 1986: 90). He also noted the presence of an old maize garden on the slope directly in front of the shelter (Figure 3.16). Contemporary human uses of Bui Ceri Uato are
relevant to interpretations of the stratigraphy of the site, and will be discussed in further detail later in this chapter.

Figure 3.16 Plan and cross section of Bui Ceri Uato
(From Glover, 1986: Fig.19a)

THE EXCAVATION

Details of the excavation at Bui Ceri Uato are published in Glover (1986: 24-44, 90-126) and only a summary is provided here.

During the excavation of the nearby cave of Lie Siri, Glover surveyed the western edge of the Baucau Plateau for rock shelters and caves with excavation potential. Bui Ceri Uato appeared promising given the number of flakes eroding from the slope in front of the shelter. A small test pit produced more flaked stone
than any other site investigated previously and Glover decided to excavate the shelter further (1986: 90).

Bui Cero Uato was excavated in two discontinuous periods in September and November of 1967 (Glover, 1986: 90). The excavation was extensive, involving eight 1 x 1 metre squares (Figure 3.16), a maximum depth of 1.45 metres and 8.7 m$^3$ of excavated deposit (Glover, 1986: 96; Table 38). Excavated Squares N5E2, N6E2 and N7E2 formed a row along the rear wall of the shelter, Squares N5E1, N6E1 and N7E1 formed a parallel row, and Squares N6E0 and N6W1 extended toward the mouth of the shelter (Figure 3.16).

An additional trench was excavated at the southwestern end of the shelter, where two 1 x 1 metre squares S2E1 and S1E1 were dug to a depth of about 70 cm (Figure 3.16) (Glover, 1986: 92). The deposits in this part of the shelter were comparatively rocky, poor in artefacts and faunal remains and soil layers were difficult to correlate with the main trench (Glover, 1986: 92). For these reasons the stratigraphy of S2E1 and S1E1 were not recorded and artefactual/faunal materials derived from these squares were not analysed in Glover (1972a, 1986). Similarly, the contents of this second trench are also excluded from the present study.

Glover had initially intended to extend the excavated trench out onto the talus slope (Figure 3.16) (1986: 91). However, the excavation revealed that preservation of charcoal and bone was better in the drier conditions along the rear of the shelter so Glover concentrated his work there. This had the advantage of focussing his excavation on the area where the stratigraphy was more clearly defined (Glover, 1986: 91).
The excavation was carried out in arbitrary 10 cm spits or smaller removals where stratigraphic changes were recognised. Spit 1 comprised goat dung and Spit 2 the white ash layer directly underneath. Below this, stratigraphic layers were either too thick to dig as single units or too indistinct to follow with certainty, and were removed in 10 cm spits (Glover, 1986: 92, 95). Spit numbers ranged from 1 (the floor of the shelter) to a maximum of 16 (at the base of the trench). This spit range occurred in Square N6E1, where the greatest depth of 1.45 metres was reached (Glover, 1986: 95, Table 37).

The contents of spits at equivalent depths in the trench were combined to form 10 sub-assemblages or horizons. These ranged from Horizon X at the surface to Horizon I at the base of the trench (Glover, 1986: Table 37). Table 3.1 outlines this division of excavated deposits (1986: Table 37).

Table 3.1 Bui Ceri Uato, squares and associated spit and horizon ranges

<table>
<thead>
<tr>
<th>Square</th>
<th>Spits</th>
<th>Horizons</th>
</tr>
</thead>
<tbody>
<tr>
<td>N7E1</td>
<td>1 to 14</td>
<td>X to I</td>
</tr>
<tr>
<td>N7E2</td>
<td>1 to 12</td>
<td>X to I</td>
</tr>
<tr>
<td>N6W1</td>
<td>1 to 10</td>
<td>X to II (1)</td>
</tr>
<tr>
<td>N6E0</td>
<td>1 to 13</td>
<td>X to II (1)</td>
</tr>
<tr>
<td>N6E1</td>
<td>1 to 16</td>
<td>X to I</td>
</tr>
<tr>
<td>N6E2</td>
<td>1 to 13</td>
<td>X to II</td>
</tr>
<tr>
<td>N5E1</td>
<td>1 to 8</td>
<td>X to V (2)</td>
</tr>
<tr>
<td>N5E2</td>
<td>1 to 13</td>
<td>X to II</td>
</tr>
</tbody>
</table>

(1) Squares N6W1 and N6E0 were not dug to bedrock.

(2) Square N5E1 extended to Horizon V only. This square was also not excavated to bedrock.

The stratigraphy of Squares N5E2, N6E2, N7E2 and N5E1, N6E1, N7E1 and where horizons and spits divide the deposits are illustrated in Figures 3.17a, 3.17b, 3.18a, 3.18b and 3.18c (derived from Glover, 1986: Figs.19b, 19c, and
20a, 20b, and 20c, respectively). Unfortunately, sections of Squares N7E1 and N5E1 are not available in Glover (1972a, 1986).

Of the 8 m² squares excavated, only 5 m² extended to bedrock. The three squares not dug to bedrock comprise N6E0, N6W1 and N5E1 (Figure 3.18). Squares N6E0 and N6W1 were dug to approximately 1.10 metres below the surface (Figure 3.18), but no further due to the poor preservation of charcoal and bone and hard clayey deposits in this part of the shelter (Glover, 1986: 92). N5E1 comprised 8 spits and extended to Horizon V. However, as this square was not drawn in cross-section it is not possible to note its excavated depth. But, given that Horizon V ranged approximately 60-80 cm below the surface over the extent of the trench (Figures 3.17b, 3.18b), it would be reasonable to propose that N5E1 was similarly dug to around this depth.

All deposits were double-sieved on 6 mm and 3 mm screens (Glover, 1986: 25). This means that all bone, shell and stone artefacts greater than 3 mm in diameter should have been recovered from the excavated deposits. Initial sorting of excavated materials occurred on-site, with subsequent sorting and analysis taking place in Australia (Glover, 1986: 25).

Spit volume was measured via a combination of two methods (Glover, 1986: 28). The first measured the area and average depth of each spit. Large rocks were measured and excluded. In the second, the number of buckets from each spit were counted. This method was relied on when nearing the bottom of the trench where rocks made the calculation of volume by measurement difficult (Glover, 1986: 29).
Figure 3.17 Bui Ceri Uato: Squares N7E2, N6E2 and N5E2
a. Soil stratification in the south section of Squares N7E2, N6E2, and N5E2
b. Horizon correlations projected onto the section
(Adapted from Glover, 1986: Figs.19b and 19c)
Note: errors in Glover, 1986: Figure 19b. In the key (Figure 3.17a): brown 10YR 5/3 and light brownish grey 10YR 6/2 labels are swapped around, as is yellowish red 5YR 4/6 with pale brown 10YR 6/3.
Figure 3.18 Bui Ceri Uato: Squares N6W1, N6E0 and N6E1
a. Soil stratification on the east section of Squares N6W1, N6E0, and N6E1
b. Horizon correlations projected onto the section
c. Excavated units projected onto the section
(From Glover, 1986: Figs. 20a, 20b, and 20c, respectively)
THE STRATIGRAPHY

The stratigraphy of Bui Ceri Uato is discussed in some detail here and in Appendix B. This is relevant to assessing the integrity of horizons, which form the unit of assemblage analysis in Glover (1986).

Squares N5E2, N6E2 and N7E2 extended along the rear wall of the shelter (Figure 3.16) and were found to have the most clearly visible stratigraphy. The seven sediment layers observed in these squares formed the main stratigraphic divisions established at the site (Glover, 1986: 28, 92). From the surface deposit through to the base of the trench, were Layers:

1. Goat dung (10YR 4/3);
2. White ash (7.5 YR 8/0);
3. Dark grey charcoal rich layer (10YR 4/1);
4. Pale brown oxidised soil (10YR 6/3);
5. Brown (10YR 5/3);
6. Light brownish-grey (10YR 6/2); and

Textural descriptions of each sediment layer were not provided in Glover (1972a, 1986). This implies that he differentiated between these above sediment layers on the basis of colour change (Figures 3.17a and 3.18a).

The stratigraphy consisted of both depositional phases of sediment accumulation and post-depositional soil formation. Layer 1 (goat dung) and Layers 2 and 3 (ash and charcoal) were distinct depositional phases most likely produced by recent human use of the shelter (as a goat pen and fire event/s probably associated with the parching of corn) (Figures 3.17a and 3.18a) (Glover, 1986: 91). Layer 4 (pale brown - 10YR 6/3) was recognised as the oxidised surface of Layer 5 (brown - 10YR 5/3) and structurally belonged with
this underlying layer (Glover, 1986: 28). On the other hand, Layers 5 through to 7 at the base of the trench reflect natural post-depositional changes in the stratigraphy created by the development of a soil profile. That is, Layers 5 through to 7 do not directly represent discrete phases of sediment deposition. These layers were recognised primarily by colour, an attribute subject to post-depositional chemical alteration resulting from the leaching of organic matter and the accumulation of iron salts with depth (Courty et al., 1989: 8, 165, 167; Spriggs, 1999: 17). Layers 5 through to 7 showed a naturally occurring progression of increasingly leached soils, and basal Layer 7 uniform clayish soils and red colour graduations characteristic of iron rich soils.

Leaching was prominent in N6E0 and N6W1 which were positioned at the mouth of the shelter and most exposed to rainwater (Figures 3.16 and 3.18a). Layer 7 occurred higher in the profile in these squares compared with the rest of the trench and rain action obscured the upper stratigraphy of N6W1 (Figure 3.18a) (Glover, 1986: 92).

Numerous postholes visibly disrupted the stratigraphy and were common in the top 15-20 cm of N6E0, N6E2 and N7E2 (Figures 3.16 and 3.17) (Glover, 1986: 92, 96). A rotten post projected 40 cm into the deposit in the northern section of N7E2 and another of 20 cm diameter penetrated 65 cm below the surface in the south section of N6E2 (Figure 3.17) (Glover, 1986: 92, 96). Postholes were likely caused by contemporary human use of the shelter, probably associated with the use of poles on which to hang corn for parching (see Glover, 1986: 90-91).

A main feature of the excavation was a hearth or thick bed of charcoal approximately 1 metre in diameter and located 45-50 cm below the surface on
the corners of Squares N6E1, N6E2, and N7E1, N7E2 (Figures 3.16, 3.18a) (Glover, 1986: 92). The hearth was entirely removed during the excavation, the charcoal collected and stored at the Australian Museum, Sydney. Charcoal extracted from this hearth was radiocarbon dated by Glover (1986) (and also by the present study, see Chapter 6). Glover’s radiocarbon dating outcomes at Bui Ceri Uato are discussed later in this chapter.

Other features in the excavation included two smaller charcoal concentrations located adjacent to one another at approximately 30-60 cm below the surface in N6W1 Spits 5 and 6 (Horizons VI and VII) (Figure 3.18). In addition, a grey lens with fine burnt shell was located in Horizon III of N7E2 (Figure 3.17). It is not certain whether these charcoal and shell concentrations were sampled or otherwise collected during the excavation.

Further stratigraphic details are provided in Appendix B and are relevant to Horizon delineations in the trench.

HORIZONS

The Bui Ceri Uato cultural assemblage was subdivided by Glover (1986) into ten horizons. Horizon X is located at the floor of the shelter and Horizons IX, VIII, VII, VI, V, IV, III, II and I extend to the base of the trench (Figures 3.17b and 3.18c).

Horizons were formed by combining the contents of spits at equivalent depths across the expanse of the trench (Glover, 1986: Table 37). Horizon X contained materials derived from the layer of goat dung across the floor of the shelter and Horizon I materials from basal spits across the extent of the trench (Figures 3.17 and 3.18). In this manner, materials when combined into each
horizon could be treated separately - i.e. as notionally distinct sub-assemblages (Glover, 1986: 29).

Horizons formed the unit of intra-assemblage analysis adopted by Glover (1986) and the means of detecting sequential/temporal change in cultural materials deposited at the site. Consequently, the chronological integrity of horizon contents is crucial to the accuracy and/or reliability of patterning in the cultural materials as well as interpretations of human behaviour made by Glover at the site.

Temporarily setting aside radiocarbon dating determinations, the integrity of horizon contents can be assessed from the perspective of rigour in the standard of excavation. The integrity of horizon contents at Bui Ceri Uato can be assessed by observing: the level of recording of section drawings of excavated squares, spit thickness, the correlation between horizon delineations and the stratigraphy of the trench, overlapping horizon depths in the trench, as well as premises involved in combining spit contents across the trench. These are ranked in order of increasing concern to the integrity of horizon contents.

LEVEL OF RECORDING OF EXCAVATED SQUARES

In examining the integrity of horizon contents, we are dependant on the level of recording of each excavated square made available by the excavator. Table 3.2 summarises the stratigraphy, horizon delineations and spit boundaries drawn in section for each square excavated at Bui Ceri Uato.
Table 3.2 The stratigraphy, horizon delineations and spit boundaries drawn in section for each excavated square at Bui Ceri Uato

<table>
<thead>
<tr>
<th></th>
<th>N6W1</th>
<th>N6E0</th>
<th>N6E1</th>
<th>N7E2</th>
<th>N6E2</th>
<th>N5E2</th>
<th>N7E1</th>
<th>N5E1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stratigraphy</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Horizon</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Delineations</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spit</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Boundaries</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

This information is derived from Glover, 1986: Figs. 19b, 19c, 20a, 20b and 20c.

The stratigraphy of N7E1 and N5E1 were not drawn in section nor were horizon delineations represented in this part of the trench (Table 3.2). In only three squares were spit boundaries drawn in section i.e. Squares N6W1, N6E0 and N6E1 (Table 3.2). Section drawings of the stratigraphic contours, spit boundaries and horizon delineations over the entire expanse of the trench are not available. Consequently, the means of assessing the integrity of horizon contents are somewhat limited i.e. to Figures 3.17 and 3.18.

**SPIT THICKNESS**

Relevant to the integrity of materials combined into horizon contents, is spit thickness. Spit boundaries were drawn in section in N6E1, N6E0 and N6W1, only (Table 3.2). Instances of exaggerated spit thickness may have contributed to some degree of spatial sampling bias in some horizons. For instance, there were three spits observed from Figure 3.18c obviously thicker than the 10 cm spit standard (loosely) adopted at the excavation. These were Spit 13 and Spit 14 in N6E1, and Spit 9 in N6W1. Such instances of exaggerated spit thickness result in exaggerated volumes for individual spits, and some spits in some squares may have inflated numbers of finds as a consequence of this sampling bias. Spit boundaries were not drawn in section in the remaining squares (Table 3.2), so it
is not possible to note other such instances of differential spit thickness or to assess the level of spatial bias in horizon contents.

Such spatial bias sampling in horizon contents can lead to inaccurate interpretations of human activities conducted at the site, simply because humans may have used different areas of the shelter for different kinds of activities.

**HORIZON DELINEATIONS AND STRATIGRAPHY**

Of concern to the integrity of horizon contents is the relationship between horizon delineations and stratigraphic contours. This is important because Horizons IV, V, VI, VII, VIII, IX and X each combined materials derived from different sediment layers. This is illustrated in Table 3.3.

Horizons combined materials derived from a variety of different sediment layers as a result of two outcomes. The first, was because spit boundaries did not always adhere to stratigraphic contours. This was the case in Squares N6E1, N6E0 and N6W1 toward the mouth of the shelter (Table 3.3). This means single spits in N6E1, N6E0 and N6W1 contained materials derived from more than one sediment layer (Table 3.3). The second, was the practice of combining the contents of spits located at equivalent depths across the expanse of the trench. As the thickness of corresponding layers changed in the soil profile toward the mouth of the shelter, the outcome was the combination of materials derived from different sediment layers (compare Figures 17a and 18a; Table 3.3).
Table 3.3 Horizons and soil layers, Bui Ceri Uato

<table>
<thead>
<tr>
<th>Horizon</th>
<th>Squares N7E2, N6E2 and N5E2</th>
<th>Square N6E1</th>
<th>Square N6E0</th>
<th>Square N6W1</th>
</tr>
</thead>
<tbody>
<tr>
<td>X</td>
<td>Goat dung (10YR 4/3)</td>
<td>(10YR 4/3)</td>
<td>(10YR 4/3)</td>
<td>(10YR 4/3)</td>
</tr>
<tr>
<td>IX</td>
<td>White ash (7.5 YR 8/0); Charcoal layer (10YR 4/1);</td>
<td>(7.5 YR 8/0); (10YR 4/1);</td>
<td>Yellowish brown (10YR 5/4); Grey brown (10YR 5/2)</td>
<td></td>
</tr>
<tr>
<td>VIII</td>
<td>Pale brown (oxidised) (10YR 6/3)</td>
<td>Light brown (10YR 6/3)</td>
<td>Light brown (10YR 6/3);</td>
<td>Yellowish brown (10YR 5/4)</td>
</tr>
<tr>
<td>VII</td>
<td>Brown (10YR 5/3)</td>
<td>Light brownish grey (10YR 6/2)</td>
<td>Light brownish-grey (10YR 6/2)</td>
<td>Light brownish-grey (10YR 6/2)</td>
</tr>
<tr>
<td>VI</td>
<td>Brown (10YR 5/3)</td>
<td>(extensive charcoal bed)</td>
<td>Light brownish-grey (10YR 6/2)</td>
<td>Reddish yellow (7.5YR 6/6) (charcoal)</td>
</tr>
<tr>
<td>V</td>
<td>Light brownish-grey (10YR 6/2)</td>
<td>Light brownish-grey (10YR 6/2)</td>
<td>Light brownish-grey (10YR 6/2)</td>
<td>Reddish yellow (7.5YR 6/6)</td>
</tr>
<tr>
<td>IV</td>
<td>Yellowish-red (5YR 4/6 - 5/6)</td>
<td>Light brownish-grey (10YR 6/2)</td>
<td>Light brownish-grey (10YR 6/2)</td>
<td>Reddish yellow (7.5YR 6/6)</td>
</tr>
<tr>
<td>III</td>
<td>Yellowish-red (5YR 4/6 - 5/6)</td>
<td>Yellowish-red (5YR 5/6)</td>
<td>Yellowish-red (5YR 5/6)</td>
<td>Reddish yellow (7.5YR 6/6)</td>
</tr>
<tr>
<td>II</td>
<td>Yellowish-red (5YR 4/6 - 5/6)</td>
<td>Yellowish-red (5YR 5/6)</td>
<td>Yellowish-red (5YR 5/6)</td>
<td>Reddish yellow (7.5YR 6/6)</td>
</tr>
<tr>
<td>I</td>
<td>Yellowish-red (5YR 4/6 - 5/6)</td>
<td>Yellowish-red (5YR 5/6)</td>
<td>Yellowish-red (5YR 5/6)</td>
<td>Reddish yellow (7.5YR 6/6)</td>
</tr>
</tbody>
</table>

Derived from Glover, 1986: Figs. 19b-c, 20a-b.

Bold signifies where soil layers in Squares N6E1, N6E0 and N6W1 toward the mouth of the shelter, do not correspond with the soil layer in the equivalent horizon in Squares N7E2, N6E2 and N5E2 along the rear wall of the shelter.

Those without infill depict soils not in the main stratigraphic sequence.

The stratigraphy and horizon delineations in Squares N7E1 and N5E1 were not drawn in section in Glover (1986) and therefore could not be incorporated in the above table.

The colour of the infill does not necessarily directly reflect the Munsell colour represented.

In gauging the impact of combined materials derived from different sediment layers to the integrity of horizon contents, the stratigraphy of Bui Ceri Uato must be considered further. The stratigraphy of the site is characterised by
distinct layers of accumulation as well as natural soil layers formed by post-depositional alterations of the soil profile, which means that the chronological integrity of horizon contents is, in part, independent of the stratigraphy.

**Distinct layers of accumulation**

Layers 1, 2 and 3 (dung, ash and charcoal) occurred at the top portion of the trench and mark discrete phases of accumulation. This means the correlation between stratigraphic contours and horizon delineations in this part of the trench is meaningful and can be an indication of the chronological integrity of Horizon VIII, IX and X contents (Table 3.3).

While recognising post-depositional movement of materials in the deposits of the shelter was likely to have occurred to some extent (i.e. the vertical and horizontal displacement of artefactual materials) and is a process which occurs independent of stratigraphic contours, the principle that materials in identical stratigraphic layers should be segregated from materials derived from other layers still applies in the assessment of the integrity of horizon contents. In other words, the integrity of Horizon X, IX, and VIII contents can be assessed in terms of this excavation principle.

Horizon X largely contained materials derived from Layer 1 (goat dung) (Table 3.3), however, materials from Layer 5 (brown, 10YR 5/3) scraped from Spit 1 of N6W1 may also have been included in this horizon (Figure 3.18). This is a minor overlap between horizon delineations and stratigraphic contours and not considered a serious concern to the integrity of Horizon X contents by the present study.

Horizon IX contained materials derived from Layers 2 and 3 (ash and charcoal) in squares along the rear of the shelter (Table 3.3). As this horizon
extended toward the mouth of the shelter, materials derived from Layer 4 (light brown, 10YR 6/3), Layer 5 (brown, 10YR 5/3, Spits 2 and 3 of N6W1), grey brown (10YR 5/2), and yellowish brown (10YR 5/4) were also combined into Horizon IX (Table 3.3). The combination of materials derived from Layer 4, Layer 5, grey brown (10YR 5/2) and yellowish brown (10YR 5/4), with those embedded in Layers 2 and 3, likely resulted in mixed Horizon IX contents.

The second occurrence of light brown (10YR 6/3) in N6E1 (and which extended across to N6E0) was identical in colour to that recognised as oxidised Layer 4 in the main stratigraphic sequence. However, in interpreting the stratigraphy of the trench it is uncertain whether this occurrence of light brown (10YR 6/3) reflected a continuation of Layer 4 in these squares, or was distinct from that established as oxidised Layer 4 in the main stratigraphic sequence. That is, it is uncertain whether these identically coloured soils contained equivalent deposited materials or represented unrelated deposits. This is relevant to the integrity of Horizon VIII contents. For instance: Horizon VIII contained materials from Layer 4 and Layer 5 (its non-oxidised equivalent) from squares along the rear of the shelter (Table 3.3). As Horizon VIII extended toward the mouth of the shelter, materials embedded in light brown (10YR 6/3) were included (Spit 4 of both N6E1 and N6E0) (Table 3.3, Figures 3.18a and 3.18c). The appropriateness of combining materials from light brown (10YR 6/3) in N6E1 and N6E0 into Horizon VIII is ultimately dependent on the stratigraphic interpretation adopted.

Natural soil layers

In contrast, Layers 5, 6 and 7 occurred in the lower portion of the trench and were natural layers produced by the development of a soil profile. That is,
they do not mark distinct phases of accumulated deposit. These layers were recognised primarily by colour, an attribute subject to post-depositional chemical alteration. This was particularly evident in N6W1 and N6E0 (toward the mouth of the shelter) where the effects of leaching were pronounced. Consequently, the combination of materials derived from Layers 5, 6 and 7 into Horizons IV, V, VI, VII and VIII (Table 3.3) does not necessarily imply the mixing of materials from different phases of deposition. On the other hand, the uniformity of Layer 7 at the base of the trench does not imply materials in Horizons I, II and III were equivalently deposited. That is to say, the homogeneity of Layer 7 does not necessarily reflect the chronological integrity of Horizon I, II, and III contents (Table 3.3). In essence, the chronological integrity of materials in Horizons I-VIII is independent of stratigraphic contours and can only be tested by radiocarbon dating.

**OVERLAPPING HORIZON DEPTHS**

Perhaps of greater concern to the integrity of horizon contents are overlaps in depth where horizon delineations divided the trench. This is examined on two levels. The first level involves overlaps in horizon depths along each trench extension i.e. along adjacent Squares N7E2, N6E2, N5E2 at the rear of the shelter, and along adjacent Squares N6W1, N6E0, N6E1 toward the mouth of the shelter. The second level involves horizon depth comparisons between the two trench extensions i.e. between Squares N7E2, N6E2, N5E2 at the rear of the shelter and Squares N6W1, N6E0, N6E1 toward the mouth of the shelter. Overlaps in depth where horizon delineations divided the trench meant that there were zones (i.e. inter-horizon zones) where materials at the equivalent depth were combined into different horizons. This may have resulted in inter-horizon
duplication of materials, which acts to obscure sequential changes in the cultural materials deposited at the site (i.e. obscures sequential changes from the base to the top of the trench).

**Overlaps in horizon depths along each trench extension (i.e. along N7E2, N6E2, N5E2 and along N6W1, N6E0, N6E1)**

Spit surface levels commonly show a sharp rise or fall in depth at the point where adjacent squares transected. Margins of overlapping depth existed between spit surfaces across adjacent N7E2, N6E2, N5E2 and adjacent N6W1, N6E0, N6E1 (Figures 3.17b, and 3.18b, 3.18c). This was largely a result of the sequence or order by which spits were excavated. For example, the uniformity of spit surfaces across Squares N6E0 and N6E1 is best explained in terms of spits at corresponding depths being excavated contemporaneously in both squares (Figure 3.18c). In contrast, spit surface levels in N6W1 correlated poorly with N6E0 and N6E1 (Figure 3.18c) and can be best explained in terms of Square N6W1 being a later extension of the trench (Figure 3.16). That is, N6W1 was likely to have been excavated after N6E0 and N6E1.

The outcome of irregular spit surface levels is an overlap in depth where horizon delineations divide the trench. This means some inter-horizon mixing of materials across Squares N7E2, N6E2, N5E2 and N6W1, N6E0, N6E1 was inevitable where horizon delineations divide the deposit. Table 3.4 shows the approximate minimum and maximum depth from the surface of each horizon across N7E2, N6E2, N5E2, and across N6W1, N6E0, N6E1. There is an overlap zone ranging between 5-10 cm where adjacent horizons are delineated in each trench extension.
Overlaps in horizon depths between the two trench extensions (i.e. between N7E2, N6E2, N5E2 and N6W1, N6E0, N6E1)

The second level of comparison of horizon depths is between the two trench extensions i.e. between N7E2, N6E2, N5E2 and between N6W1, N6E0, N6E1. Table 3.4 shows that apart from Horizons IX and X, all other horizon delineations overlapped in depth along the extent of the trench. There is an overlap zone ranging between 5-20 cm between adjacent horizon delineations along the extent of the trench. Table 3.4 shows horizons V, IV, III, II and I were positioned lower in the trench in N7E2, N6E2 and N5E2 along the rear of the shelter, compared to equivalent horizons in N6W1, N6E0, N6E1 toward the mouth of the shelter. This means that materials in these lower horizons derived from deeper deposits along the rear of the shelter and were combined with materials at overlapping (but not equivalent) depths toward the mouth of the shelter. For example, materials deposited into Horizon III from N7E2, N6E2 and N5E2 correspond in depth to materials grouped into Horizon II from N6W1, N6E0 and N6E1 (Table 3.4). In the case of Horizons IV and III, materials deposited into Horizon IV from N7E2, N6E2 and N5E2 at the rear of the shelter corresponded exactly in depth to materials grouped into Horizon III from N6W1, N6E0 and N6E1 toward the opening of the shelter (Table 3.4). If it is assumed materials increase in age with depth in the deposit, slightly older materials deposited at the rear of the shelter may have been combined with relatively younger materials deposited toward the mouth of the shelter in these lower horizons i.e. Horizons I, II, III, IV and V.
Table 3.4 Horizon depths below surface in Squares N7E2, N6E2, N5E2 and N6W1, N6E0, N6E1, Bui Ceri Uato

<table>
<thead>
<tr>
<th>Horizon</th>
<th>I</th>
<th>II</th>
<th>III</th>
<th>IV</th>
<th>V</th>
<th>VI</th>
<th>VII</th>
<th>VIII</th>
<th>IX</th>
<th>X</th>
</tr>
</thead>
<tbody>
<tr>
<td>Approximate depth below surface (cm)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Squares N7E2, N6E2, N5E2</td>
<td>130-135</td>
<td>105-130</td>
<td>95-110</td>
<td>80-100</td>
<td>65-90</td>
<td>45-70</td>
<td>20-50</td>
<td>20-30</td>
<td>5-20</td>
<td>0-5</td>
</tr>
<tr>
<td>Overlap between adjacent horizons (cm)</td>
<td>0</td>
<td>5</td>
<td>5</td>
<td>10</td>
<td>5</td>
<td>5</td>
<td>10</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Squares N6W1, N6E0, N6E1</td>
<td>120-145</td>
<td>95-120</td>
<td>80-100</td>
<td>75-85</td>
<td>60-75</td>
<td>45-70</td>
<td>30-50</td>
<td>20-30</td>
<td>5-20</td>
<td>0-5</td>
</tr>
<tr>
<td>Overlap between adjacent horizons (cm)</td>
<td>0</td>
<td>5</td>
<td>5</td>
<td>0</td>
<td>10</td>
<td>5</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Overlap between adjacent horizons over both N7E2, N6E2, N5E2 and N6W1, N6E0, N6E1 trenches (cm)</td>
<td>0</td>
<td>10</td>
<td>15</td>
<td>20</td>
<td>15</td>
<td>10</td>
<td>5</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Approximate depth below surface is estimated based on section drawings Fig.19c and Fig.20b (Glover, 1986). Horizon depths in Squares N7E1 and N5E1 could not be included. These squares were not drawn in section in Glover (1986).
COMBINING SPIT CONTENTS

The overall chronological integrity of horizon contents is dependent on the premise that the contents of spits located at approximately equivalent depths across the trench were deposited at more or less the same period. This premise is now examined in context of the nature of the stratigraphy of the shelter.

As mentioned previously, materials deriving from different stratigraphic layers were combined into Horizons X, IX and VIII as horizon delineations extended into Squares N6E1, N6E0 and N6W1, toward the mouth of the shelter (Tables 3.3 and 3.4). As stratigraphic contours reflected phases of accumulated deposits in this upper portion of the trench, the practice of combining spits at equivalent depths contributed to some degree of mixing of cultural materials in these upper horizons.

In contrast, natural processes in soil profile development produced stratigraphic contours in the lower portion of the trench. This means the chronological integrity of deposits in Horizons I, II, III, IV, V, VI and VII can only be tested by radiocarbon dating. A precondition for the overall chronological integrity of contents combined into lower horizons requires a more or less equal rate of accumulation and erosion of sediments across the entire 8 m² expanse of the trench, equivalent at all times throughout the span of human occupation at the site. This is, however, an unlikely scenario. Rather, differing spatial and temporal rates of sediment accumulation - as well as erosion - may have operated at the site. Sediments toward the opening of the shelter were most exposed to wind and rain action and thus potentially subject to higher rates of erosion and differential deposition compared with those from more protected areas of the deposit toward the rear of the shelter.
In summary, instances of exaggerated spit thickness may have contributed, in some degree, to spatial sampling bias in some horizon contents. As spit boundaries were not drawn in section across the entire trench it is not possible to clearly assess the extent to which spatial bias may have occurred. Horizon IX and possibly Horizon VII may combine cultural materials derived from different stratigraphic layers. Stratigraphic contours in the lower portion of the trench are probably produced by post depositional changes leading to the formation of soil profiles. This masks evidence of possible disturbance in the deposit. Of greater concern to the integrity of horizon contents are the overlapping horizon delineations in the depth of the trench. Apart from Horizons IX and X, all other horizon delineations overlapped, ranging between 5-20 centimetres in depth. This was likely to have resulted in the inter-mixing of materials combined into Horizons I through to VIII. Overall, the chronological integrity of horizon contents is based on the premise that the contents of spits located at equivalent depths across the extent of the trench were deposited at more or less similar periods in prehistory. This can only be tested/verified by radiocarbon dating.

RADIOCARBON DATING DETERMINATIONS

Glover submitted two charcoal samples, ANU-325 and ANU-327, to the Radiocarbon Dating Laboratory at the Australian National University (1986: Table 1). Despite their substantial depths in the trench both samples yielded relatively modern dates. Consequently, Glover (1986) was unable to determine the age of materials deposited at the site, nor the initial timing of human occupation of the shelter. Rather, the modern dates obtained from the charcoal
samples, particularly ANU-327, raised concerns of unrecognised disturbance in the trench (Glover, 1986: 31, 96-97).

ANU-325

ANU-325 resulted in a modern date (Glover, 1986: Table 1). During excavation, small traces of charcoal were observed near bedrock, 1.4 metres below the surface in Spit 15 of Square N6E1, Horizon I (Figure 3.18) (Glover, 1986: 30, 96). While ANU-325 was thought to have derived from this part of the trench, the charcoal was collected from the sieves. Glover recognised such conditions never allow much certainty about the origin of the charcoal in the deposit (1986: 96). ANU-325 was consumed during the dating process, so it was not possible to redate the sample after treating for possible contamination with modern carbon (Glover, 1986: 31). The modern date obtained by ANU-325 was rejected by Glover (1986) as not providing a reliable estimation of the age of materials at the base of the trench.

ANU-327

ANU-327 dated to 220 ± 80 BP (uncalibrated) (Glover, 1986: Table 1). When calibrated using CALIB 5.0 (Stuiver and Reimer, 1993) spans between 458 BP and modern at a 95% confidence interval i.e. two standard deviations.

The sample derived from a thick bed of charcoal, located 50 cm below the surface on the corners of Squares N6E1, N6E2, N7E1 and N7E2 (Figures 3.16, 3.18a) (Glover, 1986: 92). This hearth reached about one metre in diameter and was sealed by a light brownish grey soil layer (10YR 6/2) (Glover, 1986: 92). ANU-327 was taken from the cleaned surface of this hearth, in Spit 6 of N7E1, Horizon VI (Glover, 1986: 96).
The modern date obtained by ANU-327 conflicted with the seeming integrity of the hearth, which was extensive and at a substantial depth in the deposits of the shelter. This conundrum was discussed by Glover in terms of disturbance from postholes, possible contamination with modern carbon and, more broadly, from the overall sequential change in the cultural materials (i.e. the faunal remains and the introduction of pottery) at the site (1986: 31, 96-97).

Disturbance from post holes

Postholes were common in the top 15-20 cm toward the rear of the shelter, where the hearth was also located. A particularly intrusive posthole in N6E2 (Figure 3.17a) even reached below that of the hearth (Figure 3.18a) (Glover, 1986: 92, 96). However, postholes were easy to see during excavation because of the interruption they made in the layers of goat dung and ash in the stratigraphy (Glover, 1986: 96). For this reason, Glover was confident that the hearth from which ANU-327 was taken was not contaminated by disturbance caused by postholes (1986: 96).

Contamination with modern carbon

ANU-327 was resubmitted for radiocarbon dating having undergone chemical pre-treatment to remove possible contamination with modern carbon. This did not alter the outcome. No humic acid was found and ANU-327 again yielded a modern date (Glover, 1986: 97). This indicated ANU-327 was indeed modern charcoal.

Overall sequential change in the cultural materials at the site

Glover (1986) believed that the consistency of the archaeological sequence at the site (i.e. broadly, native fauna followed by imported fauna and
pottery) was a convincing argument against any recent disturbance on a sufficient scale to permit the introduction of the large hearth from which ANU-327 was taken. On this basis, he argued that the hearth was in situ (Glover, 1986: 96).

The consistency of the archaeological sequence, however, is not a convincing argument when examined (albeit somewhat crudely) in context of the volume of the excavated deposits. For instance, the hearth was approximately one metre in diameter and located 50 cm below the surface of the trench. Should the hearth be intrusive, about one half of a cubic metre of overlaying deposit would need to have been removed/disturbed for its introduction. Yet, the excavation comprised a total volume of 8.7 m$^3$ of deposit. This means the relative impact of an intrusive hearth in interrupting the archaeological sequence at Bui Ceri Uato would be minimal i.e. not at a sufficient level of resolution to detect an interruption such as that made by an intrusive hearth.

Should the hearth be in situ and ANU-327 a reliable age of materials at the equivalent depth in the trench, this would imply 50 cm of deposit accumulated between 458 BP (at the most) and the present. This is the equivalent of approximately one third of the volume of deposit in the trench. There are major implications raised by such an extremely dramatic rate of deposition of sediments and embedded materials at the shelter. Primarily, this would imply extremely intense human occupation of the site within the last few hundred years. While conceding such a dramatic change as 'possible', Glover argued pottery, flaked stone, shell artefacts, and shell and bone food remains formed a coherent sequence which paralleled that of the three other main excavated sites (i.e. Lie Siri, Uai Bobo 1, and Uai Bobo 2), that there was a similar pattern of
low human occupation at all sites (1986: 31, 96) and that the sequence of faunal changes (i.e. the replacement of wild by introduced animals) could be correlated with acceptable precision between them (1986: 31). On these grounds, he reasoned ANU-327 was not a reliable guide to the age of materials at the equivalent depth in the trench. It looked as if ANU-327 was, in fact, modern charcoal and yet the hearth from which it was taken was extensive and, he believed, in situ (Glover, 1986: 31).

Unable to explain the modern age of charcoal samples ANU-325 and 327, Glover concluded it was easier to believe that the dates reflected modern disturbances not noticed during excavation (1986: 31). Given these radiocarbon dating outcomes, it is incumbent upon the present study to renew the attempt to establish a dated chronology at Bui Ceri Uato. Dating determination results of marine shell and one charcoal sample collected from the excavation by Glover (1986) and submitted by the present study for radiocarbon dating are presented in Chapter 6, and will be found to be relevant in examining the integrity of the hearth.

In the absence of reliable dates, correlation with the better-dated sites of Lie Siri and Uai Bobo 2 were the only means available to Glover (1986) to construct a chronological framework at Bui Ceri Uato. Glover’s suggested age of materials in each horizon and the timing of the appearance of pottery and faunal changes at the site are summarised in Table 3.5.
Table 3.5 Glover's estimated chronology at Bui Ceri Uato and cultural changes

<table>
<thead>
<tr>
<th>Horizon/s</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>X and IX</td>
<td>The past 500-1,000 years, considering the evidence of contemporary human use of Bui Ceri Uato shelter;</td>
</tr>
<tr>
<td>VI, VII and VIII</td>
<td>A decline in the number of murids estimated at approximately 2,000 BP; The appearance of incised pottery and impressed pottery, estimated between about 2,000-3,500 BP;</td>
</tr>
<tr>
<td>VI</td>
<td>Domesticated animals were first introduced (with confidence), estimated at about 3,500 BP;</td>
</tr>
<tr>
<td>V</td>
<td>The first appearance of pottery, estimated between 4,000-5,000 BP;</td>
</tr>
<tr>
<td>I</td>
<td>There was no guide for the earliest human occupation at the shelter, but between 7,000-9,000 BP was suggested based on a correlation with Lie Siri.</td>
</tr>
</tbody>
</table>

Derived from Glover (1986: 97, Table 39)

The present study submitted marine shell from Bui Ceri Uato for radiocarbon dating, results of which now directly provide a dated chronology for deposits in the shelter (see Chapter 6). This means that the suggested estimated chronological framework adopted by Glover (1986) at Bui Ceri Uato (Table 3.5) can be set aside.

A full exegesis of the materials excavated from Bui Ceri Uato shelter, such as flaked stone artefacts, pottery, faunal material, pounders, anvils and grindstones, ochre, shell artefacts, marine shell, human bones and plant remains, are published in Glover (1986: 90-126) and will not be repeated here. Instead, the main contents of the assemblage are summarised in Table 3.6 and include sherd and flaked stone artefact counts, the estimated minimum number of individuals of each faunal species and the major faunal changes evident at the site.

On the basis of the cultural contents of the excavation recorded by Glover (1986), evidence of post-depositional movement of cultural materials in the trench is investigated in Appendix C. This is relevant to describing the cultural contents and assessing the integrity of deposits at Bui Ceri Uato.
Table 3.6 The estimated chronological framework suggested by Glover (1986), flaked stone counts, sherds and MNI fauna, Bui Ceri Uato

<table>
<thead>
<tr>
<th>Horizon</th>
<th>BP years estimated in Glover, 1986</th>
<th>Flaked stone no. (Total per m³)</th>
<th>Waste flakes per m³ (%)</th>
<th>Pottery no. of sherds (MNI)</th>
<th>Large Murids (MNI)</th>
<th>Small Murids (MNI)</th>
<th>Domesticated and large land mammals (MNI)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Canis</td>
</tr>
<tr>
<td>X</td>
<td>(500)</td>
<td>124</td>
<td>435 (1)</td>
<td>232 (33)</td>
<td>1(pc)</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>IX</td>
<td>(1000)</td>
<td>851</td>
<td>799 (2)</td>
<td>566 (20)</td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>VIII</td>
<td>1500</td>
<td>2531</td>
<td>3129 (8)</td>
<td>628 (25)</td>
<td>1(pc)</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>VII</td>
<td>2500</td>
<td>4439</td>
<td>2698 (7)</td>
<td>920 (17)</td>
<td>1</td>
<td>1(pc)</td>
<td>1</td>
</tr>
<tr>
<td>VI</td>
<td>3500</td>
<td>6876</td>
<td>4830 (12)</td>
<td>193 (4)</td>
<td>2(pc)</td>
<td>1(pc)</td>
<td>1</td>
</tr>
<tr>
<td>V</td>
<td>4500</td>
<td>6163</td>
<td>5494 (14)</td>
<td>20 (1)</td>
<td>5</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>IV</td>
<td>5500</td>
<td>5279</td>
<td>7329 (19)</td>
<td>3</td>
<td>3</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>III</td>
<td>6500</td>
<td>5315</td>
<td>6361 (16)</td>
<td>3</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>II</td>
<td>7500</td>
<td>6038</td>
<td>4710 (12)</td>
<td>7</td>
<td>4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I</td>
<td>8500</td>
<td>1969</td>
<td>3680 (9)</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>39,585</td>
<td>23</td>
<td>13</td>
<td>5</td>
<td>5</td>
<td>5</td>
</tr>
</tbody>
</table>

% pottery per cubic metre corrects sampling bias from unequal horizon volume.
(pc) included counts of post-cranial murid bones (Glover, 1986: 119).
? 'probable' identification of bone
* was likely disturbed
CONCLUSION

Contextual information of Bui Ceri Uato shelter and its excavation were presented. The stratigraphy of the deposit was discussed in detail and provided a basis to assess the chronological integrity of cultural materials combined into horizons (see also Appendix B and C). Glover's (1986) radiocarbon dating outcomes at Bui Ceri Uato were provided, along with a description of the cultural contents at the site. The flaked stone technology at Bui Ceri Uato and Glover's (1986) lithic analysis outcomes form the focus of the next chapter.
CHAPTER 4

GLOVER'S LITHIC OUTCOMES

The methodology by which flaked stone artefact density trends were determined in Glover (1986) and the range of interpretations invoked to explain apparent trends are critically examined in this chapter. This is followed by an examination of Glover's analysis of cores at Bui Ceri Uato and his general statements about the nature of the stone technology at the site.

FLAKED STONE ARTEFACT DENSITY TRENDS

Glover (1986) calculated two measures of flaked stone artefact density. These included the rate of occurrence of stone artefacts with secondary working (i.e. the estimated number of years per secondary worked flake) and the number of 'waste flakes' per m$^2$. Trends in flaked stone artefact density were generalised across the various sites to present a broad model of human settlement and subsistence changes in the prehistory of East Timor. A suite of explanations were invoked to explain observed lithic density trends, including: population increase with the (inferred) adoption of agricultural practices, the replacement of flaked stone with the introduction of either metal and/or cultivation of bamboo and generalised statements of the nature and intensity of human occupation at his four main excavated sites (Glover, 1986).

Measures of flaked stone density, however, suffered from major methodological limitations which undermine the reality of observed trends. Of further concern, the suite of factors invoked to explain observed lithic density
trends were not rigorously tested by the archaeological data whereby competing explanations were not adequately considered and eliminated. These issues are discussed in greater detail below.

SECONDARY WORKED FLAKES AND POPULATION INCREASE

Glover calculated that secondary worked flakes (i.e. flakes with retouch) increased in occurrence in pottery-containing levels in the various sites (1986: Table 125). Secondary worked flakes at Bui Ceri Uato were estimated at 1 in every 4 years in pottery levels compared with 1 every 11 years in pre-pottery levels. A similar trend was observed at Lie Siri and Uai Bobo 1 (1 every 33 and 30 years in pre-pottery levels compared with every 6 and 12 years in pottery levels, respectively). Uai Bobo 2 was the exception, where the occurrence of secondary worked flakes remained the same pre- and post-pottery levels (Glover, 1986: Table 125). These estimates were calculated on the assumption that pottery appeared at 4,500 BP and worked stone tools (i.e. secondary worked flakes) were abandoned at 2,000 BP (Glover, 1986: 207). This apparent increase in the occurrence of secondary worked flakes in pottery containing levels was interpreted by Glover in terms of reflecting an increasing population associated with the adoption of some form of food production (1986: 202, 207).

There are, however, serious methodological and theoretical shortcomings which question the reality of depicted secondary worked flake trends and the link with population increase. The reality of depicted estimates of the rate of occurrence of secondary worked flakes in pre- and post-pottery levels is dependant on the reliability and accuracy of the chronological parameters adopted (i.e. the appearance of pottery at 4,500 BP and the abandonment of secondary worked flakes at 2,000 BP). Based on subsequent decades of
archaeological research in the region, the appearance of pottery in East Timor at 4,500 BP may be somewhat early given the regional context of the spread of pottery in Island Southeast Asia (see Spriggs, 2003). More recently, Spriggs has suggested that pottery is unlikely to have reached Timor before 3,800-3,600 BP (pers. comm. 2006). Further excavation, radiocarbon dating and resolution of archaeological deposits, cautious of post-depositional vertical movement of sherds (Spriggs, 1999), would be able to test and refine this estimate.

The abandonment of flaked stone at 2,000 BP also requires further investigation and validation. There is preliminary archaeological and historical evidence to suggest that stone tool technology was not completely abandoned in Timor within the last couple of thousand years. Flakes with secondary working continued to the very surface of the trench, including Horizon X which comprised goat dung on the floor of Bui Ceri Uato (Glover, 1986: Table 41). Bühler reported the use of flaked stone by the local Timorese in the early 1900s associated with the use of gun flints and strike-a-lights (Glover, 1972b: 121).

Finally, the validity of a simple association between an apparent increase in the occurrence of secondary flakes as an index of human population growth is untenable. The relationship between flaked stone artefact density and inferred population trends is complex and requires rigorous testing (Hiscock, 1984).

Secondary worked flakes comprised only a fraction (2%) of the flaked stone artefacts in the Bui Ceri Uato lithic assemblage (Glover, 1986: Table: 41). Trends in the rate of occurrence of flaked stone would be more realistic if inclusive of the entire lithic assemblage rather than restricted to one class of flaked stone artefact. Quantitative measures of flaked stone artefact assemblages
in association with a bracketed radiocarbon dated chronology would be ultimately placed in determining trends in the rate of occurrence of flaked stone in archaeological assemblages (Hiscock, 2002). On the basis of radiocarbon dating determinations obtained by the present study and Glover’s (1986) quantification of the Bui Ceri Uato lithic assemblage, trends in the rate of flaked stone artefact discard at the site are calculated and results are presented in Chapter 6.

‘WASTE FLAKES’ AND MATERIAL REPLACEMENT

The number of ‘waste flakes’ per m$^3$ declined in upper layers in the various excavated sites (see Glover, 1986: Tables 7, 40, 67, and 98). For instance, 3129 ‘waste flakes’ per m$^3$ were calculated at Bui Ceri Uato in Horizon VIII, 799 in Horizon IX, and 435 in Horizon X (see Table 3.6). Since ‘waste flakes’ comprised the majority of flaked stone in the lithic assemblages (e.g. 92% at Bui Ceri Uato; Glover, 1986: Table 42), the observed decline in the number of ‘waste flakes’ per m$^3$ in upper levels represents an overall decline in flaked stone counts at the various sites. The observed decline in the numbers of flaked stone artefacts in upper levels was explained by Glover in terms of the gradual replacement of flaked stone with either metal (suggested previously by Bühler) and/or bamboo (1986: 202-203).

Caves excavated by Bühler in 1935 in West Timor (Nikiniki) also depicted a decline in flaked stone in upper deposits (see Glover, 1971: 171). Discussing this, Bühler recognised the possibility that metal tools traded from centres of Asian civilisation could have replaced stone prior to the arrival of the Portuguese to the island of Timor in the 16th Century (Glover, 1986: 202, 1972b: 117). It is known from Portuguese historical records that metal was already in
use by the local population by this period and was commonly exchanged for sandalwood and beeswax by early traders (see Glover, 1971: 172, 1972b: 117).

Glover observed the 'popularity' (i.e. abundance) of flaked stone in the various excavated sites started to decline at about 3,000 BP and speculated that this may mark the introduction of metal tools to East Timor (1986: 203, 1971: 172). He stated that between 3,000-2,000 BP flaked stone was abandoned (Glover, 1986: 204) and that by 2,000 BP metal was sufficiently common to replace stone for most purposes (Glover, 1971: 172). Alternatively, he speculated bamboo could be a replacement to flaked stone (cf. Pope, 1989) and that it was likely that some of the large bamboos - common to Timor today - were introduced as cultivated plants (see Muller et al, 1998). But, given the perishable nature of plant material, they had not survived in the archaeological deposits (Glover, 1986: 203).

There is a major methodological limitation, however, concerning Glover's (1986) observations of a decline in flaked stone numbers (i.e. in 'waste flakes' per m³) in upper levels in the various sites. The number of 'waste flakes' per m³ was not bracketed by a radiocarbon-dated chronology. This is crucial in determining temporal trends in the rate of deposition of flaked stone. The apparent decline in flaked stone counts in upper levels across the various sites is yet to be confirmed.

Glover argued direct evidence of metal in the various excavations remained negative (1986: 202). Rather, indirect evidence in the form of possibly metal-induced butchering marks on two pig bones at Uai Bobo 2, Horizons XI and XII (estimated at 2,000-1,500 BP) (Glover, 1986: Plate 46, pp.202-203) was
suggested as lending some support for the introduction of metal to Timor. Specialist examination of the bone markings is required to test this claim.

Glover suggested that the absence of metal in the excavations should not be altogether surprising given the remote likelihood of valuable and precious metal items (such as swords and knives) being incorporated into archaeological deposits in caves and rock-shelters (1986: 202; see also Zerner, 1981 for the importance of spiritual connections associated with metal in Indonesia). However, metal was in fact recovered by Glover (1986) in a datable context, at Uai Bobo 1. An ornament of soldered copper and bronze wire was located in Horizon IIIc, in the same spit with charcoal dated to 2,190 ± 80 BP (ANU-237; Glover, 1986: 153, Plate 36). Yet, Glover did not believe that this date could be used to time the arrival of metal to eastern Timor (1986: 153). He argued that a single object is always subject to disturbance in the deposit and did not believe the metal ornament could be used to support the traditional timing for the introduction of metal (bronze and iron) into the Indonesian archipelago as suggested by van Heekeren (1958, 1972) at about 2,000 BP (Glover, 1986: 153, 1971: 172).

Glover's (1986) reasoning in rejecting the significance of the metal ornament at Uai Bobo 1 in deposits dated to 2,190 ± 80 BP (ANU-237) is not clear. The metal ornament derived from the same spit as charcoal dated by ANU-237. While post-depositional movement of the ornament is possible, no major disturbance was evident at the site (Glover, 1986: Fig.32, p.127), a consistent radiocarbon dated sequence was obtained (Glover, 1986: 131) and sherds that could be conjoined all derived from within a single horizon (Glover, 1986: 131). ANU-237 would have been generally accepted as consistent with expectations of
the arrival of metal into the eastern islands of the Indonesian archipelago (Glover, 1972a: 364, see also 1986: 203).


THE NATURE AND INTENSITY OF HUMAN OCCUPATION

Glover made the general claim that the various excavated sites were at no time permanent living sites and that there were no substantial changes in the nature of use of the caves/shelters despite the major changes in the economic base adopted by humans (i.e. such as animal husbandry and some form of agriculture) (1986: 206, 207). In pottery-containing levels these interpretations
were based on the nature and abundance of sherds and, in pre-pottery levels, assumed on the basis of ethnographic observations of hunter-gatherers around the world.

**Levels containing pottery**

Glover interpreted the simple nature of pottery vessels and low estimates of whole pottery vessels as indicative of an intermittent nature of human occupation in pottery-containing levels at the various sites. The simple nature of pottery vessels and restricted number of vessel forms suggested only the most utilitarian cooking and eating ware reached the various shelters (Glover, 1986: 207). The rate of deposition of whole pottery vessels (based on rim sherd counts and the assumption pottery appeared at 4,500 BP), was estimated at 1 separate vessel every 55 years at Bui Ceri Uato, and ranged from 1 vessel every 44 years at Lie Siri, to 1 every 120 years at Uai Bobo 2 (Glover, 1986: Table 125). These low estimates were interpreted by Glover (1986) as indicative of the less than permanent occupation of the shelters in pottery levels. He conceived the nature of human use of the shelters in pottery levels as similar to contemporary human use of caves in East Timor. That is, as regular but temporary camps for parties out hunting, travellers on the way to markets and for family groups gardening fields distant from their houses (Glover, 1986: 206). He further proposed that the apparent decline in flaked stone counts in upper levels did not mean that the shelters were less commonly frequented in more recent times, because sherd counts (per m$^3$) increased toward the surface (1986: 202, Fig.49, Tables 22, 82 and 113; see Table 3.6 for sherd counts at Bui Ceri Uato). Based on such pottery trends, he concluded that the sites continued to be used by humans as frequently - if not more frequently - than in pre-pottery levels (1986: 202). He stipulated that
an increase in population with the adoption of agriculture might have led to an even greater frequency in the use of the shelters, even though the various sites were occupied only as temporary camps (1986: 202).

Major methodological limitations and poorly constructed arguments are obvious in Glover’s statements of the frequency of human occupation in pottery-containing levels at the various shelters. The number of sherds per m$^3$ of deposit is not, in itself, a reliable temporal indicator of pottery trends as fragmentation by taphonomic processes can greatly inflate pottery counts. The weight of pottery per horizon (correcting for unequal horizon volumes) would be a more useful indicator of pottery trends. However, pottery weight was not recorded at Bui Ceri Uato. In addition, trends in the number of sherds per m$^3$ are meaningless until bracketed by a radiocarbon-dated chronology. The observed increase in the number of sherds toward the surface of the excavations may not be a true indication of discard rate, but more a feature of taphonomic processes. Furthermore, interpreting apparent trends in pottery sherd counts as a direct indicator of frequency of human use of the shelters is fundamentally simplistic.

**Pre-pottery levels**

Glover considered human subsistence strategies in pre-pottery levels at the various sites in terms of shifting groups of mobile hunter-gatherers. Ethnographic observations of hunter-gatherer preferences for open camps in Australia and Africa were argued in support of a transient and intermittent human occupation in pre-pottery levels (1986: 206). A major limitation is that no attempt was made to test this hypothesis on the basis of the contents of the excavations.
In summary, flaked stone and pottery density trends were afflicted by major methodological limitations. Artefact counts were not in all cases bracketed by a dated chronology (or suggested chronology, given the dating problems experienced at Bui Ceri Uato). Flaked stone densities were restricted to only two classes (i.e. 'waste flakes' and secondary worked flakes) and pottery weight was not recorded at Bui Ceri Uato. The study assumed direct and simplistic correlations between single strands of observed flaked stone and pottery count trends with that of population growth and frequency of human use of the various sites, respectively. A more rigorous and holistic examination of archaeological contents at each site is required before statements concerning the frequency of human occupation of the various shelters can be proposed. Higham's (1988: 79) review of Glover (1986) stated that the study "sensibly refrains from pressing the data for conclusions which are not there". However, the present overview refutes this. Rather, there is a tendency towards interpreting artefact trends to support preconceived agricultural/population causal models without adequate analysis of the archaeological data.

BUI CERI UATO: CORES

In this section, the nature and outcomes of the analysis of cores in the Bui Ceri Uato lithic assemblage as well as general statements of the nature of stone knapping activities made by Glover (1986: 97-110) at the site are reviewed.

Core types and a single metrical measurement (maximum core diameter) formed the principal means of Glover's (1986) analysis of cores at Bui Ceri Uato.
TYPOLOGICAL OUTCOMES

A total of 852 cores were identified by Glover (1986: Table 43). This contrasted with the present study which identified 395 cores, but adopted different identification criteria to that of Glover (1986).

Three types of cores were defined by Glover (1986: 99) at Bui Ceri Uato. These comprised of multi-platform cores, disc cores and fabricators (or bipolar cores) and are illustrated in Figure 4.1. The vast majority of cores were multi-platform. No clear chronological trends in the frequency of occurrence of the three core types were depicted (Glover, 1986: Table 43). It could be concluded that no obvious information value was derived from this core type classification at Bui Ceri Uato.

![Figure 4.1 Core types identified by Glover (1986) at Bui Ceri Uato](image)

**Figure 4.1 Core types identified by Glover (1986) at Bui Ceri Uato**

Multi-platform cores: a (4465, V), b (4659, IV) and c (6327, I)
Bipolar core: d (3823, VI)
Disc cores: e (5126, IV), f (3224, VII), g (6335, I) and h (6326, I)
(From Glover, 1986: Fig.21)

MAXIMUM CORE DIAMETER

The mean maximum diameter of (non-broken) multi-platform cores in each horizon was recorded (Glover, 1986: Table 44). A sequential reduction in
the size of multi-platform cores was inferred. The mean diameter of multi-platform cores in Horizon I at the base of the trench was 37.9 mm. In comparison, a mean diameter of 25.3 mm was calculated from the combined sample of multi-platform cores in Horizons VIII-X, near the surface of the trench (Glover, 1986: Table 44). On average, multi-platform cores near the top of the trench were about two-thirds the size of cores at the base of the trench (Glover, 1986: 100). This reduction in core size was continuous where by each horizon depicted a decline in mean core diameter toward the surface. Interestingly, an overall chronological decline in the size of ‘waste flakes’ (mean weight), utilised flakes (mean dimensions) and scrapers (mean dimensions) was also observed (Glover, 1986: Tables 42, 45 and 47). The possible factors directing this observed chronological decline in the average size of cores and all other classes of flaked stone artefacts at Bui Ceri Uato were not explored further.

**GENERAL STATEMENTS OF THE LITHIC TECHNOLOGY**

Glover stated the decline in the density of artefacts (i.e. ‘waste flakes’ per m³) and the overall reduction in size (of all classes) of flaked stone artefacts, were accompanied by a “decline in the technical expertise in stone flaking towards the top of the deposit” (1986: 110). This decline in expertise was described generally in terms of irregular and less carefully worked stone tools and the absence of long ‘blade scrapers’ (Glover, 1986: 110). He also noted most of the retouched ‘blades’ in Horizons I-VIII were made from grey chert and that this material, together with ‘blades’ (i.e. flakes at least twice as long as they are wide), became less common towards the surface (Glover, 1986: 101).
While some of the cores would have provided the occasional ‘blade’, Glover stated there was no evidence among the cores for the regular manufacture of ‘blades’ at the site (1986: 100). He inferred that some of the ‘side scrapers’ were made on large ‘blades’ (e.g. three scrapers illustrated in Glover, 1986: Fig.23a-c), and that these must have been brought onto the site (Glover, 1986: 100). This reasoning was not explained, and no quantitative or metric data was discussed to support this statement. It is likely that this conclusion (i.e. that large ‘scrapers’ could not have derived from the cores and must therefore have been produced off-site) was probably derived from the observation of consistently smaller sized cores (mean diameter) compared to the larger size of the ‘scrapers’ (mean length) (Glover, 1986: Tables 44 and 47). If this logic was adopted by Glover (1986), it does not consider the reductive nature of stone knapping technology. For instance, the consistently smaller mean core diameter versus mean scraper length can be explained by subsequent reduction of the cores upon further flake removal. As yet, there is no convincing evidence to suggest the large flakes or blades at Bui Ceri Uato were brought into the shelter (i.e. were not manufactured on-site).

Bui Ceri Uato contained the most abundant lithic assemblage, a higher proportion of cores to worked and utilised stone, and more ‘waste flakes’ to worked and utilised stone of Glover’s sites in East Timor (1986: 207). Bui Ceri Uato also contained a large number of hammerstones and anvils (i.e. 50 and 34, respectively), which Glover considered principally in terms of stone working implements (1986: Table 48, p.110). On the basis of these observations, Glover suggested stone working had been a more important activity at Bui Ceri Uato than in his other excavated sites (1986: 98, 207).
CONCLUSION

Glover's analysis of the lithic technology at Bui Ceri Uato was reviewed. Flaked artefact discard calculations are evident of major methodological concerns which question the validity of observed trends and his interpretations of observed flaked stone artefact density trends were also shown to be lacking in rigour. Chapter 6 of the present study calculates flaked stone artefact discard rates at Bui Ceri Uato on the basis of a radiocarbon dated chronology. The present study re-evaluates the nature of human occupation at Bui Ceri Uato in Chapters 7 and 10.

Glover's analysis of core artefacts at Bui Ceri Uato was severely limited whereby only a single metrical measurement was recorded (i.e. maximum core diameter) and detected a chronological reduction in core size. Given the statistically amenable core artefact sample size as well as the archaeological importance of Bui Ceri Uato in depicting subsistence changes in the prehistory of East Timor, a more comprehensive analysis of the cores is merited. The present study undertakes a technological oriented analysis, based on an understanding of the process of stone knapping and core reduction. These processes form the focus of the next chapter.
CHAPTER 5

STONE KNAPPING AND CORE REDUCTION

Stone knapping technology as well as the process of core reduction forms the main interest of Chapter 5, which comprises three broad sections. In the first section, criteria for identifying a core in the context of flaked stone assemblages are made explicit. The definition of a core adopted by the present study establishes a flaked stone artefact classification system that is entirely based on characteristic fracture surfaces inherent to all flaked stone. This raises functional considerations of the role of cores in stone artefact assemblages. Two pathways of reduction resulting in the production of cores are also outlined.

The second section describes the process of stone knapping along with four main considerations adopted by the present study involved in the assessments of the extent/length of core reduction (covered in greater detail in Chapter 8). These comprise stone material considerations such as the type of raw stone material, the technique of heat-treatment and physical characteristics of stone materials. A second consideration is the technique by which force is applied to the core. A third consideration relevant to the extent/length of core reduction discussed by the present study includes the surface topography of the core. The final consideration discussed is inertia, which acts a limit to the extent/length of core reduction. Other factors relevant to controlling flake morphology but are not directly relevant to gauging the extent/length of core
reduction (as adopted by the present study) include angle of the applied force, the point of force application and the exterior platform angle. For this reason, these stone knapping variables are not discussed. The chapter concludes with attributes and attribute states recorded in the present study relevant to assessing the extent/length to which cores at Bui Ceri Uato were reduced.

CORE IDENTIFICATION

Stone knapping is the process by which flaked stone artefacts were manufactured in the prehistoric past. Stone knapping can be described simply in terms of placing a blow on the surface of a mass of suitably fracturing stone. The force of the blow initiates a fracture, which propagates through the rock, terminating when it reaches the external surface at the other end of the rock and thus removing a piece of stone named a ‘flake’. The fragment of stone remaining is the ‘core’, and contains the negative indentation (i.e. flake scar) of the flake that was removed (Figure 5.1). Usually, the flake is of a smaller mass than the core from which it derives.

The present study follows that of Hiscock whereby a core is identified as “a piece of stone with one or more negative flake scars but no positive flake scars” (1984: 129). Consequently, characteristic fracture surfaces are the sole criteria relevant in flaked stone artefact identification procedures adopted. This definition of a core has certain advantages over other forms of classification in that:

1. by applying such a rigid definition, inter-observer ambiguity in the classification system is minimised;
2. a class of cores is established along a naturally occurring division which is inherent to all flaked stone assemblages;
3. a classification system independent of flaked stone artefact function is established;
4. inference has no role in the classification; and
5. a mutually exclusive class of 'cores' which is distinct from all 'flake' classes is established (Clarke, 2000; Hiscock, in press, Rozen and Sullivan, 1989: 182).

These classificatory traits contrast with typology-based approaches to flaked stone artefacts (e.g. Glover, 1986). Contrasts between typological and more materialist/technologically-oriented approaches to the classification of flaked stone artefacts in lithic assemblages are examined comprehensively in Hiscock (in press) and will not be discussed here.

Figure 5.1 Cores (b, e and f) and corresponding flakes detached from the core face (a, c, d, g and h) (From Andrefsky, 1998: Figure 2.1)
FUNCTIONAL CONSIDERATIONS OF CORES

Cores are involved in the production of flakes. This is obvious from their surface morphology which are characterised by flake scars and, thus, evident of flake removal. As a flake is detached, the mass of the core from which it was struck declines and the morphology of the core face becomes altered (it features the negative impression of the flake which had been removed).

Flake production or the removal of flakes from a core, is the corollary of core reduction. For instance, as flakes are struck from a core, the mass of the core declines in proportion to the mass of the flakes removed. In this way, the core is said to become 'reduced'.

Cores may not, however, be necessarily be restricted to the role of providing a source of flakes in stone knapping activities (cf. Baumler, 1995: 15, who adopts the view that the primary goal of core reduction is flake production). The definition of a core adopted by the present study (i.e. negative but no positive flaked surfaces) does not preclude cores from also being used as tools (i.e. used directly in a task). In other words, artefacts that are technically cores may also have functioned as cutting or scraping tools (e.g. Shen, 2001). It is usually the edge angle (i.e. the 'working' edge) that is considered to be of the greatest relevance to functional considerations of flaked stone (e.g. Crabtree, 1973).

The only means of detecting whether a flaked stone artefact was utilised is by examining all margins for evidence of residue and use-wear (Hiscock, in press; e.g. Fullagar, 1988; Fullagar et al, 1996; Fullagar and Jones, 2004; Kamminga, 1982). However, this level of analysis is beyond the scope of the present study, which does not aim to identify core artefacts utilised directly as
tools at Bui Ceri Uato. The value of conducting such an analysis (in the context of the present study) would be to compare any potential differences in reduction of core artefacts which display evidence of use (i.e. were used as tools) against those which show no evidence of utilisation (and whose primary purpose may then be interpreted mainly in terms of a source of flake supply in knapping activities). This may be of interest for future lithic research. In this study, core artefacts from Bui Ceri Uato are analysed exclusive of functional considerations, which may or may not have a role to play in directing the nature and extent of reduction of cores discarded at the site.

In essence, the present study arbitrarily divides the Bui Ceri Uato lithic assemblage on the basis of mechanical fracture surfaces (cores as distinct from flakes) and analyses a single class of artefacts (cores) on the basis of this division.

PATHWAYS OF REDUCTION: CORES IN LITHIC ASSEMBLAGES

Cores can be produced from two independent pathways of reduction. Most commonly, a core initiates as a nodule of suitable raw stone material which is then struck and has flakes removed from it. It is also possible for what is technically a flake to be transformed into a core. For example, a core can be produced from what technically originated as a flake, which then has evidence of its original flake detachment (i.e. the ventral surface) erased by subsequent reduction. In other words, further reduction with the elimination of all identifiable positive features associated with the original flake form, could also produce a core (in accordance with the above definition). These two pathways of reduction are illustrated in Figure 5.2.
There are a few contrasts between these two alternate pathways of reduction resulting in the production of cores in lithic assemblages. In the first pathway, a mass of stone undergoing flake removal remains a core throughout the entirety of its life history. In contrast, the second pathway of reduction transfers across flaked stone classificatory boundaries and forms a progressive reduction through various stages (from a flake, to a retouched flake and, with complete removal of the original flake ventral surface, a core). Obviously, the original flake form would have to (of necessity) be of a sufficiently large size to accommodate subsequent mass removal to the extent that any identifiable evidence of positive flake fracture origins are removed. Consequently, the original flake form would have to consist of a sufficient size/mass whereby increasing inertia does not prevent the reduction pathway reaching the stage of a core. Given the greater number of stages and extent of reduction involved, this
second pathway of core production is likely to be comparatively less common in lithic assemblages.

With the exception of conjoining (which can link a core with its detached flakes e.g. Cahen et al, 1979; Kamp and Whittaker, 1986, Schäfer, 1990), there is no certain way of knowing which pathway of reduction produced a particular core. It is, however, reasonable to suggest that cores with a small proportion of total surface area covered by negative flake scars which do not extend across an entire face (such that there is no possibility of removal of a ventral flake surface) most likely derived directly from the reduction of a nodule of stone (rather than reduction of what was originally a flake). On the other hand, it would be expected that a core that had derived originally from what was technically a flake to be sufficiently covered in flake scars to obscure/remove any positive flake features. It is possible that this distinction in core morphology between these two pathways of core production may be reflected in terms of a bimodal distribution in the combined attributes of sizeflake scar area in a sample of cores in a lithic assemblage. For instance, a core reduced directly from a nodule of stone will eventually experience difficulties on the part of the knapper due to inappropriate shape or high platform angles and/or difficulties posed by the morphology of the core face and, thus, may be abandoned/discarded when further reduction becomes too difficult to continue (Hiscock, 1988). In contrast, it would be expected that cores produced from what were originally flakes may be comparatively smaller in size, with surface areas almost completely covered in flake scars at the stage when reduction is discontinued. Given these morphological distinctions, a bimodal distribution in combined attributes of sizeflake scar area of cores in a lithic assemblage may be expected. For
example, one peak may represent comparatively larger cores with a relatively low proportion of their surface area covered by flaked scars, whereas the other peak may represent smaller sized cores with a greater proportion of their surface area covered by flake scars. The separation of the two peaks is dependent on the upper and lower size-limits of the stone materials being knapped and the extent to which cores produced directly from a nodule of stone were reduced before difficulties in knapping became too great and core reduction was discontinued.

Irrespective of which pathway of reduction a core was produced, the definition of a core adopted by the present study constructs an exclusive class of flaked stone within lithic assemblages.

STONE KNAPPING

Stone knapping is the process by which cores at Bui Ceri Uato were manufactured. That is to say, core artefacts were reduced/knapped by people occupying the shelter (in whatever capacity) in the remote past. In order to investigate ways in which the reduction of these cores may have been manipulated across the span of human occupation of the shelter it is essential to have a basic understanding of the process of stone knapping and some technical considerations involved in core reduction activities.

As mentioned previously, stone knapping can be described simply in terms of placing a blow onto the surface of suitably fracturing stone. The force of the blow initiates fracture, which can be broken down into three main phases: initiation, propagation and termination (Cotterell and Kamminga, 1987; 1990). The mechanics of fracture propagation are not directly relevant from the perspective of the knapper and so will not be outlined here (see Bonnichsen,

**INITIATION PHASE OF FLAKE FORMATION**

Fracture is initiated in knapping activities when a sufficient amount of force to remove a flake is transmitted into a mass of stone (Phagan, 1976: 7). There are three main types of fracture initiation: Hertzian, bending and wedging (Figure 5.3).

![Figure 5.3 Initiation](image)

**Figure 5.3 Initiation**
(a) Hertzian;
(b) bending and;
(c) wedging
(Adopted from Andrefsky, 1998: Figure 2.13)
These form the three major morphologies of conchoidal, bending and bipolar flakes, respectively, found in flaked stone assemblages (Figure 5.4) (Cotterell and Kamminga, 1990, 1987). Recognition of the characteristics of these different flake morphologies and (more pertinent to this study) corresponding scars on the core face are essential on a practical working level in flaked stone artefact identification procedures (for diagnostic flake features see Andrefsky, 1998: 17-20; Cotterell and Kamminga, 1987; Crabtree, 1975: 107; Hiscock, 1988: 12-3; Kooymen, 2000: 12-14; Speth, 1972: 35; Whittaker, 1994: 14-17).

Figure 5.4 Flake types (a) bending; (b) conchoidal and; (c) bipolar flake types (From Andrefsky, 1998: Figure 2.11)
TERMINATION PHASE OF FLAKE FORMATION

Once a fracture has been initiated, it propagates through the stone material and terminates when it reaches the external surface of the core (usually at the opposite end from where the blow was struck) whereby a flake is detached (Cotterell and Kamminga, 1987: 694). There are four main modes by which fracture can terminate and this refers to the distal margin of the flake (or flake scar on the core face). Termination types include feather, hinge, step and outrepassé (or plunging) (Figure 5.5) (Whittaker, 1994: 17-19; for additional terminations see Cotterell and Kamminga, 1986, 1990: 134; Pelcin, 1997a: 1109).

Figure 5.5 Terminations (a) feather; (b) hinge; (c) step and; (d) outrepassé (From Andrefsky, 1998: Figure 2.8)
STONE KNAPPING VARIABLES

Some techniques and variables considered relevant by the present study to assessments of the extent/length of core reduction include stone material considerations (such as the type of raw material, physical characteristics of the stone selected for knapping, heat-treatment), the technique of force application and hammer considerations, the topography of the core face and the inertia of a core (Andrefsky, 1998; Dibble, 1981; Hiscock, 1988; Phagan, 1976; Dibble and Whittaker, 1981; Whittaker, 1994). (Other main factors which determine fracture outcomes but are not considered by the present study as directly relevant to assessments of the extent/length of core reduction include the point of application of force, the platform angle, the direction and amount of applied force. Consequently, these technological considerations will not be discussed here).

Stone Material Considerations

Stone is the medium being manipulated by the knapper. In this role, it defines the limits or realm of possible knapping outcomes (Kooyman, 2000: 97). Specific to the present study, the characteristics of the stone being knapped has a role in determining the comparative length/extent to which a core can be reduced. Stone material considerations include the fracture characteristics of different types of raw stone materials, the process of heat-treatment and more general physical characteristics such as size, shape, the nature of the external surface of the rock, disconformities in the body of the material such as cracks, macroscopically visible pores and inclusions. These are discussed from knapping perspectives.
Raw Stone Material

The initial control a knapper has over fracture is the selection of suitable stone material for reduction (Hiscock, 1988: 14; Phagan, 1976: 10). Stone suitable for flaking is homogeneous (the same throughout, physically uniform), isotropic (has no preferred direction of fracture), elastic (deformation is temporary) and brittle (breaks relatively easily). These properties allow some rocks to be flaked in a controlled and predictable manner (Andrefsky, 1998: 23; Cotterell and Kamminga, 1987: 677; Crabtree, 1972a: 29; Hiscock, 1988: 10; Luedtke, 1992: 79-84; Macgregor, 2001: 18-19; Purdy, 1973: 132; Whittaker, 1994: 12-14). In rocks without these properties, control over the fracture is difficult (Hiscock, 1988: 14).

Some raw materials suitable for flaking include obsidian, chert, quartzite and silcrete. Their flaking properties differ considerably, principally in ‘fracture toughness’ which determines the amount of force that is required to initiate fracture propagation. Consequently, some stone material types are easier to work with than others (Cotterell and Kamminga, 1987: 677-678, 1990: 127-130). The workability of different stone materials in part determines the degree to which the form of the flaked stone produced is governed by the raw material (e.g. Domanski and Webb, 2000; Schiffer, 1976: 158-161) and the relative ease with which a core can be reduced. On a broader level, the range of raw stone materials has an important role in explaining variability in lithic assemblages (Andrefsky, 1994b; Barton, 1988: 102-103; Bernaldo de Quiros and Cabrera Valdes, 1996; Byrne, 2004; Dibble, 1981: 6-7; Dibble and Rolland, 1992: 10-11; Miller-Antonio et al, 2004; Otte, 1992: 47-48; Seong, 2004; Straus, 1980, 1996; Toth, 1985; but also cf. Moloney, 1996; Raposo, 1996).
In very general terms, the most ideal naturally occurring stone material for flaking is obsidian followed by chert (Cotterell and Kamminga, 1987: 677). Obsidian is crystalline in structure, fractures very easily, produces very sharp edges, has smooth fracture surfaces and is very brittle (Whittaker, 1994: 66, 69). In comparison, chert is a cryptocrystalline silicate, has greater fracture toughness (thus requiring more force to initiate fracture), does not produce as sharp edges and fracture surfaces range from smooth to slightly rough depending on the quality of the chert being worked (Phagan, 1976: 25; Whittaker, 1994: 66). The flaking properties of chert can be noticeably improved by controlled heat-treatment. In some cases, heat-treated chert has been described as almost as 'flakeable' as obsidian (Crabtree and Butler, 1964; Domanski et al, 1994).

*Heat-Treatment*

Control over fracture not only involves the selection of suitable stone material, but can also include alteration of the fracture characteristics of the material (Hiscock, 1988: 14). Controlled heat-treatment of some silicious stone such as chert can considerably improve the flaking properties of the material (Ahler, 1983; Collins, 1973; Crabtree and Butler, 1964; Domanski and Webb, 1992; Flenniken and Garrison, 1975; Flenniken and White, 1983; Griffiths et al, 1983; Mandeville and Flenniken, 1974; Parry, 1987: 52; Purdy, 1974; Whittaker, 1994: 72). Ethnographic and archaeological evidence indicate that heat treatment was a relatively widespread technology in the manufacture of flaked stone in prehistory (Akerman, 1979; Collins, 1973; Collins and Fenwick, 1974; Crabtree and Butler, 1964; Edwards and Edwards, 1990; Flenniken and White, 1983, 1985; Mandeville, 1973; Olausson and Larsson, 1982: 275-276; Purdy, 1973).
Heat-treatment involves subjecting a piece of silicious material (such as chert) to gradually increasing heat until an optimal temperature is maintained and then slowly cooled (for discussion how heat changes the fracture properties of chert and the conditions required for this to take place see Ahler, 1983; Crabtree and Butler, 1964; Domanski and Webb, 1992; Domanski et al, 1994: 201; Kooymen, 2000: 65-7; Luedtke, 1992: 91-7; Mandeville, 1973; Olausson and Larsson, 1982: 282-283; Purdy, 1974; Purdy and Brooks, 1971).

The main benefit of heat-treatment is a significant reduction in the fracture toughness of the silicious material. This means fracture is easier to initiate. When compared with unheated samples, heat-treated chert does not require as much force to initiate fracture (Parry, 1987: 52). That is, heat-treatment makes chert more brittle and thus more prone to fracture (Domanski and Webb, 1992; Domanski et al, 1994; Flenniken and White, 1983: 43; Luedtke, 1992: 96; Purdy, 1973, 1974; Purdy and Brooks, 1971; Whittaker, 1994: 72). The elasticity of chert also increases when it is heat-treated whereby heat-treated chert becomes slightly stiffer, aiding fracture propagation and making the material easier to flake (Domanski and Webb, 1992: 603; Domanski et al, 1994: 199). These properties have tangible benefits to the knapper in terms of the relative ease with which fracture can be accomplished and controlled. In addition to facilitating knapping, heat-treatment also produces noticeably sharper (but not particularly strong) edges on chert which may have functional benefits (i.e. for utilisation as a tool) (Luedtke, 1992: 96; Parry, 1987: 52; Rick and Chappell, 1983: 74; Whittaker, 1994: 73).

There are a number of visual changes accompanying heat-treated chert. These include more lustrous or glossy fracture surfaces, smoother fracture
surfaces, and may also involve a change in colour (Ahler, 1983; Collins, 1973: 462; Cotterell and Kamminga, 1987: 678, 1990: 128; Crabtree and Butler, 1964; Domanski and Webb, 1992: 602; Edwards and Edwards, 1990; Elston, 1990: 169; Flenniken and White, 1983: 43; Kooyman, 2000: 65; Luedtke, 1992: 95; Mandeville and Flenniken, 1974; Purdy, 1974; Purdy and Brooks, 1971; Whittaker, 1994: 72-73). This increase in glossiness is visible only on flake scars created after heat-treatment has taken place and is not evident on the original surface of the chert material. There is usually no external and initially obvious indication that heat-treatment has occurred and only after a flake has been removed will any change in colour or glossier surfaces be revealed (Collins and Fenwick, 1974: 137; Crabtree and Butler, 1964: 2). Depending on the chert material, the contrast in lustre may be anywhere from very light to very distinct (Collins and Fenwick, 1974: 137). Colour change can also be very variable, and varies with different cherts due to alterations in impurity minerals within the material. More commonly, chert will turn red or pink as a result of oxidation of various iron compounds (Luedtke, 1992: 94).

Depending on the reduction strategy adopted, heat-treatment may take place prior to the commencement of knapping (e.g. the heat-treatment of a nodule of stone in its naturally occurring physical form) or may occur after some initial knapping has taken place (e.g. once cortex has been knapped off a nodule). One sure way to identify whether a stone artefact had been heat-treated is if older flake scars with duller textures contrast with more recent scars indicative of having been created after the material was heat-treated (i.e. they are comparatively glossier and smoother) (Collins, 1973; Collins and Fenwick, 1974: 137; Crabtree and Butler, 1964: 3; Purdy and Brooks, 1971: 324; Whittaker,
1994: 73). In the absence of such older scars, lustrous or glossy flaked surfaces are often the best indication of heat-treatment, especially if a portion of the flaked stone artefact specimen retained its original natural surface (i.e. is comparatively duller and not as smooth in texture). Although this increase in lustre or glossiness is considered to be the most consistent and distinctive heat-induced change visible to the naked eye (Domanski and Webb, 1992: 602), it is best to compare with an unheated material from the same source for a definite indication (Domanski and Webb, 1992: 612). This process can give the investigator knowledge of the ‘normal’ range of surface lustre of the material in its natural unaltered state (Collins, 1973: 462).

Lustre, however, is not always a reliable indication of heat-treatment. This is because lustre can be caused by processes other than heat-treatment e.g. wind polish (Collins and Fenwick, 1974: 140; Domanski and Webb, 1992: 602). Investigators need to be able to distinguish between differential lustre on flaked stone artefact specimens as a result of differential weathering as opposed to heat-treating (Collins and Fenwick, 1974: 140; Collins, 1973: 462). On the other hand, weathering, soil activity and bioturbation may actually remove lustre on flaked stone artefacts (Price et al, 1982: 468). For these reasons, more empirical methods to test whether heat-treatment has taken place may be required. This could include measuring the fracture toughness of the material. Thermally-treated chert will have a reduced fracture toughness compared to unheated samples (Domanski and Webb, 1992: 612; Purdy, 1974). Although this is a reliable method for recognising heat treatment, it results in partial destruction of the artefact tested (Domanski and Webb, 1992: 612). Other reliable but less destructive ways to identify heat-treated artefacts include scanning electron
micrographs of fracture surfaces (Collins and Fenwick, 1974; Domanski and Webb, 1992; Flenniken and White, 1983; Mandeville, 1973; Olausson and Larsson, 1982; Price et al, 1982; Purdy, 1974; Purdy and Brooks, 1971) and thermoluminescent determination (Melcher and Zimmerman, 1977; Pavlish and Sheppard, 1983; Price et al, 1982; Purdy, 1974).

While heat-treatment has noticeable benefits it is an optional technological step in the manufacture of flaked stone. One example where heat-treatment may not be entirely necessary is the situation where good quality chert is available. That is, in the situation where the material can be knapped with highly predicable and controlled outcomes without the aid of thermal alteration (Olausson and Larsson, 1982). However, good quality sources of stone material are not ubiquitous and heat-treatment acts to maximise the knapping quality of stone resources that are available. It would be expected that heat-treatment would be an important step in situations where pressure flaking is the main knapping technique adopted in the manufacture of flaked stone. This is because of force application limitations of the technique whereby large amounts of force cannot be applied to the surface of the core. Evidence of heat treatment has been found almost exclusively in connection with pressure flaking in the Americas. This suggests that heat-treatment was an important, indeed perhaps necessary, part of the knapping process in the manufacture of flaked points (Olausson and Larsson, 1982: 276; Crabtree and Butler, 1964).

Heat-treatment involves certain risks, particularly that of thermal shock. This occurs when excessive temperatures are reached and/or when part of the rock becomes much hotter or colder than the rest. That is, when there are differences in the rate of contraction or expansion of the material (Luedtke, 1992:
This causes the material to crack and results in excessive brittleness, rendering the material unworkable and likely to crumble apart when struck (Domanski and Webb, 1992: 603; Domanski et al, 1994: 201; Luedtke, 1992: 91).

The main factor that needs to be taken into account in heat-treatment is the relative size of the stone (Crabtree and Butler, 1964: 2). Large nodules or cobbles are most susceptible to thermal shock because they do not heat or cool evenly (Crabtree and Butler, 1964: 2). For this reason, they require very slow rates of heating and cooling (Luedtke, 1992: 91). In comparison, heat-treating thinner pieces (e.g. flakes) is more reliable and likely to be most successful. This is because thickness is more regular along the length of the specimen and uniform heating and cooling rates are more easily achieved (Crabtree and Butler, 1964; Whittaker, 1994: 73).

In contrast to controlled heat-treatment is uncontrolled heating. Evidence of uncontrolled heating (and cooling) of stone material is indicated by crazing, pot lids, crenated fracture, cracking and convoluted surfaces (where the rock surface explodes as a result of thermal stresses). Such thermal damage is caused by overly rapid heat-up times, direct contact between chert and fire and/or excessive heating temperatures (Luedtke, 1992: 97). These heat fractures are not usually evidence of intentional heat-treatment. It should be noted, however, that poorly controlled heat-treatment attempts can produce all of these fractures. When heat fractures overlie flake scar surfaces on a stone artefact, this indicates that thermal damage occurred after knapping had taken place and likely to have resulted from accidental exposure to fire (such as a hearth) after the flaked stone was discarded (Parry, 1987: 52; Zerger and Elston, 1990: 196).
Heat fractures on flaked stone artefacts indicate the presence of fire. Consequently, concentrations of heat-fractured flaked stone artefacts may pinpoint (or at least be spatially associated with) possible locations of a hearth at a site. Quantitative measures of heat fractured flaked stone artefacts in lithic assemblages may also provide insights into the nature and frequency of fires at a site and lead to statements of the intensity of human site use over time (Hiscock, 1984: 144-146; Hall and Hiscock, 1988: 58-59). These spatial and quantitative measures are assessed at Bui Ceri Uato in Chapter 6 of the present study, along with investigations of cores with thermal damage.

**Physical Characteristics**

Some physical characteristics relevant to stone knapping and more specifically, to core reduction, include the size, shape and external surface of the rock, disconformities in the body of the stone material such as cracks and/or macroscopically visible pores, as well as inclusions or clasts.

As stone knapping is a reductive process, the maximum size of the core is limited and constrained by the size of the rock selected for knapping. At the level of the assemblage, the upper size limit of cores is determined by the size of the available raw stone materials which may range from small sized pebbles to large cobbles. The size of the rock also limits the length or extent of the core reduction process. For instance, a core knapped from a rock that is small in size may encounter limitations posed by inertia much more quickly compared with a core knapped from a larger sized rock.

The shape of the rock is also an important consideration in core reduction. For instance, stone material that is angular in form may have naturally-appropriate occurring (platform) angles from which flakes could be
struck. In contrast, stone material that is rounded may require more elaborate preparation of suitable platform surfaces. For example, pebbles may require the striking off of a large flake and subsequent use of this flake scar surface as a platform for further flake removal. In this way, the shape of the available raw stone material is important in establishing suitable platforms and preparing the face of the core for subsequent flake removal.

At least in initial stages of core reduction, blows are directed onto the external surface of the rock. In this capacity, the nature of the external surface of the rock is relevant to the effectiveness to which force is transferred into the body of the material. The external surface of a mass of chert in its natural state can consist of a combination of patina and/or cortex. Cortex forms at the same time as the chert and is essentially a transition zone or interface between the chert and its surrounding matrix. On the other hand, patina is a thin weathered outer rind and forms much later as the result of irreversible chemical and mechanical changes in the chert (Luedtke, 1992: 98). External surfaces of patina are preferable to cortex in terms of controlling fracture and preparing the core for further flake removal. This is because patina is a very thin rind, whereas cortex can range from hard to soft types, varies in thickness, may not transmit force as readily, and may require more elaborate preparation for its removal. For instance, when a blow is struck on cortex that is soft and thick it may absorb too much force, transmitting force poorly into the body of the core and result in unpredictable and/or undesirable outcomes e.g. hinge terminations. In this way, the thickness of cortex on a rock may act to initially hinder flake removal. Cortex is usually immediately flaked off by the knapper, and this exposes the superior
quality chert material immediately beneath the cortical surface (Hiscock, 1988: 15).

Ideally, a rock of suitable flaking raw material should be largely homogeneous and relatively free of macroscopically visible flaws such as cracks, macroscopically visible pores (i.e. spherical cavities) and inclusions. The homogeneity of suitably fracturing stone determines its workability. That is, it may not fracture conchoidally. Cracks, large pores, inclusions and other flaws or disconformities can arrest fracture propagation and make the stone fracture unpredictably or in undesirable directions (e.g. result in step or other aberrant terminations) (Cotterell and Kamminga, 1987: 700; Crabtree, 1972b: 5, 70; Whittaker, 1994: 12). Pores and cracks weaken a rock considerably, and longer cracks are more dangerous than short ones (Luedtke, 1992: 81). This is critical to the level of control that can be exerted by the knapper over the fracture process and the extent to which core reduction can take place.

**Application of Force: Pressure and Percussion Techniques**

Fracture is initiated when sufficient force to remove a flake is transmitted into the stone (Phagan, 1976: 7). The two main techniques of applying force in stone knapping are by pressure flaking or by percussion.

Pressure flaking operates under static loading (i.e. by pressing) (Figure 5.6). Force is usually applied by an object that tapers to a point, such as bone or antler. The main advantage of pressure flaking is the accuracy of positioning the blow on the platform. However, pressure flaking is restricted by the amount of force that can be directly applied to the core (Andrefsky, 1998: 11). For this reason, pressure flaking is most useful in removing relatively small flakes and is a technique generally associated with retouch along edges of flakes or bifaces.
(Whittaker, 1994: 33, 131). The removal of flakes via pressure technique requires a very different understanding and manipulation of knapping variables compared with percussion flaking (see Whittaker, 1994: 132-133).

Percussion flaking applies a dynamic load to the core whereby a blow is struck onto the core surface (Figure 5.7). Usually another rock (i.e. a hammerstone) is used to load force into the core. To be effective, the hammerstone must have a greater resistance to fracture than the core (Hiscock, 1988: 17). That is, the hammerstone must consist of material that is tougher and less brittle than the material being worked (Whittaker, 1994: 87). The size of the hammerstone is also an important consideration in knapping. It should be lighter than the core being struck (this assists in avoiding the application of too much or unnecessary force into the core) yet heavy enough to detach a flake of the appropriate size (Hiscock, 1988: 17).

It is reasonable to suggest that percussion flaking was the dominant knapping technique adopted by humans occupying Bui Ceri Uato and (specifically relevant to the present study) the technique by which cores discarded at the shelter were reduced. This is supported by the abundance of hammerstones recovered from the excavation (referred to as ‘pounders’ in Glover, 1986: Table 48, p.110) and the overwhelming predominance of conchoidal flakes and flake scars comprising the lithic assemblage (pers. obs.). While pressure flaking is also capable of producing conchoidal fracture, conchoidal flakes are most commonly produced in percussion flaking with a hard hammer (Cotterell and Kamminga, 1987: 686).
The surface topography of the core is strongly determined by the direction of the fracture path and hence the shape/size of the flake being detached. In turn, the size of flakes and corresponding scars on the core face is relevant to estimations of the flaked surface area on a core. Along with the number of flake scars, estimations of flake scar areas on a core provide one indication of the extent/length to which a core has been reduced (see Chapter 8). Also worthy of consideration is the way in which the surface topography of the
core can limit the extent/length of core reduction and increase the likelihood of the knapper discarding a core. This is pertinent to the number of platforms as a further indicator of the extent/length of core reduction (see Chapter 8).

The face of the core determines the shape/size of the resultant flake and, in particular, flake length. Where the core face is flat or gently curved the fracture path spreads and the resulting flakes are comparatively wider and shorter (Hiscock, 1988: 15; Whittaker, 1994: 106). Rather, positioning the blow above a ridgeline on the core face will produce comparatively longer flakes and is a phenomenon that is taken advantage of in the production of blades (i.e. flakes more than twice as long as they are wide) (Figure 5.8) (Cotterell and Kamminga, 1987: 693; Whittaker, 1994: 105, 230-231; e.g. Crabtree, 1968; Owen, 1989).

Another instance that takes advantage of ridgelines involves the removal of cortex which acts to establish a series of flake scar ridges on the core face. In this way, the comparative length of flakes subsequently removed from the core can be increased. However, when distinct ridgelines continue underneath the core then the fracture may also follow and result in an outrepasé termination (Hiscock, 1988: 15). This would be particularly undesirable in situations of diminishing core size and where the availability of suitable raw material is limited (i.e. in circumstances where stone is a limited resource and requires some economising in knapping activities).

Hinge and step terminating flakes leave a protruding mass on the core face (Figure 5.9) and this stacking effect can alter the fracture pathway of subsequent flakes removed from the core (Hiscock 1988: 15, Macgregor, 2001). As the fracture path approaches such an irregularity velocity decreases, energy is dissipated and a repeated hinge or step termination becomes more likely.
Repeated step or hinge terminations produce a stack on the core face and the failure to remove such a problem is often the reason for discarding a core (i.e. discontinuing core reduction) or requires a change in strategy on the part of the knapper in order for core reduction to continue (McNiven and Hiscock, 1988; Macgregor, 2001: 90, 104; Whittaker, 1994: 109).

A protruding step or hinge termination or a stack of repeated step and/or hinge terminations can be overcome by striking off a thick flake (Macgregor, 2001: 66, 86; Whittaker, 1994: 109). In this way, the irregularity is removed from the core face and, instead, becomes located on the dorsal surface of the thick flake detached. The more pronounced the hinge/step termination and the further the irregularity is located towards the distal portion of the fracture path along the core face, the thicker the required flake able to propagate past the irregularity to remove it (Macgregor, 2001: 6). As a rule, flakes of higher platform thickness require more force to be detached, but due to limitations posed by inertia, the smaller the core then the lower the maximum platform thickness from which flakes can be detached by freehand percussion (Macgregor, 2001: 97). Consequently, a protruding step/hinge termination or stack of repeated terminations on a small core will present more of a problem to continued reduction than an irregularity of the same size on a larger core. On a smaller core, the knapper will face more of a problem in detaching a flake of sufficiently large platform thickness to remove the irregularity (Macgregor, 2001: 97).

The raw material being knapped will also have an effect on the relative difficulty of removing a step/hinge scar termination or stack of any given size on the core face (Macgregor, 2001: 97). Materials with low fracture toughness
would be less problematic compared with materials with higher fracture toughness in the removal of a step/hinge scar termination or stack of any given size on the core face. This is because the knapper would be better able to strike flakes of sufficiently large platform thickness to remove the irregularity (Macgregor, 2001: 97-98). Consequently, it would be comparatively easier to remove a step/hinge scar termination or a stack of terminations on an obsidian core than an irregularity of the same size on a similar-sized chert core.

Striking off a thick flake may remove a substantial portion of a core and, thus, may not be a suitable solution to overcoming a protruding step/hinge termination on the core face (Whittaker, 1994: 109). Using an alternative platform can overcome the difficulty of a step/hinge scar on the original platform (Figure 5.10) (Macgregor, 2001: 90). That is, a flake oriented and struck from a different platform can remove a step/hinge scar termination or stack on the core face (Crabtree, 1968: 467; Whittaker 1994: 109). The presumption that step/hinge terminated scars or stacking on the core face will present a problem for reduction is dependent on the unavailability of alternative platforms (Macgregor, 2001: 90). Multi-platformed cores can be viewed as a means to overcome such irregularities on the core face. Such a strategy would be advantageous in situations of diminishing core size and where more economical use of stone in core reduction may be required.
Figure 5.8 The production of obsidian blades by positioning the blow above a ridgeline (From Whittaker, 1994: Figure 3.19, after Holmes 1900)

Figure 5.9 Repeated hinge and/or step terminations producing a stack on the core face (From Whittaker, 1994: Figure 6.28)

Figure 5.10 Using an alternative platform to remove step/hinge terminations on the core face
(a) core before step/hinge terminations are produced;
(b) large flake scar with a hinge termination, and a smaller flake scar with a seep step termination, preventing any further flake removals from this platform;
(c) a cortical flake removed from a different edge along the same platform leaves a scar that can be used as a platform;
(d) a flake is struck from this newly created platform to remove the step/hinge terminations (From Whittaker, 1994: Figure 6.29)
Inertia

Inertia can be described as the "tendency of a motionless object to remain motionless" (Phagan, 1976: 28) and is the key factor determining limits to core reduction. The inertia of an object is directly proportional to its mass (Phagan, 1976: 28). If a core is relatively small then the application of a blow can more easily overcome its low inertia and result in movement of the core rather than initiating fracture (Hiscock, 1988: 18; Phagan, 1976: 28; Macgregor, 2001: 97). In contrast, a core of a larger mass has a greater tendency toward stability and a larger application of force is correspondingly required to move it (Phagan, 1976: 28).

In essence, the smaller the core the more difficult it is for the knapper to immobilise it. Immobilising the core is important because if the core is unstable under the application of force it is difficult to control all of the variables involved in knapping (Hiscock 1988: 19). Detrimental alterations to the structure of the core are also more likely in situations of low inertia. Large amounts of force that crush, batter and initiate fractures but do not remove flakes are likely to result in the creation of incipient cones and hinge/step terminations. Such irregularities alter the morphology of the core and make further reduction difficult (Hiscock, 1988: 19).

Attempts can be made to work within the knapping constraints posed by low core inertia. For instance, the tendency for the core to move when struck declines if less force is applied. By reducing the size of the intended flake, the amount of force applied to initiate fracture is reduced to a level that the core’s inertia is able to tolerate (Phagan, 1976: 29). Also, greater attention to preparing
the platform angle and the core face for flake detachment maximises the efficiency of initiating fracture with the least amount of force required.

Inertia steadily decreases with further reduction of the core such that “difficulties in knapping will increase gradually until they are so great that continued reduction of the same type is either no longer profitable or no longer possible” (Hiscock, 1988: 23-24). Where knapping procedures are no longer adequate, the knapper may respond by ceasing reduction and discarding the core or by employing an alternative technique that will enable reduction to continue (Hiscock, 1988: 23-24; Macgregor, 2001: 95).

The two main techniques that can be employed to immobilise a core of low inertia comprise direct-rest and bipolar flaking. Direct-rest is where a core is simply leant against the anvil. This helps to immobilise the core. Bipolar flaking is where a core is placed on the anvil and force is applied to it at an angle close to 90 degrees (Figure 5.11). This develops large amounts of compressional stresses through the rock and allows large forces to be applied to small cores (Hiscock, 1988: 13, 18). While bipolar flaking does not allow a great deal of control over the shape of the resultant flake, it is the most efficient means of reducing a core of a small mass and overcoming inertia when freehand percussion is no longer possible or profitable in terms of flake removal. However, with even further reduction the inertia problem cannot be overcome and eventually all cores are discarded.
CORE ATTRIBUTES AND ATTRIBUTE STATES

Knowledge of stone knapping technology and, in particular, the process of core reduction allows assessments of the extent/length of core reduction to be proposed (see Chapter 8) and understood within the constraints determined by the technology.

A list of attributes and attribute states relevant to measuring the extent/length of reduction of cores at Bui Ceri Uato is provided in Chapter 8 and listed in Appendix A. Attributes include the type and quality of the raw material, evidence of heat treatment, size (e.g. weight, length, volume, surface area, surface area to weight ratio), rotation (indicated by the number of platforms and the number of flake scar directions) and flake scars (indicated by the number of flake scars, percentage of flake scar area as a proportion of surface area of the core and the amount of cortex).

Temporal trends in the extent/length of core reduction provide one indicator of the level of necessity for stone resources experienced by humans occupying Bui Ceri Uato in the prehistoric past. Placed in the context of the availability of suitable stone materials in the surrounding landscape, temporal
changes in levels of necessity of flaked stone (as depicted by fluctuations in the extent/length of core reduction) can be linked to relative levels of human occupation of the shelter over time and, in turn, broader processes including palaeoenvironmental conditions and changes in human subsistence/settlement strategies.

In the next chapter, sedimentation rates and flaked stone artefact discard rates at Bui Ceri Uato are assessed on the basis of dated shell sequence obtained by the present study at the site. Along with the frequency of occurrence of cores with thermal damage (assessed in Chapter 7), these provide an indication of temporal trends in relative levels of human occupation of the shelter.
As discussed previously Glover was unable to obtain reliable dates for Bui Ceri Uato (see Chapter 3). Radiocarbon analyses of eight marine shellfish and one charcoal sample submitted by this study are presented. On the basis of these determinations, a base-line chronology for the cultural deposits of Bui Ceri Uato shelter can be established for the first time.

The cores were divided into four chronological subgroups and form the unit of analysis adopted by the present study in assessing temporal changes in the extent/length of reduction of cores at Bui Ceri Uato. Subgroup 1 is dated to the earlier Pleistocene, Subgroup 2 to the terminal Pleistocene, Subgroup 3 to the early Holocene and Subgroup 4 spans the majority of the Holocene. Sedimentation rates are calculated by a proposed age/depth curve. Rates of flaked stone artefact discard and core-flake ratios are also calculated and compared between subgroups. Sedimentation rates and flaked stone artefact discard rates (along with the frequency of occurrence of cores with thermal damage, calculated in Chapter 7) provide the main indicators of levels of human occupation at Bui Ceri Uato adopted by this study. These outcomes are discussed
in the context of broad changes in the cultural sequence at the shelter as well as palaeoenvironmental changes in the region.

**DATING DETERMINATIONS**

Shellfish and charcoal were collected by Glover during his excavation of Bui Ceri Uato shelter and made available by the Australian Museum, Sydney, where contents of the excavation are currently held in storage. Marine shellfish is the principal material submitted by the present study to date the cultural contents of the shelter. Unfortunately, the excavator did not provide accompanying documentation to allow attribution of shellfish samples to square and spit of origin. That is, shellfish were only provenanced to horizon (Glover, 1972a, 1986). Given the concerns with the chronological integrity of horizon contents (outlined in Chapter 3 of the present study), it is particularly unfortunate that the limited provenance of dated shell does not allow for a more controlled approach to the timing of deposition of cultural materials across the expanse of the excavation. While shell artefacts (e.g. shell fishhooks, shell ornaments and a shell adze) were documented to square and spit of origin (Glover, 1986: Plate 32), the small size of the shell artefacts and their intrinsic rarity would require accelerator mass spectrometry (AMS) dating procedures. However, use of this technique was beyond the limited means of the present study and would have required multiple AMS samples in order to obtain better chronological resolution. Given these limitations, the present study establishes only a broad chronological framework for the cultural deposits of Bui Ceri Uato shelter.

In total, nine radiocarbon dated samples were submitted to the Radiocarbon Dating Laboratory at the Australian National University (ANU).
These included eight marine shells (ANU-11741, 11740, 11739, 11879, 11878, 11877, 11737, and 11738) and one charcoal sample (ANU-11742). Radiocarbon dates with 13C measurements are presented in Appendix D. Ages are calibrated with CALIB 5.0 (Stuiver and Reimer, 1993) with a regional deltaR correction factor of the northwestern Australia/Java region (ΔR = 67 ± 24; P. J. Stuiver, pers. comm. 2006, Marine Reservoir Correction Database; Southon et al, 2002). Results of the radiocarbon dating and conversion to calibrated calendar years BP are calculated in Appendix E.

Four species of marine shellfish were submitted for conventional radiocarbon dating. These included: *Trochus maculatus, Lambis lambis, Turbo marmoratus* and *Strombus* sp (Appendix E). It is assumed the different taxa have not biased the age determination outcomes between shell samples. The shell specimens were selected on their physical condition (i.e. fresh looking or non-chalky shell) and of sufficient mass to date by conventional radiocarbon dating methods.

ANU-11738 comprised two specimens of *Strombus* sp., weighing in total 51 grams (Appendix E). Both specimens were sent to the laboratory to ensure there was sufficient carbon to date the shell material by conventional radiocarbon dating. It is not known if both specimens were consumed in the dating process, and the ANU Radiocarbon Dating Laboratory was not able to locate the remaining shell material. Missing dating residue samples also include: ANU-11737, -11742, -11739, -11740, and -11741 (Appendix E). That is to say, the remaining material of these shells and charcoal sample could not be located post radiocarbon dating. The present study intended to analyse some of these shell
samples (particularly the oldest sample, ANU-11738) by X-Ray Diffraction (XRD) to determine whether any recrystallization of the carbonate had occurred.

**RECRYSTALLIZATION**

Only ANU-11877, -11878 and -11879, all *Turbo marmoratus*, were examined to determine the proportion of aragonite and calcite in these respective shells. The detection of calcite in samples ANU-11877, -11878 and -11879 would indicate the possibility that their respective age determinations were unreliable, being composed partly of external sources of carbon. Samples were submitted for XRD analysis at the Department of Earth and Marine Sciences at ANU.

The results of the XRD analysis demonstrated that ANU-11877 and -11879 comprised pure aragonite. That is, age determinations obtained for Horizons II (cal. 13,059-12,789 BP at two sigma) and Horizon V (cal. 10,549-10,216 BP at two sigma) (Appendix E) demonstrated no recrystallization.

ANU-11878 comprised 84.8% aragonite and 15.2% calcite in weight. The sample was run again, this time separating the brown and white parts of the shell. The results showed that the brown parts were pure calcite and the white was almost pure aragonite (i.e. ANU-11878: brown 100% calcite; white 97.4% aragonite and 2.6% calcite in weight). It is uncertain which portion of ANU-11878 was submitted for radiocarbon dating. The results of the XRD analysis of this sample indicate the possibility of recrystallization in the brown areas of the shell. Graph results of the XRD analysis of sample ANU-11878 are presented in Appendix F.
OVERALL CHRONOLOGY

The age determinations from the dated shell samples provide a broad chronological sequence extending from the base of the deposit through to the trench surface and are tabled in Appendix E. Humans initially occupied Bui Ceri Uato in the Pleistocene (26,520 ± 340 BP, ANU-11738, Appendix E), provisionally calibrated to 30,660-29,200 cal. years at two standard deviations (R. Gillespie, pers. comm. 2006, Appendix E). ANU-11738 far exceeds Glover's estimation of a suggested age of earliest occupation at about 9,000-7,000 BP, which was based on a correlation with the nearby site of Lie Siri (1986: 97). The uniformity of archaeological materials in the lower deposits and lack of chronological markers means that this significant chronological extension of human occupation at Bui Ceri Uato was in no way apparent until otherwise indicated by radiocarbon dating. There is a need for caution in accepting ANU-11738 as no study of recrystallization was possible. However, the antiquity of occupation at Bui Ceri Uato is supported by other known Pleistocene sites in East Timor, including Lene Hara cave where initial human occupation is dated to about 34,650 ± 630 BP (O'Connor et al, 2002a) and Matja Kuru 2 with near basal dates of 32,220 ± 300 BP (Veth et al, 2004).

The majority of deposits and embedded cultural materials at Bui Ceri Uato accumulated between about 13,191-10,216 cal. BP, suggesting that the majority of human occupation at the shelter occurred during this period (Appendix E, ANU-11879, -11878, -11877, -11737).

The first 20 cm of deposit consisted of mainly goat dung, modern charcoal and ash (see Figures 3.17a and 3.18a) and most likely accumulated from recent human use of Bui Ceri Uato as a goat pen and a place to parch corn. The
age of cultural materials between 20-70 cm below the surface are dated to between 9,256-5,661 cal. BP (Appendix E). The apparent absence of deposits younger than the mid-Holocene may be explained by two possible scenarios. The first, is that sediments and embedded cultural materials that may have been deposited between the mid-Holocene and the present were partially removed. This is a not unlikely scenario, given the contemporary practice in East Timor of removing rich soils from caves/rock shelters to nearby gardens. Indeed, Glover (1986) noted the presence of an old maize garden on the talus slope at the front of the shelter at the time of the excavation (see Figure 3.16). Alternatively, there may have been relatively little human occupation and therefore little subsequent accumulation of sediments and cultural materials at Bui Ceri Uato as of the mid-Holocene, when major changes in human subsistence/settlement strategies are thought to have occurred (see Chapters 1 and 2).

The charcoal sample ANU-11742 derived from Square N6E1 Spit 7, about 45-55 cm below the surface (see Figure 3.18c), where the extensive hearth was partially located in the trench. On this basis, it can be deduced that the charcoal sample ANU-11742 dates this extensive hearth. Interestingly, ANU-11742 produced a date of 505-297 cal. BP at two standard deviations (Appendix E), despite being chemically pre-treated for possible contamination with modern carbon (see Appendix D). This is in agreement with Glover’s ANU-327 charcoal sample collected from N7E1 Spit 6 (1986: Table 1), which also dates this hearth (see Chapter 3). The Test Sample Significance function on CALIB 5.0 indicates that there is no statistical difference between the dating determinations of ANU-11742 and Glover’s ANU-327 at the 95% level of probability ($t=1.44$, $n=2$). ANU-11742 confirms that the extensive hearth from which it derives was dug
into the deposit from a higher level. Further support for the intrusive nature of the hearth is provided by the age determinations of the shell samples (Appendix E), which indicate that the modern dates obtained by charcoal samples ANU-327 (Glover, 1986) and ANU-11742 (Appendix E) do not represent the age of midden materials at the equivalent depth in the excavated deposits of the shelter. Glover (1986) noted that no disturbance was visible in the stratigraphy of the trench above the hearth (see Chapter 3). These dating outcomes support the interpretation that stratigraphic colour divisions largely result from post-depositional changes in the soil profile of the shelter (see Chapter 3).

**Inversions**

There are three chronological inversions in the dated horizon shell sequence. They include Horizon II with IV, Horizon VI with VII, and between Horizons I and II. While Horizons II and IV overlap in age (Appendix E) the dates are not statistically different. For instance, when a Test Sample Significance CALIB 5.0 function was run between ANU-11877 and -11878 there was no significance difference at a 95% level of confidence ($t=62.9$, $n=2$) (Appendix E). The VI with VII, and I with II inversions are discussed further below.

**Horizon VI with Horizon VII**

Horizon VII is dated between 9,256-8,788 cal. BP and (ANU-11740) whereas the underlying Horizon VI is dated between 5,967-5,661 cal. BP (ANU-11739) (Appendix E). The cal. age difference between ANU-11739 and -11740 is statistically different at the 95% level when tested with CALIB 5.0 ($t=913.89$, $n=2$). There is a maximum of about 5 cm of overlapping trench depth between
Horizon VI and VII boundaries (Appendix E). It is possible for the ANU-11739 shell to have derived from deposits in this zone of inter-horizon mixing and to have been combined into Horizon VI. This circumstance would explain the inversion of dates between Horizons VI and VII. An alternative interpretation is that ANU-11739 may represent localised disturbance and should, therefore, be rejected. This is particularly convincing as the overlying Horizons VII and VIII are in chronological sequence (Appendix E).

**Horizon I with Horizon II**

Horizon II is dated to between 13,059-12,789 cal. BP (ANU-11877) whereas the underlying basal Horizon I dates to a younger 11,912-11,219 cal. BP (ANU-11737) (Appendix E). There is a maximum range of approximately 10 cm of overlapping trench depth between Horizon I and II boundaries (Appendix E). It is possible for the ANU-11877 dated shell to have derived from deposits in this zone of inter-horizon mixing and combined into Horizon II. This could account for the inversion in the dates between Horizons I and II (i.e. between ANU-11877 and ANU-11737). However, ANU-11737 is statistically significantly different at the 95% level with ANU-11877 when tested with CALIB 5.0 ($t=41.1$, $n=2$). ANU-11737 is also statistically different from ANU-11878 in Horizon IV (CALIB 5.0, $t=62.9$, $n=2$). This means that ANU-11737 is statistically significantly younger in age than the approximately 45-55 cm of deposit directly above it (Appendix E). For this reason, it is more compelling to suggest that ANU-11737 derived from localised disturbance and may have filtered down into Horizon I (which is otherwise older). This alternative is supported by the nature of the stratigraphy in lower deposits which was created by post-depositional chemical alteration which acts to mask evidence of disturbance (see Chapter 3),
as well as preliminary evidence of post-depositional movement of materials in the trench (see Appendix C).

With the rejection of the dates of ANU-11739 and -11737, which are not considered by the present study to represent the age of the majority of materials at similar levels in the trench, the remaining dated shell samples show that the age of cultural materials deposited at Bui Ceri Uato increases with depth (Appendix E). The deposits of Bui Ceri Uato shelter demonstrate broad chronological integrity from the base to the surface of the trench.

**DATING DETERMINATIONS AND THE CULTURAL SEQUENCE**

Data from Bui Ceri Uato are unable to refine the timing of the adoption of animal husbandry and the introduction of pottery (with their possible association with the establishment of village settlements) in East Timor (see Chapter 2). This is because the limited provenance of the dated shell samples, faunal material and plain body sherds to the level of horizon (see Table 3.6) severely limit our ability to date accurately the introduction of pottery and exotic fauna at Bui Ceri Uato. At best, only very broad statements about the timing of the arrival of imported fauna and the appearance of pottery can be made.

Pottery first appears at Bui Ceri Uato in Horizon V (see Table 3.6). However, sherd counts show a filtering downwards effect (see Appendix C). This means that it is unlikely that pottery was actually first introduced at Bui Ceri Uato in Horizon V deposits. More realistic is the likelihood of the first appearance of pottery in overlying Horizons VI and/or VII. The earliest convincing appearance of exotic fauna at the site is in Horizon VI with dog and *Bos* bone (see Table 3.6). Given the broad chronological resolution at Bui Ceri
Uuto, it is reasonable to suggest that the arrival of exotic fauna and the introduction of pottery to East Timor occurred less than 9,022 cal. BP (the midpoint of ANU-11740, Horizon VII, Appendix E).

SEDIMENTATION RATES: AGE/DEPTH CURVE

Sedimentation rates are indicated by the construction of a notional age/depth curve. In normal age/depth procedures, the dated sample is calculated at the midpoint of the excavation unit or spit (e.g. Hiscock, 1984; Hughes and Djohadze, 1980; O’Connor, 1999). Appendix G presents age/depth curve calculations at Bui Ceri Uuto. Depth below surface was taken at the midpoint of upper and lower horizon depths. Ages were taken at the midpoint of calibrated years BP. Horizons II-IV were combined to give a midpoint of depth and of cal. BP, given the overlapping dates obtained by ANU-11877 and -11878 (Appendix G). The age/depth curve is presented in Figure 6.1, and shows the history of the accumulation of deposits at Bui Ceri Uuto at a very broad level of resolution.

![Figure 6.1 Age/depth curve, Bui Ceri Uuto](image-url)
Bui Ceri Uato shows initial human occupation at about 26,520 BP or between 30,660-29,200 cal. BP (provisional), after which there is a hiatus and/or extremely sporadic use of the shelter until between about 13,191-12,789 cal. BP (Figure 6.1, Appendix G). This interpretation is based on the assumption that sediment build up is synonymous with human occupation (see Haberle and David, 2004: 171). Although Figure 6.1 presents a continuous and gradual rate of sedimentation in the Pleistocene, in actuality this may well have been a short, sharp burst in sedimentation rates coinciding with initial human occupation of the shelter, followed by general abandonment with very little subsequent sediment build up until the terminal Pleistocene. Future dating of Horizon I deposits would be able to refine sedimentation rates and hence the nature of human occupation at Bui Ceri Uato in the Pleistocene.

Between about 12,990-10,383 cal. BP there is a steep sedimentation rate, which peaks between about 10,383-9,022 cal. BP (Figure 6.1, Appendix G). These trends suggest that there is a dramatic increase in the rate of accumulation of deposits (and embedded cultural materials) at the terminal Pleistocene/early Holocene. Indeed, the majority of deposits date to the terminal Pleistocene/early Holocene and this is suggestive of relatively intense human occupation of Bui Ceri Uato shelter in this general period.

There is a relative decline in sedimentation rates between about 9,022-7,022 cal. BP (Figure 6.1, Appendix G). About 7,260-6,783-cal. BP represents the youngest dated sediments at the shelter, but may be extended to between 5,967-5,661 cal. BP if ANU-11739 represents material derived ultimately from above Horizon VIII which had suffered downward displacement (Appendix E).
Other measures indicative of levels of human occupation of Bui Ceri Uato include flaked stone artefact discard rates (as well as the frequency of occurrence of cores with thermal damage, calculated in Chapter 7). This is calculated in each subgroup.

**SUBGROUPS: THE UNIT OF ANALYSIS**

Subgroups 1, 2, 3 and 4 are established as the means of investigating temporal trends in levels of human occupation of Bui Ceri Uato shelter as well as temporal trends to the extent/length of reduction of cores. Subgroups were adopted because the present study expressed concern regarding the chronological integrity of horizon contents constructed by Glover (1986) (see Chapter 3).

The dated horizon shell sequence (Appendix E) and the archaeological sequence (see Table 3.6) formed the basis of considerations in the construction of subgroups. There was very little choice but to work within the confines of horizon delineations in the construction of subgroups. This was because of the limited provenance information of dated shell samples, which could only be sourced to the level of horizon. Subgroups attempted to separate Pleistocene aged-deposits and also to separate horizons with pottery and introduced fauna from the remaining deposit. Chronological boundaries were calculated as the midpoint of calibrated ages (Appendix E).

The provenance, number and percentage of cores in each subgroup, subgroup chronological boundaries and the rationale adopted are outlined in Table 6.1. Subgroups are arranged in profile whereby Subgroup 1 is located at the base of the trench and Subgroup 4 towards the trench surface.
6.1 Subgroups and core artefacts, Bui Ceri Uato

<table>
<thead>
<tr>
<th>Subgroups</th>
<th>Horizon(s)</th>
<th>Subgroup chronological boundaries (cal. BP)</th>
<th>Rationale</th>
<th>Number of cores</th>
<th>% of cores</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>VI, VII, VIII, IX and X</td>
<td>9,022-Present</td>
<td>Pottery and imported fauna: Holocene</td>
<td>89</td>
<td>22.5</td>
</tr>
<tr>
<td>3</td>
<td>V</td>
<td>10,383-9,022</td>
<td>Early Holocene</td>
<td>55</td>
<td>13.9</td>
</tr>
<tr>
<td>2</td>
<td>II, III and IV</td>
<td>12,990-10,383</td>
<td>Terminal Pleistocene</td>
<td>213</td>
<td>53.9</td>
</tr>
<tr>
<td>1</td>
<td>I</td>
<td>29,930-12,990</td>
<td>Comparatively earlier Pleistocene</td>
<td>38</td>
<td>9.6</td>
</tr>
</tbody>
</table>

Subgroup 1 contains cores in Horizon I, only. This subgroup was constructed based on the rationale that Horizon I contains comparatively earlier Pleistocene aged deposits (Table 6.1). On this basis of antiquity, it was considered that cores contained within Horizon I are best analysed separately from those in overlying late Pleistocene and Holocene-aged deposits. In this way, the morphology of cores discarded at Bui Ceri Uato during the initial Pleistocene occupation could be compared and contrasted with the morphology of cores discarded in the later periods of human occupation of the shelter.

Subgroup 2 combines cores from Horizons II, III and IV and dates to the terminal Pleistocene (Table 6.1). Horizons II-IV were combined to give a midpoint of 12,999 cal. BP, given the overlapping dates obtained by ANU-11877 and -11878 (Appendix E).

Subgroup 3 contains cores from Horizon V, only, and dates to the early Holocene (Pleistocene boundary) (Table 6.1). Relevant to the construction of this subgroup are overlapping Horizon IV, V and VI delineations within the depth of the trench (see Table 3.4). This zone of inter-horizon IV, V and VI mixing may act in part to obscure sequential changes in core morphology between Subgroups 2, 3 and 4. While pottery first occurs in Horizon V, the low number of sherds suggests that this is most likely a result of pottery filtering downwards in the
depth of the deposit (see Appendix C). No introduced faunal materials were recovered in this horizon (see Table 3.6). These considerations suggest that cores in Subgroup 3 were deposited prior to the introduction of pottery and domesticated animal species.

Subgroup 4 contains cores combined from Horizons VI, VII, VIII, IX and X. These horizons contain pottery and introduced fauna and extend to the surface of the trench. For this reason, cores in Subgroup 4 may be considered in terms of the inferred changes in human subsistence and (associated with the appearance of pottery) settlement changes in East Timor. Dated from about 9,022 BP (Table 6.1), however, Subgroup 4 deposits most likely represent a mix of both pre-agricultural as well as agricultural periods in East Timorese prehistory. Sediment and artefact discard calculations are given for Subgroup 4 in awareness of the possibility that partial removal of deposits in these upper levels may have occurred.

In this way, the cores are divided into comparatively earlier Pleistocene (Subgroup 1), the terminal Pleistocene (Subgroup 2), and early Holocene (Subgroup 3). This is followed by cores in Subgroup 4, which dates to the Holocene and is considered by the present study as associated with broader changes in human subsistence/settlement strategies in East Timor (see Chapters 1 and 2).

Subgroup 1 contains the lowest number of cores (38 or 9.6% of the cores in the Bui Ceri Uato lithic assemblage, Table 6.1). Subgroup 2 contains the highest number of cores (213 or 53.9%). Subgroup 3 contains 55 cores (13.9%). Subgroup 4 contains 89 cores (22.5%). Importantly, the number of cores in each subgroup is sufficiently large to be amenable to statistical testing. Note: the
number of cores identified at Bui Ceri Uato by the present study (395) varies from that of Glover (1986) as different identification criteria were applied (see Chapter 5).

**SUBGROUPS AND FLAKED STONE DISCARD**

Appendix H shows flaked stone artefact discard rate calculations, core discard rates and the core:flake ratio where subgroups divide the deposits of Bui Ceri Uato.

Flaked stone artefact discard rates were calculated in Subgroup 1, in awareness of the need for more refined dating of basal Bui Ceri Uato deposits. A similar calculation was made for Subgroup 4, despite concerns that deposits younger than the mid-Holocene may have been partially removed from the shelter. Flaked stone artefact discard rates were calculated to the present, simply because flaked stone occurred to the very surface of the deposit at the site (see Table 3.6). For these reasons, flaked stone artefact discard rates can only be considered at a very broad level of resolution.

**Trends in flaked stone artefact discard rates**

The rate of flaked stone artefact discard is calculated as the number of flaked stone artefacts per m$^3$/100 years in each subgroup (Appendix H). In calculating the rate of flaked stone artefact discard at Bui Ceri Uato the present study was reliant on total flaked stone artefact numbers recorded by Glover at the site (1986: Table 41), excluding six non-artefactual lithic specimens which resulted from heat fractures and/or natural breaks and were not evident of flaked surfaces such as those characterised by knapping (Appendix I, see Chapter 5). A quantitative analysis of the entire lithic assemblage was beyond the limited scope
of the present study (e.g. Hiscock, 2002, 2005). For this reason, rates of flaked stone artefact discard presented below should only be considered as broad temporal lithic trends pending future quantitative studies of the flake component of the Bui Ceri Uato lithic assemblage.

Flaked stone artefact discard rates shown in Figure 6.2 follow the same trend as that depicted by the age/depth curve (Figure 6.1). Discard rates are relatively low in Subgroup 1 in the Pleistocene, dramatically increase in Subgroup 2 at the terminal Pleistocene, and peak in Subgroup 3 in the early Holocene (Figure 6.2). The dramatic increase in flaked stone artefact discard rates in Subgroup 2 and 3 indicate a great intensity of knapping activities conducted by humans at Bui Ceri Uato around the terminal Pleistocene/early Holocene boundary. However, this trend is not sustained and Subgroup 4 depicts a noticeable decline in the rate of flaked stone artefact discard in the Holocene in deposits associated with pottery and imported fauna (Figure 6.2). The broad chronological resolution of deposits in Subgroup 4 (dated to younger than 9,022 cal. BP) does not allow the present study to confirm and/or refine Glover’s (1986) observations of a decline in abundance of flaked stone artefacts within the last 3,000 BP (see Chapter 4).

The rate of core artefacts discarded in each subgroup is calculated (number of cores per m$^3$/100 years, Appendix H) and presented in Figure 6.3. The rate of core artefact discard follows similar trends such as that displayed by the total number of flaked stone artefacts which predominantly comprise flakes (Figure 6.2, Appendix H). For example, both the rate of core artefact discard and flaked stone artefact numbers peak in Subgroup 3 in the early Holocene (Figures 6.2 and 6.3). A minor contrast, however, the rate of core artefact discard is
slightly higher in Subgroup 1 in the earliest phase of human occupation compared with Subgroup 4 in the Holocene, whereas this trend is reversed with the total number of flaked stone artefacts (Figures 6.2 and 6.3).

Trends in the rate of core artefact discard (Figure 6.3) are best interpreted in terms of a quantitative relationship with flake numbers. This is achieved with core:flake ratios, which are calculated in each subgroup and are standardised by volume of sediment and in time (Appendix H, Figure 6.4). There is an increase in the number of flakes for each core discarded at Bui Ceri Uato from Subgroup 1 to Subgroup 4 (Figure 6.4). This may be indicative of a continuous increase in the extent/length of reduction of cores at Bui Ceri Uato from initial human occupation of the shelter through to the present. This possibility is investigated further in Chapter 9 of the present study, where temporal trends in the extent/length of reduction of core artefacts at Bui Ceri Uato are assessed.

A further consideration that could explain the continuous increase in the core:flake ratio over time is a corresponding rise in the frequency of occurrence of retouched flakes (i.e. whereby flakes are struck off other flakes). However, this would require further research to investigate as the flake component of the Bui Ceri Uato lithic assemblage was beyond the scope of analysis of the present study.

Also involved in considerations of core:flake ratio trends at Bui Ceri Uato is the likelihood of offsite/onsite transportation of flaked stone artefacts from or to the shelter. It is likely that there was some exchange of cores and/or flakes at the site, whereby flaked stone may have been manufactured elsewhere and brought into the shelter and/or may have been manufactured onsite and subsequently transported elsewhere. This complexity of human movement and
transportation of flaked stone could bias patterning in the core:flake ratio and associated interpretations of human behaviour. Consequently, trends in the core:flake ratio presented in Figure 6.4 need to be viewed in terms of only broad trends spanning the Pleistocene to the Holocene.

Figure 6.2 Flaked stone artefact discard rate (# per m$^3$ per 100 years) according to subgroups, Bui Ceri Uato

Figure 6.3 Core artefact discard rate (# per m$^3$ per 100 years) according to subgroups, Bui Ceri Uato
LEVELS OF HUMAN OCCUPATION, THE PALAEOENVIRONMENT
AND THE CULTURAL SEQUENCE

Bui Ceri Uato was first occupied by humans between 30,660-29,200 cal. BP (provisional, Appendix E). The shelter was then used either extremely sporadically and/or largely abandoned as a site of human occupation until the terminal Pleistocene between about 12,990-10,383 (Table 6.1). This interpretation is based on relatively extremely low rates of sediment accumulation and flaked stone artefact discard in the initial period of Pleistocene occupation (Figures 6.1, 6.2 and 6.3). These dates occur prior to and after the Last Glacial Maximum (LGM) which is now seen as extending between 28,000-18,000 cal. BP and characterised by colder, more arid climatic conditions and lower sea levels (see Chapter 2). The period of the LGM represents the greatest vertical distance between Bui Ceri Uato and the coastline over the span of human occupation at the shelter (see Chapter 3). It may be that people largely abandoned these higher altitudes and focussed more on low lying areas closer to coastal resources during the LGM. This scenario could explain the low indices of human occupation (i.e. sedimentation and flaked stone artefact discard rates) at Bui Ceri
Uato in this earlier Pleistocene phase of human occupation. By the terminal Pleistocene (i.e. about 12,990-10,383, Table 6.1) Bui Ceri Uato was used more intensively, presumably by human groups re-colonising the surrounding Baucau region after environmental conditions had ameliorated and sea levels rose.

Sedimentation and flaked stone artefact discard rates peak dramatically at the terminal Pleistocene/early Holocene and are suggestive of relatively intense human occupation of Bui Ceri Uato shelter spanning the period between 12,990-9,022 cal. BP (Table 6.1). Interestingly, the nearby site of Lie Siri similarly shows a dramatic increase in sedimentation rates between about 8,091-7,511 cal. BP (Glover, 1986: Table 1). When calibrated with CALIB 5.0 (Stuiver and Reimer, 1993), ANU-236 (7,270 ± 160 BP) and ANU-171 (6,635 ± 140 BP) gave respective ranges of 8,393-7,789 and 7,757-7,265 at two sigma BP. This comparatively later peak in sedimentation at Lie Siri may be explained by poor chronological resolution of basal deposits at this shelter. For instance, ANU-236 constitutes the lowest date obtained for the site, collated from charcoal 10-20 cm above bedrock combined across 7 m² (Glover, 1986: Table 1). Re-dating of the basal deposits of Lie Siri would refine sedimentation rates at the site and allow more reliable comparisons with sedimentation rates observed by the present study at Bui Ceri Uato. These preliminary findings of dramatic increases in sediment accumulation as well as rates of flaked stone artefact discard at Bui Ceri Uato and a similar peak in sedimentation rates at Lie Siri are suggestive of intensive human occupation of the plateau in the early Holocene. Further excavation of rock shelters on the Baucau plateau would determine whether such trends in sedimentation and flaked stone artefact rates were common to the region in the early Holocene.
There are additional factors requiring consideration in interpreting the peaks in sedimentation and flaked stone artefact discard rates on the Baucau Plateau. For instance, it would remain difficult to determine whether such a dramatic increase in sedimentation and flaked stone artefact discard rates were a result of increased numbers of people on the Baucau region or were simply a general intensification in the amount of activities conducted by humans on the plateau (Hiscock, 1984: 135). It is reasonable to speculate that both these factors (i.e. population increase and a general intensification in human activities) were involved in the process of human re-colonisation of the Baucau Plateau.

Changes in the system of manufacture of flaked stone may also have a role in explaining the comparatively high rate of flaked stone artefacts discarded at Bui Ceri Uato at the terminal Pleistocene/early Holocene (cf. Hiscock, 1984: 134; Hiscock and Hall, 1988b). A technological consideration may include greater reduction of stone material and is investigated in Chapters 8 and 9 of the present study with assessments of core reduction. After about 9,022 cal. BP both sedimentation and flaked stone artefact discard rates decline but remain higher than in the Pleistocene.

CONCLUSION

This chapter has provided broad chronological resolution of the cultural deposits of Bui Ceri Uato. Temporal changes in sedimentation and flaked stone artefact discard rates were calculated in each subgroup, which form the unit of analysis in the detection of temporal changes in core artefact morphology at the shelter. In this way, sedimentation and flaked stone artefact discard rates can be
correlated with assessments of temporal changes in core morphology (in Chapters 7 and 9 of the present study).

Bui Ceri Uato provides limited evidence of human occupation in the mid to late Holocene, which is associated with the introduction of pottery and introduced fauna and inferences of human subsistence/settlement changes in East Timor (see Chapter 2). These changes occur in Subgroup 4 deposits, which are dated to less than 9,022 cal. BP (see Table 6.1).

Sedimentation and flaked stone artefact discard rates show parallel trends, with very low rates of deposition in the earliest phase of human occupation in the Pleistocene (i.e. between about 29,930-12,990 cal. BP, Table 6.1). This could be interpreted in terms of a hiatus and/or extremely sporadic human occupation as a response to colder and more arid climatic conditions and/or dramatically lower sea levels which would have increased the vertical distance of Bui Ceri Uato to the coastline (see Chapters 2 and 3). Should humans have focussed largely on a coastal subsistence strategy during the LGM, increased access difficulty reaching coastal resources may be one factor contributing to the relatively low indices evident of human occupation at the shelter in this period. Further archaeological research is required to test this scenario of human movement responding to low sea levels.

The terminal Pleistocene/early Holocene shows a dramatic increase in sedimentation rates and flaked stone artefact discard rates, suggesting relatively intense occupation of Bui Ceri Uato shelter in this period (i.e. between about 12,990-9,022 cal. BP, Table 6.1). Such trends may be indicative of intensive re-occupation of the Baucau Plateau by human groups responding to ameliorated climatic conditions more conducive to human habitation and/or rising sea levels.
This is partly supported by a similar peak in sedimentation rates at the nearby site of Lie Siri, but requires further dating of basal deposits at that site in order to refine the timing of accumulation of sediments. This suggestion of relatively higher levels of human occupation on the Baucau Plateau at the terminal Pleistocene/early Holocene is investigated further in the next chapter, where temporal trends in the frequency of occurrence of cores at Bui Ceri Uato with heat-fractures are assessed and may be regarded as a further indicator of levels of human occupation.
CHAPTER 7

TAPHONOMIC IMPACTS

In this chapter, taphonomic impacts (both mechanical and thermal damage) displayed on the core artefacts at Bui Ceri Uato are quantified. Cores were excluded from analyses when they had been damaged in ways which made it invalid to employ particular measurements from them. This allows taphonomic affects to be separated from knapping in the creation of core morphology. This consideration of taphonomic changes in flaked stone artefact assemblages was not adopted in Glover (1986) and may have led to observations of lithic patterning that were the product of a combination of taphonomic influences as well as direct outcomes of human actions.

Cores with thermal fractures (crazing, pot lid scars, crenated fracture and convoluted surfaces) are quantified to provide an indication of the extent of occurrence of cores with thermal damage. Spatial concentrations of heat-fractured cores are assessed as these may provide insight into the location of hearths in the excavated area of the shelter (see Chapter 3). The relationship between raw stone materials, core size, and core shape with the occurrence of thermal damage is also explored. This analysis investigates whether such morphological characteristics (stone material, core size and shape) are relevant to evaluations of the frequency of cores with thermal damage which, in turn, is of importance to the accuracy and/or reliability of interpretations of the frequency of fire/hearth use at Bui Ceri Uato. This
analysis forms the focus of the second section of the present chapter, where the frequency of occurrence of cores with thermal damage is calculated on the basis of the dated shell sequence obtained by the present study (see Chapter 6, Appendix E). Trends in the frequency of occurrence of cores with thermal damage are an indication of levels of fire/hearth use at Bui Ceri Uato. This provides a further indication of relative levels of human occupation at the shelter.

Prior to undertaking these taphonomic assessments, however, it is first necessary to provide more general information of the cores at Bui Ceri Uato including their provenance, distribution and stone material composition.

PROVENANCE
IDENTIFICATION

A total of 395 cores are identified in the Bui Ceri Uato lithic assemblage by the present study, applying specific identification criteria (defined in Chapter 5). It was found that the sample of 852 cores classified by Glover (1986: Table 43) contained a heterogeneous collection, including flakes and retouched flakes as well as non-flaked specimens produced by heat fractures. These were excluded from the present analysis. Cores were identified in amongst Glover's various flake categories (1986, such as scrapers, miscellaneous and irregular flakes) and were included into the present analysis. The number of cores identified by the present study in Glover's (1986) flake categories as well as the number of flakes he classed as cores are documented in Appendix I.
DISTRIBUTION OF CORES

The distribution of cores in each square by spit and by horizon is presented in Tables 7.1 and 7.2, respectively. Spits are ordered with increasing depth, with Spit 16 at the base of the trench. Horizons are arranged from IX at the floor of the shelter through to Horizon I at the base of the trench.

Overall, the numbers of cores in each spit are relatively low, with counts ranging from a single core up to 17 cores. Spit 10 contains the highest number of 66 cores and is followed by Spits 9, 12, 11, 13 with 48, 39, 35 and 32 cores, respectively. No cores were identified in Spit 1, which comprised goat dung deposited on the floor of the shelter.

The numbers of cores per horizon in each square are also low, with counts ranging from a single core up to a population of 22 cores. Horizon III contains the highest count with 75 cores, followed by Horizons II, IV, V and VI with 70, 68, 55 and 52 cores, respectively.

Squares N6E1, N6E2 and N7E2 contain the highest core counts, ranging between 60 through to 82 cores. Squares N5E1, N6W1 and N6E0 contain the fewest number of cores, ranging between 12 through to 25 cores. Thirty six cores lacked provenance details.
Table 7.1 Distribution of cores by spit, Bui Ceri Uato

<table>
<thead>
<tr>
<th>Spit</th>
<th>Unprov.</th>
<th>N5E1</th>
<th>N5E2</th>
<th>N6E0</th>
<th>N6E1</th>
<th>N6E2</th>
<th>N6W1</th>
<th>N7E1</th>
<th>N7E2</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>1</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td>9</td>
</tr>
<tr>
<td>3</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>7</td>
</tr>
<tr>
<td>4</td>
<td>7</td>
<td>1</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
<td>19</td>
</tr>
<tr>
<td>5</td>
<td>1</td>
<td>4</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>6</td>
<td>1</td>
<td>10</td>
<td></td>
<td>28</td>
</tr>
<tr>
<td>6</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>4</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>12</td>
</tr>
<tr>
<td>7</td>
<td>2</td>
<td>5</td>
<td>2</td>
<td>6</td>
<td>2</td>
<td>12</td>
<td></td>
<td></td>
<td></td>
<td>30</td>
</tr>
<tr>
<td>8</td>
<td>1</td>
<td>6</td>
<td>3</td>
<td>8</td>
<td>4</td>
<td>11</td>
<td>15</td>
<td>48</td>
<td></td>
<td>66</td>
</tr>
<tr>
<td>9</td>
<td>5</td>
<td>7</td>
<td>3</td>
<td>17</td>
<td>2</td>
<td>15</td>
<td></td>
<td></td>
<td></td>
<td>66</td>
</tr>
<tr>
<td>10</td>
<td>4</td>
<td>10</td>
<td>16</td>
<td>5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>35</td>
</tr>
<tr>
<td>11</td>
<td>8</td>
<td>2</td>
<td>5</td>
<td>8</td>
<td>3</td>
<td>13</td>
<td></td>
<td></td>
<td></td>
<td>39</td>
</tr>
<tr>
<td>12</td>
<td>7</td>
<td>4</td>
<td>8</td>
<td>7</td>
<td>6</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>32</td>
</tr>
<tr>
<td>13</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>14</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>8</td>
</tr>
<tr>
<td>15</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>9</td>
</tr>
<tr>
<td>16</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>6</td>
</tr>
<tr>
<td>Total</td>
<td>36</td>
<td>12</td>
<td>39</td>
<td>25</td>
<td>60</td>
<td>74</td>
<td>19</td>
<td>48</td>
<td>82</td>
<td>395</td>
</tr>
</tbody>
</table>

Table 7.2 Distribution of cores by horizon, Bui Ceri Uato

<table>
<thead>
<tr>
<th>Horizon</th>
<th>Unprov.</th>
<th>N5E1</th>
<th>N5E2</th>
<th>N6E0</th>
<th>N6E1</th>
<th>N6E2</th>
<th>N6W1</th>
<th>N7E1</th>
<th>N7E2</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>IX</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>5</td>
</tr>
<tr>
<td>VIII</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>3</td>
<td>1</td>
<td>5</td>
<td>2</td>
<td>2</td>
<td>4</td>
<td>10</td>
</tr>
<tr>
<td>VII</td>
<td>7</td>
<td>8</td>
<td>6</td>
<td>1</td>
<td>10</td>
<td>6</td>
<td>1</td>
<td>10</td>
<td>52</td>
<td></td>
</tr>
<tr>
<td>VI</td>
<td>3</td>
<td>2</td>
<td>6</td>
<td>6</td>
<td>3</td>
<td>8</td>
<td>2</td>
<td>3</td>
<td>22</td>
<td>55</td>
</tr>
<tr>
<td>V</td>
<td>8</td>
<td></td>
<td>5</td>
<td>7</td>
<td>3</td>
<td>17</td>
<td>2</td>
<td>11</td>
<td></td>
<td>68</td>
</tr>
<tr>
<td>IV</td>
<td>9</td>
<td>4</td>
<td>10</td>
<td>16</td>
<td>4</td>
<td>15</td>
<td>17</td>
<td>17</td>
<td>75</td>
<td></td>
</tr>
<tr>
<td>III</td>
<td>6</td>
<td>15</td>
<td>13</td>
<td>15</td>
<td>2</td>
<td>8</td>
<td>5</td>
<td></td>
<td>70</td>
<td></td>
</tr>
<tr>
<td>II</td>
<td>1</td>
<td>22</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>38</td>
</tr>
<tr>
<td>Total</td>
<td>36</td>
<td>12</td>
<td>39</td>
<td>25</td>
<td>60</td>
<td>74</td>
<td>19</td>
<td>48</td>
<td>82</td>
<td>395</td>
</tr>
</tbody>
</table>

STONE MATERIALS

The cores at Bui Ceri Uato were manufactured from four types of raw stone materials: chert, obsidian, silicified limestone and volcanic material. There are only single specimens of silicified limestone and a volcanic material (Figure 7.1) and only fourteen cores manufactured on obsidian (most of which are illustrated in
Figure 7.2). The overwhelming majority of cores were manufactured on chert (n=379, 95.9%, Table 7.3).

Chert nodules are found in abundance in the Bobonaro Scaly Clays immediately adjacent to the Baucau Plateau on which Bui Ceri Uato is located (see Chapter 3). Bobonaro Scaly Clays are a minimal direct distance of approximately 8 km from the shelter (Chapter 3). Physical similarities between the chert cores in the Bui Ceri Uato lithic assemblage with geological samples of Bobonaro chert (pers. obs.) suggest that this was the most likely source of stone procured by humans occupying the shelter (Chapter 3). The chert core artefacts in the Bui Ceri Uato lithic assemblage were likely procured from this nearby source of Bobonaro chert.

One core each of silicified limestone and volcanic material occur in Horizon V (Table 7.3). With the exception of two obsidian cores located in Horizon II, all other obsidian cores are found in horizons containing pottery and introduced fauna (i.e. Horizon V and above). This association between obsidian cores as well as the single cores of silicified limestone and volcanic material in upper levels associated with changes in human subsistence/settlement may be coincidental given the small sample size of these raw stone material types (Table 7.3). Speculatively, however, the appearance of flaked obsidian at Bui Ceri Uato may be representative of changes in stone procurement strategies on the Baucau Plateau, possibly associated with changes in human subsistence/settlement and/or Austronesian maritime exchange (see Chapter 2). Future studies conducting element analysis of geological sources of obsidian possibly located on the western edge of the Baucau plateau (Glover, 1986: 56) as well as sourced obsidian in the region (e.g. Ambrose et al, 2006; Bird et al,
needed to further investigate a change in the pattern of human movement.

Figure 7.1 Cores of (a) silicified limestone (4381, V) and (b) a volcanic material (4380, V), Bui Ceri Uato
(Each square is equal to 1 cm)

Figure 7.2 Cores of obsidian, Bui Ceri Uato
From top left through to bottom right, identification number and (Horizon): 3743 (VI); 4455 (V); 3624 (VI); 3634 (VI); 3990 (VI); 3470 (VII); 4465 (V); 6080 (II); 5957 (II); 3705 (VI); 10010 (VII); 3096 (VIII).
(Each square is equal to 1 cm)
Table 7.3 Core raw stone material types, Bui Ceri Uato

<table>
<thead>
<tr>
<th>Raw stone material type</th>
<th>Horizon /</th>
<th>Chert</th>
<th>Obsidian</th>
<th>Silicified limestone</th>
<th>Volcanic</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IX</td>
<td></td>
<td>5</td>
<td></td>
<td></td>
<td></td>
<td>5</td>
</tr>
<tr>
<td>VIII</td>
<td></td>
<td>9</td>
<td>1</td>
<td></td>
<td></td>
<td>10</td>
</tr>
<tr>
<td>VII</td>
<td></td>
<td>19</td>
<td>3</td>
<td></td>
<td></td>
<td>22</td>
</tr>
<tr>
<td>VI</td>
<td></td>
<td>47</td>
<td>5</td>
<td></td>
<td></td>
<td>52</td>
</tr>
<tr>
<td>V</td>
<td></td>
<td>50</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>55</td>
</tr>
<tr>
<td>IV</td>
<td></td>
<td>68</td>
<td></td>
<td></td>
<td></td>
<td>68</td>
</tr>
<tr>
<td>III</td>
<td></td>
<td>75</td>
<td></td>
<td></td>
<td></td>
<td>75</td>
</tr>
<tr>
<td>II</td>
<td></td>
<td>68</td>
<td>2</td>
<td></td>
<td></td>
<td>70</td>
</tr>
<tr>
<td>I</td>
<td></td>
<td>38</td>
<td></td>
<td></td>
<td></td>
<td>38</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>379</td>
<td>14</td>
<td>1</td>
<td>1</td>
<td>395</td>
</tr>
</tbody>
</table>

TAPHONOMIC IMPACTS

CORES WITH THERMAL DAMAGE

A large proportion of cores at Bui Ceri Uato display damage from thermal fractures (crazing, pot lid scars, crenated fracture and/or convoluted surfaces, see illustrations in Appendix A). Almost 23% of cores are crazed, 29.9% have pot lid scars, only three cores have crenated fractures, and 11.6% have convoluted surfaces.

In total, 131 cores have evidence of thermal stress resulting from uncontrolled exposure to heating/cooling and comprise 33.2% of cores in the assemblage (Table 7.4).

Table 7.4 Cores with thermal fractures, Bui Ceri Uato

<table>
<thead>
<tr>
<th>Uncontrolled heating/cooling fractures</th>
<th>Core counts</th>
<th>% of cores</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crazing</td>
<td>89</td>
<td>22.5</td>
</tr>
<tr>
<td>Pot lid scars</td>
<td>118</td>
<td>29.9</td>
</tr>
<tr>
<td>Crenated fracture</td>
<td>3</td>
<td>0.8</td>
</tr>
<tr>
<td>Convoluted surfaces</td>
<td>46</td>
<td>11.6</td>
</tr>
<tr>
<td>Total*</td>
<td>131*</td>
<td>33.2</td>
</tr>
</tbody>
</table>

* Total is not the sum of crazing, pot lid scars, crenated fracture and convoluted surfaces because some core artefacts have more than one kind of thermal damage
SPATIAL DISTRIBUTION OF CORES WITH THERMAL DAMAGE

The spatial distribution of cores with thermal damage in the excavated deposits of Bui Ceri Uato is presented. Fractures such as crazing, pot lid scars, crenated fracture and convoluted surfaces reveal the presence of fire such that spatial concentrations of heat-fractured cores may indicate possible locations of hearths in the excavated areas of the shelter (see Chapter 3).

It was found that there are no clear spatial relationships in the concentration of cores with heat-fractures in the deposits of Bui Ceri Uato. This can be observed in Table 7.5, which shows the number/percent of cores with crazing, pot lid scars, crenated fracture and convoluted surfaces in each square by horizon. The extensive hearth located in Horizons VI and VII of Squares N7E1, N7E2, N6E2 and N6E1 (see Figures 3.16 and 3.18a) was not associated with a marked concentration of cores damaged by heating/cooling.

Interestingly, a vertical change in the proportion of cores can be observed (Table 7.5). From Horizon V through to the surface of the deposit there is an increase in the proportion of cores with thermal damage. This may be indicative of greater use of fire/hearths at the shelter in upper horizons associated with pottery and introduced fauna. These preliminary findings will be examined in further detail in the second section of this chapter.
Table 7.5 Spatial concentration of cores with thermal fractures, Bui Ceri Uato

<table>
<thead>
<tr>
<th>Horizon / Square</th>
<th>Unknown</th>
<th>N5E1</th>
<th>N5E2</th>
<th>N6E0</th>
<th>N6E1</th>
<th>N6E2</th>
<th>N6W1</th>
<th>N7E1</th>
<th>N7E2</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>IX</td>
<td>0/1</td>
<td>1/1</td>
<td>1/2</td>
<td>0/1</td>
<td>0/1</td>
<td>0/1</td>
<td>0/1</td>
<td>0/1</td>
<td>0/1</td>
<td>2/5</td>
</tr>
<tr>
<td></td>
<td>(0)</td>
<td>(100)</td>
<td>(50)</td>
<td>(100)</td>
<td>(100)</td>
<td>(100)</td>
<td>(100)</td>
<td>(100)</td>
<td>(100)</td>
<td>(40)</td>
</tr>
<tr>
<td>VIII</td>
<td>0/1</td>
<td>0/1</td>
<td>2/3</td>
<td>2/3</td>
<td>1/1</td>
<td>0/1</td>
<td>0/1</td>
<td>0/1</td>
<td>0/1</td>
<td>5/10</td>
</tr>
<tr>
<td></td>
<td>(0)</td>
<td>(0)</td>
<td>(66.7)</td>
<td>(66.7)</td>
<td>(100)</td>
<td>(0)</td>
<td>(0)</td>
<td>(0)</td>
<td>(0)</td>
<td>(50)</td>
</tr>
<tr>
<td>VII</td>
<td>4/7</td>
<td>0/1</td>
<td>2/2</td>
<td>1/3</td>
<td>1/1</td>
<td>2/3</td>
<td>2/5</td>
<td>2/2</td>
<td>2/2</td>
<td>13/22</td>
</tr>
<tr>
<td></td>
<td>(57.1)</td>
<td>(0)</td>
<td>(100)</td>
<td>(33.3)</td>
<td>(100)</td>
<td>(100)</td>
<td>(100)</td>
<td>(100)</td>
<td>(100)</td>
<td>(59.1)</td>
</tr>
<tr>
<td>VI</td>
<td>2/8</td>
<td>1/6</td>
<td>0/1</td>
<td>0/3</td>
<td>5/10</td>
<td>2/6</td>
<td>1/1</td>
<td>6/10</td>
<td>6/10</td>
<td>24/52</td>
</tr>
<tr>
<td></td>
<td>(25)</td>
<td>(16.7)</td>
<td>(0)</td>
<td>(0)</td>
<td>(50)</td>
<td>(33.3)</td>
<td>(100)</td>
<td>(60)</td>
<td>(60)</td>
<td>(46.2)</td>
</tr>
<tr>
<td>V</td>
<td>1/3</td>
<td>1/2</td>
<td>1/6</td>
<td>1/6</td>
<td>2/3</td>
<td>1/8</td>
<td>1/2</td>
<td>3/3</td>
<td>9/22</td>
<td>19/55</td>
</tr>
<tr>
<td></td>
<td>(33.3)</td>
<td>(50)</td>
<td>(16.7)</td>
<td>(16.7)</td>
<td>(66.7)</td>
<td>(12.5)</td>
<td>(100)</td>
<td>(50)</td>
<td>(66.7)</td>
<td>(40.9)</td>
</tr>
<tr>
<td>IV</td>
<td>2/8</td>
<td>0/7</td>
<td>0/3</td>
<td>7/17</td>
<td>0/2</td>
<td>1/1</td>
<td>1/15</td>
<td>1/15</td>
<td>1/15</td>
<td>13/68</td>
</tr>
<tr>
<td></td>
<td>(25)</td>
<td>(0)</td>
<td>(0)</td>
<td>(41.2)</td>
<td>(0)</td>
<td>(9.1)</td>
<td>(6.7)</td>
<td>(6.7)</td>
<td>(6.7)</td>
<td>(19.1)</td>
</tr>
<tr>
<td>III</td>
<td>2/9</td>
<td>0/4</td>
<td>1/10</td>
<td>5/16</td>
<td>0/4</td>
<td>6/15</td>
<td>6/17</td>
<td>6/17</td>
<td>6/17</td>
<td>20/75</td>
</tr>
<tr>
<td></td>
<td>(22.2)</td>
<td>(0)</td>
<td>(10)</td>
<td>(31.3)</td>
<td>(0)</td>
<td>(40)</td>
<td>(35.3)</td>
<td>(35.3)</td>
<td>(35.3)</td>
<td>(26.7)</td>
</tr>
<tr>
<td>II</td>
<td>3/6</td>
<td>4/15</td>
<td>2/6</td>
<td>3/13</td>
<td>5/15</td>
<td>2/2</td>
<td>1/8</td>
<td>2/5</td>
<td>2/5</td>
<td>22/70</td>
</tr>
<tr>
<td></td>
<td>(50)</td>
<td>(26.7)</td>
<td>(33.3)</td>
<td>(23.1)</td>
<td>(33.3)</td>
<td>(100)</td>
<td>(12.5)</td>
<td>(40)</td>
<td>(40)</td>
<td>(31.4)</td>
</tr>
<tr>
<td>I</td>
<td>1/1</td>
<td>6/22</td>
<td>16/60</td>
<td>27/74</td>
<td>8/19</td>
<td>15/48</td>
<td>30/82</td>
<td>131/395</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(100)</td>
<td>(27.3)</td>
<td>(26.7)</td>
<td>(36.5)</td>
<td>(42.1)</td>
<td>(31.3)</td>
<td>(36.6)</td>
<td>(33.2)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
TAPHONOMIC IMPACTS

The advantage of identifying taphonomic damage on core morphology is that it allows cores with taphonomically impacted morphological characteristics to be excluded from analyses. This ensures that observations of core morphology reflect the point at which reduction ceased and the cores were discarded, rather than the stage when modified by non-cultural factors. Observations of patterning of core morphology are filtered of biases introduced by taphonomy, a crucial consideration when proposing human behavioural interpretations at Bui Ceri Uato on the basis of the core artefacts in the assemblage. Taphonomic damage to cores can include impacts to core size (weight, length), rotation (the number of platforms) and flake scars (the percentage of non-flaked surface area and the amount of cortex) (see Appendix A).

Weight is the most sensitive to taphonomic damage. For instance, 116 or over 29% of cores have weight altered through the taphonomic loss of fragments of the core (Table 7.6). The recorded weight underestimates the mass of the core at the point where reduction ceased (Figure 7.3 and Table 7.7). This difference in mass between taphonomically impacted and non-impacted cores is sufficiently different to be statistically significant at the 5% level of probability (Table 7.8).

In contrast, taphonomic damage affecting core length, platforms counts, flaked surface area estimates and the amount of cortex sustained less impact to core morphology. For example, taphonomic damage to core length and platform counts affected only a minority of cores (n=29 or 7.3%, n=33 or 8.4%, respectively) (Table 7.6). Taphonomic damage tended to decrease length by removing fragments of stone.
material at the ends of the axis of measurement (Figure 7.4 and Table 7.7, see also Appendix A). However, differences in the length of cores taphonomically impacted compared with non-impacted counterparts are not sufficiently different to be statistically significant (Table 7.8). There is no real difference in platform counts between cores with and without taphonomic damage affecting this morphological characteristic (Figure 7.5, Tables 7.7 and 7.8). While 67 or 17% of cores have the percentage of non-flaked surface area estimate taphonomically affected (Table 7.6), differences in the amounts of flaked surfaces between taphonomically impacted and non-impacted cores are not statistically significant (Tables 7.9 and 7.10).

A minority of cores with cortex displayed partial removal of cortex by taphonomic impacts (n=16 or 8.9%, Table 7.6). Such impacted cores had some portion of cortex removed on heat spalls, with the result that estimates of the amount of cortex are undervalued. Comparisons between the amount of cortex on cores that have and have not had partial cortex removed by taphonomic impacts, however, do not show this trend (Tables 7.11 and 7.12). This may be explained by other (stronger) influencing factors including natural geological variation in the amount of cortex on the rock selected for knapping as well as the extent/length of core reduction that had taken place.
Table 7.6 Cores with taphonomically affected characteristics, Bui Ceri Uato

<table>
<thead>
<tr>
<th>Core counts</th>
<th>% of cores</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight</td>
<td>116</td>
</tr>
<tr>
<td>Length</td>
<td>29</td>
</tr>
<tr>
<td>Number of platforms</td>
<td>33</td>
</tr>
<tr>
<td>The percentage of non-flaked surface area</td>
<td>67</td>
</tr>
<tr>
<td>Of cores with cortex, the amount of cortex</td>
<td>16</td>
</tr>
<tr>
<td>Total*</td>
<td>116</td>
</tr>
</tbody>
</table>

Total is not the sum of weight, length, the percentage of non-flaked surface area estimate, the amount of cortex, and platform count taphonomically affected, because some cores have more than one morphological recording taphonomically affected.

Figure 7.3 Weight of cores with and without taphonomic impacts to mass

![Weight Taphonomically affected](image)
Figure 7.4 Length of cores with and without taphonomic impacts to length

Figure 7.5 Number of platforms with and without taphonomic impacts to platform counts
Table 7.7 Descriptive statistics comparing weight, length and number of platforms between cores with and without these respective characteristics taphonomically affected, Bui Ceri Uato

<table>
<thead>
<tr>
<th>Taphonomically affected</th>
<th>Weight (grms)</th>
<th>Length (mm)</th>
<th>Number of platforms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>12.9 ± 10.5</td>
<td>19.7 ± 6.2</td>
<td>5.3 ± 2.4</td>
</tr>
<tr>
<td>N=116</td>
<td>N=29</td>
<td>N=33</td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>23.4 ± 35.8</td>
<td>23.2 ± 8.4</td>
<td>5.1 ± 2.6</td>
</tr>
<tr>
<td>N=279</td>
<td>N=366</td>
<td>N=362</td>
<td></td>
</tr>
</tbody>
</table>

Table 7.8 t-test results comparing the difference in weight, length and number of platforms between cores with and without taphonomic impacts to these respective characteristics, Bui Ceri Uato

<table>
<thead>
<tr>
<th></th>
<th>$t$</th>
<th>df</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight</td>
<td>3.099</td>
<td>393</td>
<td>0.001 Significant</td>
</tr>
<tr>
<td>Length</td>
<td>2.182</td>
<td>393</td>
<td>0.486 Not significant</td>
</tr>
<tr>
<td>Number of platforms</td>
<td>-0.426</td>
<td>393</td>
<td>0.439 Not significant</td>
</tr>
</tbody>
</table>
Table 7.9 Amount of non-flaked surface area on cores with and without taphonomic impacts to estimates of non-flaked surface area, Bui Ceri Uato

<table>
<thead>
<tr>
<th>Taphonomically affected</th>
<th>0%</th>
<th>1-10%</th>
<th>11-20%</th>
<th>21-30%</th>
<th>31-40%</th>
<th>41-50%</th>
<th>51-60%</th>
<th>61-70%</th>
<th>71-80%</th>
<th>81-90%</th>
<th>91-&lt;100%</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>4 (6.0)</td>
<td>23 (34.3)</td>
<td>7 (10.4)</td>
<td>6 (9.0)</td>
<td>3 (4.5)</td>
<td>6 (9.0)</td>
<td>2 (3.0)</td>
<td>3 (4.5)</td>
<td>5 (7.5)</td>
<td>3 (4.5)</td>
<td>5 (7.5)</td>
<td>67 (100)</td>
</tr>
<tr>
<td>No</td>
<td>11 (3.4)</td>
<td>76 (23.2)</td>
<td>38 (11.6)</td>
<td>45 (13.7)</td>
<td>46 (14.0)</td>
<td>31 (9.5)</td>
<td>13 (4.0)</td>
<td>17 (5.2)</td>
<td>18 (5.5)</td>
<td>18 (5.5)</td>
<td>15 (4.6)</td>
<td>328 (100)</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>395</td>
</tr>
</tbody>
</table>

Table 7.10 Chi-square statistics comparing differences in the amount of non-flaked surface area between cores with and without taphonomic impacts to this characteristic, Bui Ceri Uato

<table>
<thead>
<tr>
<th>Percentage of non-flaked surface area</th>
<th>$X^2$</th>
<th>$df$</th>
<th>Significance</th>
<th>Cramer’s V</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>10.5</td>
<td>10</td>
<td>0.398</td>
<td>Not significant</td>
</tr>
</tbody>
</table>

Table 7.11 Amount of cortex on cores with and without taphonomic impacts to estimates of the amount of cortex, Bui Ceri Uato

<table>
<thead>
<tr>
<th>Amount of cortex</th>
<th>Core counts (% of cores)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cortex taphonomically removed</td>
<td>1-30%</td>
</tr>
<tr>
<td>Yes</td>
<td>14 (87.5)</td>
</tr>
<tr>
<td>No</td>
<td>109 (66.9)</td>
</tr>
<tr>
<td>Total</td>
<td></td>
</tr>
</tbody>
</table>

Table 7.12 Chi-square statistics for differences in the proportion of cores with varying amounts of cortex with and without cortex taphonomically removed, Bui Ceri Uato

<table>
<thead>
<tr>
<th>Amount of cortex (%)</th>
<th>$X^2$</th>
<th>$df$</th>
<th>Significance</th>
<th>Cramer’s V</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>4.705</td>
<td>2</td>
<td>0.095</td>
<td>Not significant</td>
</tr>
</tbody>
</table>
THERMAL FRACTURES WITH STONE MATERIALS

The relationship between thermal fractures with stone material is explored in this section in order to determine whether there are differences in the occurrence of thermal damage between cores of different raw materials.

With the exception of one obsidian core with both potlidding and convoluted surfaces, it was found that cores with thermal damage were only recognised on one raw material: chert. The core of silicified limestone and the core manufactured on volcanic material are free of thermal damage (Table 7.13, see Figure 7.1). This outcome is most likely explained by sample size whereby the overwhelming majority (379) of cores were manufactured from chert (Table 7.13).

Table 7.13 Core raw stone materials and thermal fractures, Bui Ceri Uato

<table>
<thead>
<tr>
<th>Thermal fractures</th>
<th>Number of cores (% of cores of each raw stone material)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Raw stone material</td>
</tr>
<tr>
<td></td>
<td>Chert</td>
</tr>
<tr>
<td>Crazing</td>
<td>89 (23.5)</td>
</tr>
<tr>
<td>Pot lid scars</td>
<td>117 (30.9)</td>
</tr>
<tr>
<td>Crenated fracture</td>
<td>3 (0.8)</td>
</tr>
<tr>
<td>Convoluted surfaces</td>
<td>45 (11.9)</td>
</tr>
<tr>
<td>Total</td>
<td>379</td>
</tr>
</tbody>
</table>

THERMAL FRACTURES WITH CORE SIZE

Larger sized rocks are more prone to thermal stress (i.e. to suffer from heat-fractures) than relatively smaller sized rocks (e.g. Mercieca, 2000; see also see Chapter 5 and Appendix A). Are cores with thermal fractures (crazing, pot lid scars and convoluted surfaces) larger than cores absent of such thermal damage at Bui Ceri Uato? This would identify bias in the occurrence of thermal damage in relation to core size. It is determined whether core size needs to be considered in evaluating the frequency of occurrence of cores with thermal damage. This is relevant to
interpretations of temporal trends in the frequency of fire/hearth use by humans occupying the shelter (outlined later in this chapter).

The size of cores with crazing, pot lid scars and convoluted surfaces are compared with cores without thermal fractures. Cores with crenated fracture are excluded due to small sample size (n=3, see Table 7.4). Indicators of core size include: weight, length, volume, surface area and surface area to weight ratio (see Appendix A). Cores with these indicators of size taphonomically affected are excluded from these comparisons (see Table 7.6). This is because such cores are undersized (i.e. weight and length are an underestimate of the size of the core at the point when reduction ceased) and may tend to distort comparisons of size between cores with and without thermal fractures.

It was found that cores with crazing, pot lid scars and convoluted surfaces are not larger than cores absent of such thermal damage. For instance, box-and-whisper plots Figures 7.6-7.10, 7.11-7.13, 7.14-7.16 and Table 7.14, compare weight, length, volume, surface area and surface area to weight ratio of cores with and without crazing, pot lid scars and convoluted surfaces, respectively. In all comparisons, cores with crazing, pot lid scars and convoluted surfaces are smaller or of a similar size range than those absent of such thermal damage. In some comparisons, the smaller size of cores with thermal fractures is significantly different (at the 5% level of probability) compared with their non-thermally damaged counterparts, as indicated by t-test results presented in Table 7.15.

These comparisons indicate that the size of a core has no apparent role in influencing the likelihood of acquiring thermal damage. This means that core size
can be excluded from considerations of the frequency of cores with thermal damage (assessed later in this chapter). Consequently, interpretations of the frequency of fire/hearth use (and, by extension, levels of human occupation of the shelter) formed on the basis of frequency of cores with heat damage can be made without consideration of core size as an influencing factor.

Figure 7.6 Crazing and weight, Bui Ceri Uato cores
Figure 7.7 Crazing and length, Bui Ceri Uato cores

Figure 7.8 Crazing and volume, Bui Ceri Uato cores
Figure 7.9 Crazing and surface area, Bui Ceri Uato cores

Figure 7.10 Crazing and surface area to weight ratio, Bui Ceri Uato cores
Figure 7.11 Pot lid scars and length, Bui Ceri Uato cores

Figure 7.12 Pot lid scars and volume, Bui Ceri Uato cores
Figure 7.13 Pot lid scars and surface area, Bui Ceri Uato cores

Figure 7.14 Convoluted surfaces and length, Bui Ceri Uato cores
Figure 7.15 Convoluted surfaces and volume, Bui Ceri Uato cores

Figure 7.16 Convoluted surfaces and surface area, Bui Ceri Uato cores
Table 7.14 Descriptive statistics of the size of cores with and without thermal fractures, Bui Ceri Uato

<table>
<thead>
<tr>
<th>Thermal fractures / Size</th>
<th>Weight (grms)</th>
<th>Length (mm)</th>
<th>Volume (cm³)</th>
<th>Surface area (mm²)</th>
<th>Surface area to weight ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Present</td>
<td>Absent</td>
<td>Present</td>
<td>Absent</td>
<td>Present</td>
</tr>
<tr>
<td>Crazed /</td>
<td>12.9 ± 5.6</td>
<td>23.9 ± 36.6</td>
<td>12.9 ± 5.6</td>
<td>23.9 ± 36.6</td>
<td>12.9 ± 5.6</td>
</tr>
<tr>
<td></td>
<td>N=13</td>
<td>N=266</td>
<td>N=13</td>
<td>N=266</td>
<td>N=13</td>
</tr>
<tr>
<td></td>
<td>20.7 ± 5.6</td>
<td>23.8 ± 8.8</td>
<td>20.7 ± 5.6</td>
<td>23.8 ± 8.8</td>
<td>20.7 ± 5.6</td>
</tr>
<tr>
<td></td>
<td>N=70</td>
<td>N=296</td>
<td>N=70</td>
<td>N=296</td>
<td>N=70</td>
</tr>
<tr>
<td></td>
<td>695.0 ± 487.6</td>
<td>1175.4 ± 1542.1</td>
<td>695.0 ± 487.6</td>
<td>1175.4 ± 1542.1</td>
<td>695.0 ± 487.6</td>
</tr>
<tr>
<td></td>
<td>N=70</td>
<td>N=296</td>
<td>N=70</td>
<td>N=296</td>
<td>N=70</td>
</tr>
<tr>
<td></td>
<td>1441.7 ± 794.2</td>
<td>2016.9 ± 1817.9</td>
<td>1441.7 ± 794.2</td>
<td>2016.9 ± 1817.9</td>
<td>1441.7 ± 794.2</td>
</tr>
<tr>
<td></td>
<td>N=70</td>
<td>N=296</td>
<td>N=70</td>
<td>N=296</td>
<td>N=70</td>
</tr>
<tr>
<td></td>
<td>119.2 ± 50.0</td>
<td>119.9 ± 64.5</td>
<td>119.2 ± 50.0</td>
<td>119.9 ± 64.5</td>
<td>119.2 ± 50.0</td>
</tr>
<tr>
<td></td>
<td>N=13</td>
<td>N=266</td>
<td>N=13</td>
<td>N=266</td>
<td>N=13</td>
</tr>
<tr>
<td></td>
<td>950.1 ± 1237.6</td>
<td>1129.7 ± 1470.9</td>
<td>950.1 ± 1237.6</td>
<td>1129.7 ± 1470.9</td>
<td>950.1 ± 1237.6</td>
</tr>
<tr>
<td></td>
<td>N=94</td>
<td>N=272</td>
<td>N=94</td>
<td>N=272</td>
<td>N=94</td>
</tr>
<tr>
<td></td>
<td>1773.1 ± 1735.8</td>
<td>1953.2 ± 1668.8</td>
<td>1773.1 ± 1735.8</td>
<td>1953.2 ± 1668.8</td>
<td>1773.1 ± 1735.8</td>
</tr>
<tr>
<td></td>
<td>N=94</td>
<td>N=272</td>
<td>N=94</td>
<td>N=272</td>
<td>N=94</td>
</tr>
<tr>
<td></td>
<td>120.5 ± 64.7</td>
<td>120.5 ± 64.7</td>
<td>120.5 ± 64.7</td>
<td>120.5 ± 64.7</td>
<td>120.5 ± 64.7</td>
</tr>
<tr>
<td></td>
<td>N=266</td>
<td>N=266</td>
<td>N=266</td>
<td>N=266</td>
<td>N=266</td>
</tr>
<tr>
<td>Pot lid scars</td>
<td>Present</td>
<td>Absent</td>
<td>Present</td>
<td>Absent</td>
<td>Present</td>
</tr>
<tr>
<td></td>
<td>*</td>
<td>22.7 ± 35.3</td>
<td>*</td>
<td>22.7 ± 35.3</td>
<td>*</td>
</tr>
<tr>
<td></td>
<td>N=262</td>
<td>N=272</td>
<td>N=262</td>
<td>N=272</td>
<td>N=262</td>
</tr>
<tr>
<td></td>
<td>22.3 ± 8.1</td>
<td>23.5 ± 8.4</td>
<td>22.3 ± 8.1</td>
<td>23.5 ± 8.4</td>
<td>22.3 ± 8.1</td>
</tr>
<tr>
<td></td>
<td>N=94</td>
<td>N=272</td>
<td>N=94</td>
<td>N=272</td>
<td>N=94</td>
</tr>
<tr>
<td></td>
<td>950.1 ± 1237.6</td>
<td>1129.7 ± 1470.9</td>
<td>950.1 ± 1237.6</td>
<td>1129.7 ± 1470.9</td>
<td>950.1 ± 1237.6</td>
</tr>
<tr>
<td></td>
<td>N=94</td>
<td>N=272</td>
<td>N=94</td>
<td>N=272</td>
<td>N=94</td>
</tr>
<tr>
<td></td>
<td>1773.1 ± 1735.8</td>
<td>1953.2 ± 1668.8</td>
<td>1773.1 ± 1735.8</td>
<td>1953.2 ± 1668.8</td>
<td>1773.1 ± 1735.8</td>
</tr>
<tr>
<td></td>
<td>N=94</td>
<td>N=272</td>
<td>N=94</td>
<td>N=272</td>
<td>N=94</td>
</tr>
<tr>
<td></td>
<td>120.5 ± 64.7</td>
<td>120.5 ± 64.7</td>
<td>120.5 ± 64.7</td>
<td>120.5 ± 64.7</td>
<td>120.5 ± 64.7</td>
</tr>
<tr>
<td></td>
<td>N=262</td>
<td>N=262</td>
<td>N=262</td>
<td>N=262</td>
<td>N=262</td>
</tr>
<tr>
<td></td>
<td>1795.1 ± 562.0</td>
<td>1111.2 ± 1468.7</td>
<td>1795.1 ± 562.0</td>
<td>1111.2 ± 1468.7</td>
<td>1795.1 ± 562.0</td>
</tr>
<tr>
<td></td>
<td>N=32</td>
<td>N=334</td>
<td>N=32</td>
<td>N=334</td>
<td>N=32</td>
</tr>
<tr>
<td></td>
<td>1572.2 ± 640.9</td>
<td>1939.0 ± 1750.6</td>
<td>1572.2 ± 640.9</td>
<td>1939.0 ± 1750.6</td>
<td>1572.2 ± 640.9</td>
</tr>
<tr>
<td></td>
<td>N=32</td>
<td>N=334</td>
<td>N=32</td>
<td>N=334</td>
<td>N=32</td>
</tr>
<tr>
<td></td>
<td>119.9 ± 63.8</td>
<td>119.9 ± 63.8</td>
<td>119.9 ± 63.8</td>
<td>119.9 ± 63.8</td>
<td>119.9 ± 63.8</td>
</tr>
<tr>
<td></td>
<td>N=279</td>
<td>N=279</td>
<td>N=279</td>
<td>N=279</td>
<td>N=279</td>
</tr>
</tbody>
</table>

* Are excluded from comparisons of size because thermal fractures (pot lids, convoluted surfaces) remove fragments of stone material and result in undersized cores.

Table 7.15 t-tests comparing the size of cores with and without thermal fractures, Bui Ceri Uato

<table>
<thead>
<tr>
<th>Between cores with and without:</th>
<th>t</th>
<th>df</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crazing</td>
<td>1.089</td>
<td>277</td>
<td>0.159 Not significant</td>
</tr>
<tr>
<td>Weight</td>
<td>2.809</td>
<td>364</td>
<td>0.011 Significant</td>
</tr>
<tr>
<td>Length</td>
<td>2.574</td>
<td>364</td>
<td>0.004 Significant</td>
</tr>
<tr>
<td>Volume</td>
<td>2.587</td>
<td>364</td>
<td>0.004 Significant</td>
</tr>
<tr>
<td>Surface area</td>
<td>0.042</td>
<td>277</td>
<td>0.437 Not significant</td>
</tr>
<tr>
<td>Surface area to weight ratio</td>
<td>0.023</td>
<td>364</td>
<td>Significant</td>
</tr>
<tr>
<td>Pot lid scars</td>
<td>1.135</td>
<td>364</td>
<td>0.280 Not significant</td>
</tr>
<tr>
<td>Length</td>
<td>1.061</td>
<td>364</td>
<td>0.363 Not significant</td>
</tr>
<tr>
<td>Volume</td>
<td>0.893</td>
<td>364</td>
<td>0.367 Not significant</td>
</tr>
<tr>
<td>Surface area</td>
<td>0.972</td>
<td>364</td>
<td>0.018 Significant</td>
</tr>
<tr>
<td>Convoluted surfaces</td>
<td>1.208</td>
<td>364</td>
<td>0.121 Not significant</td>
</tr>
<tr>
<td>Length</td>
<td>0.972</td>
<td>364</td>
<td>0.018 Significant</td>
</tr>
<tr>
<td>Volume</td>
<td>1.176</td>
<td>364</td>
<td>0.023 Significant</td>
</tr>
<tr>
<td>Surface area</td>
<td>1.023</td>
<td>364</td>
<td>Significant</td>
</tr>
</tbody>
</table>
THERMAL FRACTURES WITH CORE SHAPE

There is the expectation that thicker rocks are more likely to result in thermal fractures than thinner rocks (e.g. Mercieca, 1999: 60-62; see also Chapter 5 and Appendix A). Are cores with thermal fractures (crazing, pot lid scars and convoluted surfaces) thicker than cores absent of such thermal damage at Bui Ceri Uato? This would identify bias in the occurrence of thermal damage in relation to core shape. It is determined whether core shape needs to be considered in evaluating the frequency of occurrence of cores with thermal damage. This is relevant to interpretations of temporal trends in the frequency of fire/hearth use at Bui Ceri Uato (assessed later in this chapter).

The shape of cores with crazing, pot lid scars and convoluted surfaces are compared with core without thermal fractures. Indicators of core shape include: the parallel index measured at the midpoint and at the endpoint, relative thickness index and longitudinal thinness index measured at the midpoint and at the endpoint (see Appendix A).

It was found that cores with crazing, pot lid scars and convoluted surfaces are not thicker than cores absent of such taphonomic damage. For instance, Figures 7.17-7.21, 7.22-7.26 and 7.27-7.31 compare parallel index (at the midpoint and endpoint), the relative thickness index and longitudinal thinness index (at the midpoint and endpoint) of cores with and without crazing, pot lid scars and convoluted surfaces, respectively. These comparisons can also be observed in Table 7.16 where descriptive statistics on the shape of cores with and without thermal fractures are provided. $t$-test results provided in Table 7.17 show that differences in
shape between cores with and without thermal fractures are not statistically significant at the 5% level of probability. In all comparisons, cores with uncontrolled heating/cooling fractures are of similar shape with cores absent of thermal fractures.

These comparisons indicate that there is no obvious bias in the shape of cores with thermal damage at Bui Ceri Uato. That is to say, core shape has no apparent role in influencing the frequency of occurrence of cores with thermal damage. This means that core shape can be excluded from considerations of the frequency of taphonomic damage from uncontrolled exposure to heating/cooling. Consequently, interpretations of the frequency of fire/hearth use (and, by extension, levels of human occupation of the shelter) formed on the basis of the occurrence of cores with heat damage can be made without consideration of core shape as an influencing factor.

Figure 7.17 Crazing and parallel index at midpoint, Bui Ceri Uato cores
Figure 7.18 Crazing and parallel index at endpoint, Bui Ceri Uato cores

Figure 7.19 Crazing and relative thickness index, Bui Ceri Uato cores
Figure 7.20 Crazing and longitudinal thinness index at midpoint, Bui Ceri Uato cores

Figure 7.21 Crazing and longitudinal thinness index at endpoint, Bui Ceri Uato cores
Figure 7.22 Pot lid scars and parallel index at midpoint, Bui Ceri Uato cores

Figure 7.23 Pot lid scars and parallel index at endpoint, Bui Ceri Uato cores
Figure 7.24 Pot lid scars and relative thickness index, Bui Ceri Uato cores

Figure 7.25 Pot lid scars and longitudinal thinness index at midpoint, Bui Ceri Uato cores
Figure 7.26 Pot lid scars and longitudinal thinness index at endpoint, Bui Ceri Uato cores

Figure 7.27 Convoluted surfaces and parallel index at midpoint, Bui Ceri Uato cores
Figure 7.28 Convoluted surfaces and parallel index at endpoint, Bui Ceri Uato cores

Figure 7.29 Convoluted surfaces and relative thickness index, Bui Ceri Uato cores
Figure 7.30 Convoluted surfaces and longitudinal thinness index at midpoint, Bui Ceri Uato cores

Figure 7.31 Convoluted surfaces and longitudinal thinness index at endpoint, Bui Ceri Uato cores
Table 7.16 Descriptive statistics of the shape of cores with and without thermal fractures, Bui Ceri Uato

<table>
<thead>
<tr>
<th>Thermal fractures / shape</th>
<th>Parallel index midpoint</th>
<th>Parallel index endpoint</th>
<th>Relative thickness index midpoint</th>
<th>Relative thickness index endpoint</th>
<th>Longitudinal thinness index midpoint</th>
<th>Longitudinal thinness index endpoint</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crazed</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Present</td>
<td>1.2 ± 0.4</td>
<td>0.8 ± 0.5</td>
<td>1.2 ± 0.5</td>
<td>0.8 ± 0.7</td>
<td>1.2 ± 0.5</td>
<td>0.8 ± 0.7</td>
</tr>
<tr>
<td>N=89</td>
<td>N=89</td>
<td>N=89</td>
<td>N=89</td>
<td>N=89</td>
<td>N=89</td>
<td>N=89</td>
</tr>
<tr>
<td>Absent</td>
<td>1.1 ± 0.4</td>
<td>0.8 ± 0.4</td>
<td>1.2 ± 0.4</td>
<td>0.8 ± 0.7</td>
<td>1.2 ± 0.9</td>
<td>0.8 ± 0.8</td>
</tr>
<tr>
<td>N=305</td>
<td>N=305</td>
<td>N=305</td>
<td>N=305</td>
<td>N=305</td>
<td>N=305</td>
<td>N=305</td>
</tr>
<tr>
<td>Pot lid scars</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Present</td>
<td>1.2 ± 0.4</td>
<td>0.9 ± 0.5</td>
<td>1.2 ± 0.4</td>
<td>0.9 ± 0.7</td>
<td>1.2 ± 0.5</td>
<td>0.9 ± 0.7</td>
</tr>
<tr>
<td>N=118</td>
<td>N=118</td>
<td>N=118</td>
<td>N=118</td>
<td>N=118</td>
<td>N=118</td>
<td>N=118</td>
</tr>
<tr>
<td>Absent</td>
<td>1.1 ± 0.4</td>
<td>0.7 ± 0.4</td>
<td>1.2 ± 0.4</td>
<td>0.8 ± 0.8</td>
<td>1.2 ± 0.9</td>
<td>0.8 ± 0.8</td>
</tr>
<tr>
<td>N=276</td>
<td>N=276</td>
<td>N=276</td>
<td>N=276</td>
<td>N=276</td>
<td>N=276</td>
<td>N=276</td>
</tr>
<tr>
<td>Convoluted surfaces</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Present</td>
<td>1.3 ± 0.4</td>
<td>0.9 ± 0.5</td>
<td>1.2 ± 0.4</td>
<td>0.9 ± 0.7</td>
<td>1.2 ± 0.5</td>
<td>1.0 ± 0.9</td>
</tr>
<tr>
<td>N=46</td>
<td>N=46</td>
<td>N=46</td>
<td>N=46</td>
<td>N=46</td>
<td>N=46</td>
<td>N=46</td>
</tr>
<tr>
<td>Absent</td>
<td>1.2 ± 0.4</td>
<td>0.8 ± 0.4</td>
<td>1.2 ± 0.4</td>
<td>0.8 ± 0.8</td>
<td>1.2 ± 0.8</td>
<td>0.8 ± 0.8</td>
</tr>
<tr>
<td>N=348</td>
<td>N=348</td>
<td>N=348</td>
<td>N=348</td>
<td>N=348</td>
<td>N=348</td>
<td>N=348</td>
</tr>
</tbody>
</table>

Table 7.17 t-tests comparing the shape of cores with and without thermal fractures, Bui Ceri Uato

<table>
<thead>
<tr>
<th>Between cores with and without thermal damage</th>
<th>t</th>
<th>df</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crazing</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Parallel index midpoint</td>
<td>-1.684</td>
<td>392</td>
<td>0.185 Not significant</td>
</tr>
<tr>
<td>Parallel index endpoint</td>
<td>-1.664</td>
<td>392</td>
<td>0.194 Not significant</td>
</tr>
<tr>
<td>Relative thickness index midpoint</td>
<td>-0.249</td>
<td>392</td>
<td>0.330 Not significant</td>
</tr>
<tr>
<td>Relative thickness index endpoint</td>
<td>-0.239</td>
<td>392</td>
<td>0.515 Not significant</td>
</tr>
<tr>
<td>Longitudinal thinness index midpoint</td>
<td>-0.198</td>
<td>392</td>
<td>0.894 Not significant</td>
</tr>
<tr>
<td>Longitudinal thinness index endpoint</td>
<td>-0.198</td>
<td>392</td>
<td>0.894 Not significant</td>
</tr>
<tr>
<td>Pot lid scars</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Parallel index midpoint</td>
<td>-1.503</td>
<td>392</td>
<td>0.420 Not significant</td>
</tr>
<tr>
<td>Parallel index endpoint</td>
<td>-2.804</td>
<td>392</td>
<td>0.636 Not significant</td>
</tr>
<tr>
<td>Relative thickness index midpoint</td>
<td>-0.22</td>
<td>392</td>
<td>0.978 Not significant</td>
</tr>
<tr>
<td>Relative thickness index endpoint</td>
<td>-0.288</td>
<td>392</td>
<td>0.712 Not significant</td>
</tr>
<tr>
<td>Longitudinal thinness index midpoint</td>
<td>-0.865</td>
<td>392</td>
<td>0.921 Not significant</td>
</tr>
<tr>
<td>Longitudinal thinness index endpoint</td>
<td>-0.865</td>
<td>392</td>
<td>0.921 Not significant</td>
</tr>
<tr>
<td>Convoluted surfaces</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Parallel index midpoint</td>
<td>-1.600</td>
<td>392</td>
<td>0.459 Not significant</td>
</tr>
<tr>
<td>Parallel index endpoint</td>
<td>-2.440</td>
<td>392</td>
<td>0.679 Not significant</td>
</tr>
<tr>
<td>Relative thickness index midpoint</td>
<td>0.880</td>
<td>392</td>
<td>0.765 Not significant</td>
</tr>
<tr>
<td>Relative thickness index endpoint</td>
<td>-0.329</td>
<td>392</td>
<td>0.809 Not significant</td>
</tr>
<tr>
<td>Longitudinal thinness index midpoint</td>
<td>-1.249</td>
<td>392</td>
<td>0.590 Not significant</td>
</tr>
<tr>
<td>Longitudinal thinness index endpoint</td>
<td>-1.249</td>
<td>392</td>
<td>0.590 Not significant</td>
</tr>
</tbody>
</table>
TEMPORAL TRENDS IN THERMAL DAMAGE

The frequency of occurrence of cores with thermal damage in each subgroup is discussed in terms of temporal trends in levels of human use of fire/hearth at Bui Ceri Uato. Involved in this discussion are sedimentation rates, since the length of time a core is exposed on or near the ground surface will be positively related to the probability of damage being sustained (Hiscock, 2005: 218). That is, there is an inverse relationship between sedimentation rates and the likelihood of incurring thermal damage. Other considerations such as core size and shape are not discussed further. The previous section of this chapter showed that larger sized cores were not more likely to incur thermal damage and that core shape had no apparent role in influencing the occurrence of thermal damage.

Along with sedimentation and flaked stone artefact discard rates (see Chapter 6), the frequency of occurrence of cores with thermal damage at Bui Ceri Uato provides a further indication of relative levels of human occupation of the shelter. This is based on the reasoning that cores with taphonomic damage such as those produced by uncontrolled exposure to heat (crazing, pot lid scars, crenated fracture and convoluted surfaces) were incidental, most likely caused by close proximity to campfires lit inside the shelter. Higher frequencies of cores with uncontrolled heat fractures may be interpreted as greater use of fire and, thus, a further indication of levels of human use of the shelter. Trends in the frequency of occurrence of cores with thermal damage, sedimentation rates and flaked stone artefact discard rates observed in Subgroups 1, 2, 3 and 4 (see Chapter 6) are discussed to provide an overall perspective on relative levels of human occupation of Bui Ceri Uato. In this
way, levels of human occupation of Bui Ceri Uato shelter can be compared in the comparatively earlier Pleistocene, terminal Pleistocene, early Holocene and Holocene periods.

THE OCCURRENCE OF CORES WITH THERMAL DAMAGE

The frequency of occurrence of cores with thermal damage in each subgroup is calculated per cubic metre of deposit per 1,000 years and presented in Table 7.18. These calculations are based on the dated sequence obtained by the present study (Appendix E) and standardise differences in the total number of cores and duration of each subgroup (see Table 6.1), and volume of deposit (derived from Glover, 1986: Table 38).

The frequency of occurrence of cores with thermal damage (crazing, pot lid scars and convoluted surfaces) is highest in Subgroup 3 in the early Holocene, followed by Subgroup 2 at the terminal Pleistocene. There are comparatively very low frequencies of cores with thermal damage in Subgroups 1 and 4 in the comparatively earlier Pleistocene and spanning the majority of the Holocene. This pattern can be observed with all heat fractures, with the exception of crenated fracture which can be explained by very small sample size (see Table 7.4).

The relatively high frequency of occurrence of cores with thermal damage in Subgroups 3 and 2 are in parallel with relatively greater rates of sedimentation at Bui Ceri Uato, as shown in Figure 7.32 (see also Chapter 6). This conjunction of sedimentation rates and frequency of occurrence of cores with uncontrolled heating/cooling fractures is the opposite of what would be expected if thermal damage was proportional to the duration of exposure on the floor of the shelter.
(Hiscock, 2005: 218). This suggests that there was a relatively high level of human use of fire/hearth within the shelter in the early Holocene and at the terminal Pleistocene.

In comparison, there is a very low frequency of occurrence of cores with thermal damage in Subgroups 1 and 4, in parallel with low rates of sedimentation (Figure 7.32). This suggests that there were relatively low levels of human use of fire/hearth within the shelter in the initial Pleistocene phase of occupation as well as spanning the majority of the Holocene.

Table 7.18 The frequency of occurrence of cores with thermal damage (# per m$^3$ per 1,000 years) and subgroups, Bui Ceri Uato

<table>
<thead>
<tr>
<th>Heat-fracture / Subgroup</th>
<th>Number of cores with thermal damage per m$^3$ per 1,000 years as a proportion of cores in each subgroup (log scale)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Crazing</td>
<td>0.60</td>
</tr>
<tr>
<td>Pot lid scars</td>
<td>1.264</td>
</tr>
<tr>
<td>Crenated fracture</td>
<td>0.212</td>
</tr>
<tr>
<td>Convoluted surfaces</td>
<td>0.316</td>
</tr>
<tr>
<td>Inclusive of all thermal fractures</td>
<td>1.368</td>
</tr>
<tr>
<td></td>
<td>(0.136)</td>
</tr>
</tbody>
</table>
TEMPORAL TRENDS IN RELATIVE LEVELS OF HUMAN OCCUPATION

Subgroups 2 and 3 contain the highest frequency of cores with thermal damage (see Table 7.18 and Figure 7.32), relatively high sedimentation rates and flaked stone artefact discard rates (see Chapter 6). These synchronous trends suggest that human occupation of Bui Ceri Uato was relatively intense at the terminal Pleistocene/early Holocene boundary. It may be that this period encompassed intensive human occupation of the Baucau Plateau after the Last Glacial Maximum,
when the coastline receded with rising sea levels and climatic conditions had ameliorated (see Chapter 2).

In comparison, the frequency of occurrence of cores with thermal damage (see Table 7.18 and Figure 7.32), sedimentation rates and flaked stone artefact discard rates (see Chapter 6) are relatively low in Subgroups 1 and 4. This suggests relatively low levels of human occupation of Bui Ceri Uato shelter in the initial Pleistocene phase of occupation and spanning the majority of the Holocene.

In considering these temporal trends in relative levels of human occupation of Bui Ceri Uato, are limitations introduced by the broad chronological resolution of deposits at the shelter. Further radiocarbon dating is needed to refine the nature and timing of initial Pleistocene occupation of the shelter. The possibility that mid to late Holocene-aged deposits may have been partially removed from the shelter also requires further validation by radiocarbon dating materials located in upper levels. For these reasons, sedimentation and flaked stone artefact discard rates calculated by the present study at the site may only be considered in terms a broad level of resolution.

Despite these chronological resolution limitations, however, synchronous patterns in the frequency of occurrence of cores with thermal damage, sedimentation and flaked stone artefact discard rates in Subgroups 1 and 4 compared with Subgroups 2 and 3 indicate broad trends of relative levels of human occupation of Bui Ceri Uato in the comparatively earlier Pleistocene, terminal Pleistocene, early Holocene and spanning the majority of the Holocene. These trends will be compared with assessments of relative levels of the extent/length of core reduction in these
respective periods in Chapter 9 of the present study. Prior to such an undertaking, the nature of the core technology is explored to investigate relationships between technological variables which may influence the extent/length of core reduction.
CHAPTER 8

TECHNOLOGICAL VARIABLES INFLUENCING CORE REDUCTION

The relationship between technological variables such as chert quality and heat-treatment with the extent/length of core reduction is explored. This may indicate human behavioural decision-making responses/considerations in the procurement and heat-treatment of chert nodules as well as the in the core reduction process. These explorations also determine whether chert quality and heat-treatment influenced the extent/length to which cores were reduced at Bui Ceri Uato. If so, temporal changes in the extent/length of core reduction (assessed Chapter 9) may be related to the manipulation of material transport costs and changes in the frequency of occurrence of heat-treated cores. Prior to these assessments, however, sampling considerations require discussion and include cores of various stone materials and those with taphonomic damage.

SAMPLING CONSIDERATIONS

STONE MATERIALS

The present study considers raw stone material type relevant to assessments of the extent/length of core reduction. This is based on the reasoning that stone such as chert, obsidian, volcanic material and silicified limestone possess different
mechanical properties and that this is relevant to defining the constraints of the material in knapping activities (see Chapter 5). For this reason, the approach adopted was that core reduction should be assessed on cores of each type of raw stone material at Bui Ceri Uato.

A total of 379 chert cores were identified by the present study at Bui Ceri Uato and these form the basis of assessments of core reduction. Cores of obsidian, volcanic and silicified limestone were excluded from further analyses on the basis of small sample size (see Table 7.3). Only the extent/length of reduction of chert cores are assessed.

**TAPHONOMICALLY IMPACTED CORES**

Chert cores with taphonomic damage affecting recorded values of size (mass and length), rotation (the number of platforms and flake scar directions) and flake scars (the total number of flake scars, the percentage of non-flaked surface area and the amount of cortex) were excluded from analyses involving these morphological attributes and summarised in Table 8.1. In this way, assessments of the extent/length of core reduction could be observed removed of biases potentially created by taphonomic impacts.

<table>
<thead>
<tr>
<th>Taphonomically affected recordings of</th>
<th>Excluded from analyses of core:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight</td>
<td>Weight</td>
</tr>
<tr>
<td></td>
<td>Core surface area to weight ratio</td>
</tr>
<tr>
<td>Length</td>
<td>Length</td>
</tr>
<tr>
<td></td>
<td>Volume</td>
</tr>
<tr>
<td></td>
<td>Surface area</td>
</tr>
<tr>
<td></td>
<td>Surface area to weight ratio</td>
</tr>
<tr>
<td>Platform counts</td>
<td>Number of platforms</td>
</tr>
<tr>
<td>Non-flaked surface area</td>
<td>Non-flaked surface area</td>
</tr>
<tr>
<td></td>
<td>Total number of flake scars</td>
</tr>
<tr>
<td></td>
<td>The number of flake scar directions</td>
</tr>
<tr>
<td>Amount of cortex</td>
<td>Amount of cortex</td>
</tr>
</tbody>
</table>
INDICATORS OF THE EXTENT OF CORE REDUCTION

Three main morphological indicators of the extent/length of core reduction were adopted. These include core size, rotation and flake scars.

SIZE

Stone knapping is a reductive process which means that core size becomes smaller with further reduction. Therefore, one indication of the extent/length of core reduction is the size of the core. Measures of core size recorded by the present study include weight, length, volume, surface area and surface area to weight ratio (see Appendix A).

The initial size of the raw material available for knapping, however, may range from small pebbles to large cobbles and hence may influence core size. A further consideration of core size as an indicator of the extent/length of core reduction is the rate at which size diminishes with reduction. For example, the relationship between core size and further reduction may not necessarily be linear (see Clarkson, 2004: 195). For these reasons, size alone is not a reliable indicator of the length/extent of the reduction of a core and other morphological characteristics also need to be considered.

ROTATION

Another indicator of the extent/length of core reduction is the number of rotations. Measures of core rotation recorded by the present study include the number of platforms and the number of flake scar directions (see Appendix A). With
further reduction a core may be expected to be rotated more frequently and display a
greater number of platforms and flake scar directions.

Yet, a core may be reduced by striking flakes from only a single platform, as
illustrated in Figure 8.1. Of further consideration, the number of rotations may be
indicative of attempts made by the knapper to avoid irregularities such as those
produced by step/hinge terminations and stacking on the core face (see Chapter 5).
For these reasons, the number of rotations may not be singularly regarded as a
reliable indication of the extent/length of core reduction.

![Figure 8.1 Core reduction with (a) no rotations and (b) two rotations](image)

(a) A single platform: flakes removed along the short axis by blows placed on the flat
cortical surface
(b) Core reduction with two platforms: flakes removed along the long axis by blows placed
on the conchoidal surface created by flaking off one end of the nodule
(Adapted from Hiscock, 1988: Figure 6:1)

**FLAKE SCARS**

Flake scars also provide information on the extent/length of core reduction.

With further reduction, more flake scars are created on the core face. This would be
indicated by higher numbers of flakes scars and lower areas of non-flaked surfaces.
Measures of flakes scars recorded by the present study include the number of flakes scars, the percentage of non-flaked surface area and the amount of cortex (estimated as a proportion of the surface area of the core) (see Appendix A).

Cores with the same number of flake scars may have variable estimates of the percentage of non-flaked surface area. This is because the size of the flake scars influences the percentage of non-flaked surface area. For example, larger flake scars may result in a smaller non-flaked surface area estimate compared with another core with the same number of flake scars of smaller size. This relationship between flake scar counts and the percentage of non-flaked surface area is illustrated in Figure 8.2, and may suggest that the amount of non-flaked surface area is a more reliable indicator of the extent/length of core reduction than numbers of flake scars.

If the external surface of the core contains cortex, then it would be expected that with further reduction there would be a decrease in the amount of cortex (as a proportion of core surface area). With even further core reduction, cortex may be removed altogether. However, the amount of cortex initially present on a chert nodule selected for knapping may naturally vary. This may range from a complete absence of cortex (whereby the external surface of the chert nodule is comprised entirely of patina) to external surfaces completely covered in cortex. For this reason, the amount of cortex may not be a reliable comparison of the extent/length of reduction between cores. In contrast, the percentage of non-flaked surface area may be regarded as a comparatively more reliable indicator of the extent/length of core reduction. This is because the percentage of non-flaked surface area divides the core surface into flaked and non-flaked areas (whereby non-flaked surface areas comprise
cortex and/or patinated surfaces). Unlike the amount of cortex, the nature of the external surface of the chert nodule prior to reduction is inconsequential to the percentage of non-flaked surface area as an indicator of the extent/length of core reduction.

Figure 8.2 The relationship between flake scar count and the percentage of non-flaked surface area
(a) Three small flake scars and a correspondingly large non-flaked surface area
(b) Three large flake scars and a correspondingly smaller non-flaked surface area
(non-flaked surface area is illustrated in grey)

These morphological indicators of the extent/length of core reduction are summarised in Table 8.2.

Table 8.2 Trends in core morphology indicative of further reduction

<table>
<thead>
<tr>
<th>Core morphology</th>
<th>Measurement/estimation/count</th>
<th>Trend</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size</td>
<td>Weight</td>
<td>Decrease</td>
</tr>
<tr>
<td></td>
<td>Length</td>
<td>Decrease</td>
</tr>
<tr>
<td></td>
<td>Volume</td>
<td>Decrease</td>
</tr>
<tr>
<td></td>
<td>Surface area</td>
<td>Decrease</td>
</tr>
<tr>
<td></td>
<td>Surface area to weight ratio</td>
<td>Increase</td>
</tr>
<tr>
<td>Rotation</td>
<td>Number of platforms</td>
<td>Increase</td>
</tr>
<tr>
<td></td>
<td>Number of flake scar directions</td>
<td>Increase</td>
</tr>
<tr>
<td>Flake scars</td>
<td>Total number of flake scars</td>
<td>Increase</td>
</tr>
<tr>
<td></td>
<td>Non-flaked surface area</td>
<td>Decrease</td>
</tr>
<tr>
<td></td>
<td>Amount of cortex</td>
<td>Decrease</td>
</tr>
</tbody>
</table>
SENSITIVITY/RESPONSIVENESS WITH CORE REDUCTION

It is reasonable to assume that there is not an equivalent level of responsiveness or sensitivity displayed by size, rotation and flake scars with the extent/length of core reduction. Rather, the sensitivity of these morphological indicators of the extent/length of core reduction is likely not only to vary between the other but also at various stages of reduction due to some of the technological considerations outlined above. It is reasonable to expect that size and the percentage of non-flaked surface area are likely to be more responsive or sensitive indicators of the extent/length of core reduction compared with rotation and percent of cortex. Quantitative experiments investigating the responsiveness/sensitivity of size, rotation and flake scars with core reduction would clarify these relationships in assessments of the extent/length of core reduction, and would be able to express these relationships objectively. In the absence of such quantitative studies specifically addressing the morphological characteristics listed in Table 8.2, statistical significance assessments comparing the extent/length of reduction of cores at Bui Ceri Uato are limited by the relatively different levels of sensitivity that these morphological indicators are likely to exhibit between the other and at different stages of core reduction.

CHERT QUALITY

The quality of chert cores at Bui Ceri Uato are assessed and may provide an understanding of stone material selection preferences adopted by humans occupying the shelter.
Morphological indicators of chert quality recorded by the present study include the homogeneity of the material, ‘smooth’ or ‘rough’ textured flake scar surfaces, the presence of macroscopically visible cracks and a grading of ‘good’, ‘medium’ and ‘poor’ chert (these groupings are somewhat subjective and are described further in Appendix A). Quality assessments of chert quality are presented in Tables 8.3, 8.4, 8.5 and 8.6, respectively.

The majority of cores (n=260, 68.6%) have macroscopically visible cracks (Table 8.5). However, cracking also results from thermal damage such as crazing (see Appendix A). This means it is not possible to distinguish the presence/absence of macroscopically visible cracks in terms of raw material considerations adopted by humans in procuring chert nodules for knapping activities versus taphonomic damage on cores. Consequently, the presence/absence of macroscopically visible cracks is not a very reliable indicator of raw material quality.

It was found that the majority (n=205, 54.1%) of the cores are of homogenous chert with ‘smooth’ flake scar surfaces (n=353, 93.1%) and of ‘good’ chert (n=249, 65.7%) (Tables 8.3, 8.4 and 8.6). A smaller proportion (n=105, 27.7%) comprised ‘medium’ chert and only a minority (n=25, 6.6%) are of ‘poor’ chert or have ‘rough’ textured flake scar surfaces (n=26, 6.9%) (Tables 8.4 and 8.6). These morphological indicators of chert quality suggest that humans were preferentially selecting better quality chert material over the range of those available from the surrounding Bobonaro Scaly Clays.

<table>
<thead>
<tr>
<th>Table 8.3 Homogeneity, Bui Ceri Uato cores</th>
</tr>
</thead>
<tbody>
<tr>
<td>Homogeneity</td>
</tr>
<tr>
<td>Homogenous</td>
</tr>
<tr>
<td>Not-homogenous</td>
</tr>
<tr>
<td>Total</td>
</tr>
</tbody>
</table>
Table 8.4 Texture of flake scar surfaces, Bui Ceri Uato cores

<table>
<thead>
<tr>
<th>Texture</th>
<th>Core counts</th>
<th>% cores</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smooth</td>
<td>353</td>
<td>93.1</td>
</tr>
<tr>
<td>Rough</td>
<td>26</td>
<td>6.9</td>
</tr>
<tr>
<td>Total</td>
<td>379</td>
<td>100</td>
</tr>
</tbody>
</table>

Table 8.5 Macroscopically visible cracks, Bui Ceri Uato cores

<table>
<thead>
<tr>
<th>Cracks</th>
<th>Core counts</th>
<th>% cores</th>
</tr>
</thead>
<tbody>
<tr>
<td>Present</td>
<td>260</td>
<td>68.6</td>
</tr>
<tr>
<td>Absent</td>
<td>119</td>
<td>31.4</td>
</tr>
<tr>
<td>Total</td>
<td>379</td>
<td>100</td>
</tr>
</tbody>
</table>

Table 8.6 Grade of chert, Bui Ceri Uato cores

<table>
<thead>
<tr>
<th>Grade</th>
<th>Core counts</th>
<th>% cores</th>
</tr>
</thead>
<tbody>
<tr>
<td>Good</td>
<td>249</td>
<td>65.7</td>
</tr>
<tr>
<td>Medium</td>
<td>105</td>
<td>27.7</td>
</tr>
<tr>
<td>Poor</td>
<td>25</td>
<td>6.6</td>
</tr>
<tr>
<td>Total</td>
<td>379</td>
<td>100</td>
</tr>
</tbody>
</table>

CHERT QUALITY AND CORE REDUCTION

There is the expectation that cores of higher quality chert material may be reduced to a greater extent than cores of lower quality chert. This expectation is based on the reasoning that a mass of higher quality chert material would facilitate more controlled knapping outcomes than a mass of lesser quality chert material (see Chapter 5 and also Appendix A). Does chert quality have a role in the extent/length to which cores were reduced at Bui Ceri Uato?

One way of investigating the relationship between chert quality and core reduction is to compare the extent/length of reduction of chert cores of ‘good’, ‘medium’ and ‘poor’ grade quality chert. These comparisons are assessed in three parts. In the first part, core size as an indicator of the extent/length of reduction is contrasted between cores of ‘good’, ‘medium’ and ‘poor’ grade chert. Morphological indicators of core size recorded by the present study include weight,
length, volume, core surface area and surface area to weight ratio (Table 8.2, see also Appendix A).

In the second part, core rotation as an indicator of the extent/length of core reduction is compared between cores of ‘good’, ‘medium’ and ‘poor’ grade chert. Morphological indicators of core rotation recorded by the present study include the number of platforms and the number of flake scar directions (Table 8.2, see also Appendix A).

In the third part, flake scars as an indicator of the extent/length of core reduction are compared between cores of ‘good’, ‘medium’, and ‘poor’ quality chert. Morphological indicators of flake scars recorded by the present study include the total number of flakes scars, the percentage of non-flaked surface area and the amount of cortex (Table 8.2, see also Appendix A).

Cores with taphonomic damage to morphological recordings are omitted from these comparisons. In this way, the extent/length of reduction of cores of ‘good’, ‘medium’ and ‘poor’ grade chert are contrasted, removed of taphonomic bias.

CHERT QUALITY AND CORE SIZE

On the basis of core size, higher quality chert cores at Bui Ceri Uato underwent further reduction. It was found that core size has a strong inverse relationship the higher the grade of quality chert. That is, an increase from ‘poor’ to ‘medium’ to ‘good’ grade chert is associated with a decline in values of core weight, length, volume and surface area. This is illustrated in the box-and-whisper plots Figures 8.3, 8.4, 8.5 and 8.6, which show a marked decline in the median (the
central-most line in the box) and the inter-quartile range (shown by the box) values of core weight, length, volume and surface area with higher quality chert. The surface area to weight ratio shows the reverse trend and increases with higher grade chert, as observed in Figure 8.7. These trends indicate greater reduction of higher quality chert cores.

Cores of 'poor' quality chert show a skewed distribution to the right in weight, volume and surface area (Figures 8.3, 8.5 and 8.6). This may be explained by a sharp drop off in size at the point where reduction was discontinued. In contrast, cores of 'medium' and 'good' grade chert show a more even spread in size above and below the median.

This decline in core size with higher grades of chert quality is also shown in Table 8.7, where the mean values of core weight, length, volume and surface area decrease from 'poor' to 'medium' to 'good' grade chert, and increase with the surface area to weight ratio. On the whole, comparisons between core size with chert quality are statistically significant. This can be observed in t-test results presented in Table 8.8. For instance, differences in the mean weight and mean length between 'good' and 'poor' grade chert cores, and 'medium' and 'poor' grade chert cores, are statistically significant (Table 8.8). Core volume and surface area are statistically significant at the 5% probability level between cores of 'good', 'medium' and 'poor' grade chert (Table 8.8). This suggests that there is a 95% probability that the difference in volume and surface area between cores in each quality grading is not an outcome of the vagrancies of chance. However, the difference between the mean
weight as well as length between cores of 'good' and 'medium' grade chert are not statistically significant at the 5% probability level.

The surface area to weight ratio increases from 'poor' to 'medium' to 'good' grade chert, as observed in Figure 8.7 and Table 8.7. This indicates a continuous reduction in core size (see Table 8.2 and Appendix A). However, differences in surface area to weight ratio between 'good', 'medium' and 'poor' grades are not statistically significant (Table 8.8). This may indicate that the surface area to weight ratio is not as comparatively sensitive to changes in core size as other measures such as weight, length, volume and surface area.

In essence, the size of cores when discarded was smaller for specimens made with higher grade chert than specimens made with lower grade chert. On the whole, this relationship is statistically significant. This relationship is indicated by most attributes related to core size (weight, length, volume and surface area). Trends in the core surface area to weight ratio also show a decrease in core size with increasing grades of chert quality, but this measure of core size was not sufficiently sensitive to be statistically significant. These analyses indicate that cores of higher quality chert are reduced further than those of lesser quality chert.
Figure 8.3 Weight and grades of chert quality, Bui Ceri Uato cores

Figure 8.4 Length and grades of chert quality, Bui Ceri Uato cores
Figure 8.5 Volume and grades of chert quality, Bui Ceri Uato cores

Figure 8.6 Surface area and grades of chert quality, Bui Ceri Uato cores
Figure 8.7 Surface area to weight ratio and grades of chert quality, Bui Ceri Uato cores

Table 8.7 Size of ‘good’, ‘medium’ and ‘poor’ grade chert cores, Bui Ceri Uato

<table>
<thead>
<tr>
<th>Grade</th>
<th>Weight (grms)</th>
<th>Length (mm)</th>
<th>Volume (cm³)</th>
<th>Surface area (mm²)</th>
<th>Surface area to weight ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Good</td>
<td>18.5 ± 20.0</td>
<td>21.8 ± 7.0</td>
<td>857.6 ± 861.8</td>
<td>1,646.4 ± 1145.3</td>
<td>121.5 ± 52.8</td>
</tr>
<tr>
<td></td>
<td>N=162</td>
<td>N=227</td>
<td>N=226</td>
<td>N=227</td>
<td>N=161</td>
</tr>
<tr>
<td>Medium</td>
<td>25.0 ± 18.8</td>
<td>24.8 ± 7.7</td>
<td>1,278.9 ± 1027.0</td>
<td>2,107.2 ± 1332.1</td>
<td>107.2 ± 53.6</td>
</tr>
<tr>
<td></td>
<td>N=181</td>
<td>N=99</td>
<td>N=99</td>
<td>N=99</td>
<td>N=81</td>
</tr>
<tr>
<td>Poor</td>
<td>58.1 ± 103.6</td>
<td>31.9 ± 15.3</td>
<td>2,522.1 ± 3911.1</td>
<td>3,894.4 ± 4337.7</td>
<td>105.4 ± 72.9</td>
</tr>
<tr>
<td></td>
<td>N=21</td>
<td>N=24</td>
<td>N=24</td>
<td>N=24</td>
<td>N=21</td>
</tr>
</tbody>
</table>

Table 8.8 t-test results comparing differences in size between cores of ‘good’, ‘medium’ and ‘poor’ grade chert, Bui Ceri Uato

<table>
<thead>
<tr>
<th></th>
<th>t</th>
<th>df</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Good – Medium</td>
<td>-2.453</td>
<td>241</td>
<td>0.242 Not significant</td>
</tr>
<tr>
<td>Good – Poor</td>
<td>-4.357</td>
<td>181</td>
<td>0.001 Significant</td>
</tr>
<tr>
<td>Medium – Poor</td>
<td>-2.744</td>
<td>100</td>
<td>0.000 Significant</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Length</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Good – Medium</td>
<td>-3.391</td>
<td>324</td>
<td>0.149 Not significant</td>
</tr>
<tr>
<td>Good – Poor</td>
<td>-5.793</td>
<td>249</td>
<td>0.001 Significant</td>
</tr>
<tr>
<td>Medium – Poor</td>
<td>-3.265</td>
<td>121</td>
<td>0.003 Significant</td>
</tr>
<tr>
<td></td>
<td>( \text{Volume} )</td>
<td>( n )</td>
<td>( p )</td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Good - Medium</td>
<td>-3.819</td>
<td>323</td>
<td>0.026 Significant</td>
</tr>
<tr>
<td>Good - Poor</td>
<td>-5.360</td>
<td>248</td>
<td>0.001 Significant</td>
</tr>
<tr>
<td>Medium - Poor</td>
<td>-2.817</td>
<td>121</td>
<td>0.001 Significant</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>( \text{Surface area} )</th>
<th>( n )</th>
<th>( p )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Good - Medium</td>
<td>-3.175</td>
<td>324</td>
<td>0.032 Significant</td>
</tr>
<tr>
<td>Good - Poor</td>
<td>-6.120</td>
<td>249</td>
<td>0.001 Significant</td>
</tr>
<tr>
<td>Medium - Poor</td>
<td>-3.508</td>
<td>121</td>
<td>0.001 Significant</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>( \text{Surface area to weight ratio} )</th>
<th>( n )</th>
<th>( p )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Good - Medium</td>
<td>1.976</td>
<td>240</td>
<td>0.854 Not significant</td>
</tr>
<tr>
<td>Good - Poor</td>
<td>1.251</td>
<td>180</td>
<td>0.095 Not significant</td>
</tr>
<tr>
<td>Medium - Poor</td>
<td>0.126</td>
<td>100</td>
<td>0.123 Not significant</td>
</tr>
</tbody>
</table>

**CHERT QUALITY AND CORE ROTATION**

On the basis of core rotation, higher grade chert cores at Bui Ceri Uato underwent further reduction. It was found that the number of platforms and flake scar directions increase with chert quality. That is, cores of 'poor' to 'medium' to 'good' quality chert are associated with an increase in the number of platforms and flake scar directions. This can be illustrated in box-and-whisper plots Figures 8.8 and 8.9, which show an increase in the median, the inter-quartile range and whiskers in the number of platforms and flake scar directions, respectively, on cores of 'poor' to 'medium' to 'good' quality chert. The mean of the number of platforms and flake scar directions increase from 'poor' to 'medium' to 'good' quality chert cores (Table 8.9). As noted with the size of chert cores, these trends are also indicative of greater reduction of higher quality chert cores.

On the whole, the difference between the mean of the number of platforms and flake scar directions between cores in each quality grade are statistically significant. This can be observed in \( t \)-tests results presented in Table 8.10. For instance, the difference between the mean number of platforms between 'good' and
‘medium’, ‘good’ and ‘poor’, and ‘medium’ and ‘poor’ quality chert cores are statistically significant at the 5% probability level. This suggests that there is a 95% probability that the number of platforms on cores in each quality grading are different (i.e. are not random or result from chance alone). The difference in the mean of the number of flake scar directions on cores of ‘good’ quality chert with ‘medium’ and ‘poor’ grades is statistically significant at the 5% probability level (Table 8.10). The exception is the number of flake scar directions between cores of ‘medium’ and ‘poor’ grade chert quality, which is not sufficiently different to be statistically significant (Table 8.10).

![Figure 8.8 Number of platforms and grades of chert quality, Bui Ceri Uato cores](image)
Figure 8.9 Number of flake scar directions and grades of chert quality, Bui Ceri Uato cores

Table 8.9 Number of platforms and flake scar directions on ‘good’, ‘medium’ and ‘poor’ quality chert cores, Bui Ceri Uato

<table>
<thead>
<tr>
<th>Grade</th>
<th>Number of platforms</th>
<th>Number of flake scar directions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Good</td>
<td>5.7 ± 2.6 N=224</td>
<td>5.1 ± 2.3 N=197</td>
</tr>
<tr>
<td>Medium</td>
<td>4.2 ± 2.1 N=99</td>
<td>3.9 ± 1.8 N=95</td>
</tr>
<tr>
<td>Poor</td>
<td>3.0 ± 1.5 N=24</td>
<td>3.1 ± 1.5 N=21</td>
</tr>
</tbody>
</table>

Table 8.10 t-test results comparing the number of platforms and flake scar directions between cores of ‘good’, ‘medium’ and ‘poor’ grade chert, Bui Ceri Uato

<table>
<thead>
<tr>
<th></th>
<th>t</th>
<th>df</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of platforms</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Good – Medium</td>
<td>5.069</td>
<td>321</td>
<td>0.004 Significant</td>
</tr>
<tr>
<td>Good – Poor</td>
<td>4.816</td>
<td>246</td>
<td>0.001 Significant</td>
</tr>
<tr>
<td>Medium – Poor</td>
<td>2.425</td>
<td>121</td>
<td>0.025 Significant</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Number of flake scar directions</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Good – Medium</td>
<td>4.428</td>
<td>290</td>
<td>0.020 Significant</td>
</tr>
<tr>
<td>Good – Poor</td>
<td>4.062</td>
<td>216</td>
<td>0.012 Significant</td>
</tr>
<tr>
<td>Medium – Poor</td>
<td>2.048</td>
<td>114</td>
<td>0.140 Not significant</td>
</tr>
</tbody>
</table>
CHERT QUALITY AND Flake SCARS

An analysis of the number of flake scars and flake scar area also suggests that chert quality influences the extent of core reduction. For instance, the total number of flake scars is suggestive of further reduction of cores of ‘good’ grade chert compared with cores of ‘medium’ and ‘poor’ grades. This can be observed in Figure 8.10 and Table 8.11, which show that the total number of flake scars increase with ‘good’ quality chert. The difference in the mean of the total number of flake scars between ‘good’ and ‘medium’ grade chert cores is statistically significant at the 5% probability level, as observed from t-test results in Table 8.12. However, the difference between the total number of flake scars between cores of ‘good’ and ‘poor’ quality chert is not statistically significant, but this may be an outcome of the small sample size of ‘poor’ grade chert cores (Table 8.11).

A higher proportion of cores of ‘good’ as well as ‘medium’ grade chert display low percentages of non-flaked surface areas compared with ‘poor’ grade chert cores. This is also suggestive of further reduction of cores of higher quality chert. For instance, the percentage of non-flaked surface area tends to be low on the majority of cores of ‘good’ grade chert, and increases with ‘medium’ to ‘poor’ grade chert cores. This can be observed in Table 8.13. This trend is statistically significant, as observed by chi-square tests presented in Table 8.14. Cramer’s V (which ranges from 0-1, indicating increasing strength of the relationship) indicates that the difference between ‘good’, ‘medium’ and ‘poor’ quality chert in estimates of non-flaked surface area is reasonably strong (Tables 8.14).
In contrast, the amount of cortex is not indicative of further reduction with higher grade chert. For instance, the proportion of cores of ‘good’, ‘medium’ and ‘poor’ grade chert with varying amounts of cortex are similar, as observed in Tables 8.15, 8.16 and 8.17. However, as discussed earlier in this chapter, the amount of cortex is not considered to be a reliable indicator of the extent/length of reduction between cores. This is simply because the amount of cortex originally on the core nodule may naturally vary and thus affect the amount of cortex displayed on the core once reduction ceased.

![Box plot showing the total number of flake scars and grades of chert, Bui Ceri Uato cores](image)

Figure 8.10 The total number of flake scars and grades of chert, Bui Ceri Uato cores
Table 8.11 The total number of flake scars on ‘good’, ‘medium’ and ‘poor’ grade chert cores, Bui Ceri Uato

<table>
<thead>
<tr>
<th>Grade quality</th>
<th>Total number of flake scars</th>
<th>Mean, standard deviation and sample size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Good</td>
<td>16.6 ± 8.3</td>
<td>N=197</td>
</tr>
<tr>
<td>Medium</td>
<td>11.8 ± 6.7</td>
<td>N=95</td>
</tr>
<tr>
<td>Poor</td>
<td>10.3 ± 6.6</td>
<td>N=21</td>
</tr>
</tbody>
</table>

Table 8.12 t-test results comparing the number of flake scars between cores of ‘good’, ‘medium’ and ‘poor’ grade chert, Bui Ceri Uato

<table>
<thead>
<tr>
<th>Total number of flake scars</th>
<th>t</th>
<th>df</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Good – Medium</td>
<td>4.886</td>
<td>290</td>
<td>0.039 Significant</td>
</tr>
<tr>
<td>Good – Poor</td>
<td>3.349</td>
<td>216</td>
<td>0.396 Not significant</td>
</tr>
<tr>
<td>Medium – Poor</td>
<td>0.930</td>
<td>114</td>
<td>0.778 Not significant</td>
</tr>
</tbody>
</table>

Table 8.13 Percentage of non-flaked surface area and ‘good’, ‘medium’ and ‘poor’ grade of cores, Bui Ceri Uato

<table>
<thead>
<tr>
<th>Grade quality / % non-flaked surface area</th>
<th>0-20</th>
<th>21-40</th>
<th>41-60</th>
<th>61-80</th>
<th>81-&lt;100</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Good</td>
<td>101 (51.3)</td>
<td>52 (26.4)</td>
<td>24 (12.2)</td>
<td>10 (5.1)</td>
<td>10 (5.1)</td>
<td>197 (100)</td>
</tr>
<tr>
<td>Medium</td>
<td>17 (17.9)</td>
<td>31 (32.6)</td>
<td>13 (13.7)</td>
<td>20 (21.1)</td>
<td>14 (14.7)</td>
<td>95 (100)</td>
</tr>
<tr>
<td>Poor</td>
<td>2 (9.5)</td>
<td>4 (19.0)</td>
<td>4 (19.0)</td>
<td>4 (19.0)</td>
<td>7 (33.3)</td>
<td>21 (100)</td>
</tr>
<tr>
<td>Total</td>
<td>313</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 8.14 Chi-square statistics for differences in the percentage of non-flaked surface area between cores of ‘good’, ‘medium’ and ‘poor’ grade chert, Bui Ceri Uato

<table>
<thead>
<tr>
<th>Percentage of non-flaked surface area</th>
<th>X²</th>
<th>df</th>
<th>Significance</th>
<th>Cramer’s V</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>60.7</td>
<td>8</td>
<td>0.001 Significant</td>
<td>0.311</td>
</tr>
</tbody>
</table>

Table 8.15 Amount of cortex on cores of ‘good’ and ‘medium’ grade chert, Bui Ceri Uato

<table>
<thead>
<tr>
<th>Grade quality / Amount of cortex (%)</th>
<th>0</th>
<th>1-30</th>
<th>31-60</th>
<th>61-&lt;100</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Good</td>
<td>138 (58.0)</td>
<td>70 (29.4)</td>
<td>29 (12.2)</td>
<td>1 (0.4)</td>
<td>238 (100)</td>
</tr>
<tr>
<td>Medium</td>
<td>52 (51.5)</td>
<td>29 (28.7)</td>
<td>17 (16.8)</td>
<td>3 (3.0)</td>
<td>101 (100)</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>339</td>
</tr>
</tbody>
</table>
Table 8.16 Chi-square statistics for differences in the proportion of cores with varying amounts of cortex in ‘good’ and ‘medium’ grade chert, Bui Ceri Uato

<table>
<thead>
<tr>
<th>Amount of cortex (%)</th>
<th>Grade quality</th>
<th>$\chi^2$</th>
<th>df</th>
<th>Significance</th>
<th>Cramer’s V</th>
</tr>
</thead>
<tbody>
<tr>
<td>Good – Medium</td>
<td>5.584</td>
<td>3</td>
<td>0.134</td>
<td>Not significant</td>
<td>0.128</td>
</tr>
</tbody>
</table>

Table 8.17 Amount of cortex on cores of ‘poor’ grade chert, Bui Ceri Uato*

<table>
<thead>
<tr>
<th>Core counts (%)</th>
<th>Grade quality / Amount of cortex (%)</th>
<th>0</th>
<th>1-30</th>
<th>31-60</th>
<th>61–&lt;100</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Poor</td>
<td></td>
<td>12 (55.6)</td>
<td>8 (33.3)</td>
<td>4 (16.7)</td>
<td>0 (0)</td>
<td>24 (100)</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>24</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* It was not possible to conduct chi-square tests comparing the amount of cortex on ‘poor’ grade chert cores with those of ‘good’ and ‘medium’ grades due to the absence of ‘poor’ grade cores with cortex greater than 60% of core surface area.

HEAT-TREATMENT

Quantitative assessments of heat-treated chert cores within ‘good’, ‘medium’ and ‘poor’ grading categories are undertaken. This may provide an understanding of stone material selection criteria adopted by humans at Bui Ceri Uato in considering chert nodules for heat-treatment.

The present study recorded the occurrence of heat-treated chert by contrasting flake scar surfaces with natural surfaces on the cores (see Chapter 5 and Appendix A). These contrasts were framed within a wider context on the basis of comparisons of freshly fractured surfaces on geological chert nodules collected by the author from Bobonaro Scaly Clays in the Baucau-Laga region of East Timor.

It was found that the majority (n=214, 56.5%) of the chert cores were heat-treated, as shown in Table 8.18. It was also found that the proportion of heat-treated cores increase with higher grades of quality chert. For instance, 28% of ‘poor’ grade chert cores are heat-treated, and increases to 40% of cores of ‘medium’ quality, with a majority of 66.3% of cores of ‘good’ grade chert having undergone heat-treatment.
Furthermore, these proportional differences in the number of heat-treated and non-heat-treated cores of ‘good’, ‘medium’ and ‘poor’ grade chert are statistically significant and unlikely to be the result of chance, as observed in the chi-square test results presented in Table 8.19.

This positive relationship between heat-treated cores with higher grades of chert suggests that only the most homogenous chert material, with smooth flake scar surfaces and low occurrence of macroscopically visible cracks were selected for heat-treatment. This implies that the knappers at the shelter were aware of the inherent advantage of better quality chert material and preferentially selected such chert nodules for heat-treatment.

<table>
<thead>
<tr>
<th>Grade of chert</th>
<th>Core counts (%)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Heat-treated</td>
<td></td>
<td></td>
</tr>
<tr>
<td>'Good'</td>
<td>165 (66.3)</td>
<td></td>
</tr>
<tr>
<td>'Medium'</td>
<td>42 (40.0)</td>
<td></td>
</tr>
<tr>
<td>'Poor'</td>
<td>7 (28.0)</td>
<td></td>
</tr>
<tr>
<td>'Total'</td>
<td>214 (56.5)</td>
<td></td>
</tr>
<tr>
<td>Non-heat-treated</td>
<td></td>
<td></td>
</tr>
<tr>
<td>'Good'</td>
<td>84 (33.7)</td>
<td></td>
</tr>
<tr>
<td>'Medium'</td>
<td>63 (60.0)</td>
<td></td>
</tr>
<tr>
<td>'Poor'</td>
<td>18 (72.0)</td>
<td></td>
</tr>
<tr>
<td>'Total'</td>
<td>165 (43.5)</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>249 (100)</td>
<td>105 (100)</td>
</tr>
<tr>
<td></td>
<td>25 (100)</td>
<td>379 (100)</td>
</tr>
</tbody>
</table>

Table 8.19 Chi-square statistics for differences in the proportion of heat-treated cores of ‘good’, ‘medium’ and ‘poor’ grade chert, Bui Ceri Uato

<table>
<thead>
<tr>
<th>Amount of cortex (%)</th>
<th>X²</th>
<th>df</th>
<th>Significance</th>
<th>Cramer’s V</th>
</tr>
</thead>
<tbody>
<tr>
<td>Good – Medium – Poor</td>
<td>29.548</td>
<td>2</td>
<td>0.001</td>
<td>0.279</td>
</tr>
</tbody>
</table>

HEAT-TREATMENT AND CORE REDUCTION

There is the expectation that heat-treated cores may have undergone further reduction than non-heat-treated cores, simply because heat-treatment improves the knappability of chert (see Chapter 5). Are heat-treated cores more reduced than non-heat-treated cores at Bui Ceri Uato?
One way to determine whether heat-treated cores are reduced further than their non-heat-treated counterparts is to compare morphological indicators of the extent or length of reduction (see Table 8.2) between heat-treated and non-heat-treated cores. Core size, rotation and flake scars as indicators of the extent/length of core reduction are contrasted between heat-treated and non-heat-treated cores (see Table 8.2 and also Appendix A). As in the previous analysis, cores with taphonomic damage to morphological recordings are excluded from these comparisons (see Table 8.1).

HEAT-TREATMENT AND CORE SIZE

There is a tendency for heat-treated cores to be smaller in size than their non-heat-treated counterparts. These findings are illustrated in the box-and-whisper plots Figures 8.11-8.15, which show a decline in the median (the central-most line in the box), the inter-quartile range (shown by the box) and whiskers in values of core weight, length, volume and surface area and an increase in the surface area to weight ratio between non-heat-treated and heat-treated cores at Bui Ceri Uato. The mean values of core weight, length, volume and surface area of heat-treated cores are lower than their non-heat-treated counterparts and the reverse of this trend is exhibited by surface area to core ratio (Table 8.20). Volume and surface area measures of core size show statistically significant differences between heat-treated and non-heat-treated cores at the 5% probability level. This can be observed in $t$-test results presented in Table 8.21.

All measures of core size indicate that heat-treated cores are smaller than their non-heat-treated counterparts. Volume and surface area measure show
statistically significant differences in size between heat-treated and non heat-treated cores. On the basis of core size, this is suggestive of further reduction of heat-treated cores compared with non-heat-treated counterparts.

Figure 8.11 Weight and heat-treatment, Bui Ceri Uato cores

Figure 8.12 Length and heat-treatment, Bui Ceri Uato cores
Figure 8.13 Volume and heat-treatment, Bui Ceri Uato cores

Figure 8.14 Surface area and heat-treatment, Bui Ceri Uato cores
Figure 8.15 Surface area to weight ratio and heat-treatment, Bui Ceri Uato cores

Table 8.20 Indicators of size and heat-treatment, Bui Ceri Uato cores

<table>
<thead>
<tr>
<th>Indicators of core size</th>
<th>Mean, standard deviation and sample size</th>
<th>Heat-treated</th>
<th>Non-heat-treated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight (grms)</td>
<td></td>
<td>18.1 ± 42.5</td>
<td>28.7 ± 27.3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>N=127</td>
<td>N=137</td>
</tr>
<tr>
<td>Length (mm)</td>
<td></td>
<td>21.2 ± 7.6</td>
<td>25.9 ± 8.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>N=193</td>
<td>N=158</td>
</tr>
<tr>
<td>Volume (cm³)</td>
<td></td>
<td>812.6 ± 1,370.7</td>
<td>1,423.7 ± 1,371.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>N=193</td>
<td>N=158</td>
</tr>
<tr>
<td>Surface area (mm²)</td>
<td></td>
<td>1,598.6 ± 1,551.6</td>
<td>2,341.2 ± 1,797.9</td>
</tr>
<tr>
<td></td>
<td></td>
<td>N=193</td>
<td>N=158</td>
</tr>
<tr>
<td>Surface area to weight ratio</td>
<td></td>
<td>125.6 ± 55.7</td>
<td>107.4 ± 53.6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>N=127</td>
<td>N=137</td>
</tr>
</tbody>
</table>

Table 8.21 t-test results comparing differences in size between heat-treated and non-heat-treated cores, Bui Ceri Uato

<table>
<thead>
<tr>
<th></th>
<th>t</th>
<th>df</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight</td>
<td>2.422</td>
<td>262</td>
<td>0.177 Not significant</td>
</tr>
<tr>
<td>Length</td>
<td>5.442</td>
<td>349</td>
<td>0.144 Not significant</td>
</tr>
<tr>
<td>Volume</td>
<td>4.155</td>
<td>349</td>
<td>0.007 Significant</td>
</tr>
<tr>
<td>Surface area</td>
<td>4.152</td>
<td>349</td>
<td>0.021 Significant</td>
</tr>
<tr>
<td>Surface area to weight ratio</td>
<td>-2.696</td>
<td>262</td>
<td>0.383 Not significant</td>
</tr>
</tbody>
</table>
HEAT-TREATMENT AND CORE ROTATION

Heat-treated cores have higher platform counts and flake scar directions than their non-heat-treated counterparts. This can be illustrated in Figures 8.16 and 8.17 and Table 8.22, which compare the number of platforms and flake scar directions between heat-treated and non-heat-treated cores. However, this slight increase in rotation is not sufficient to be statistically significant 5% probability level (Table 8.23).

Figure 8.16 Number of platforms and heat-treatment, Bui Ceri Uato cores
Figure 8.17 Number of flake scar directions and heat-treatment, Bui Ceri Uato cores

Table 8.22 Number of platforms and flake scar directions on heat-treated and non-heat-treated cores, Bui Ceri Uato

<table>
<thead>
<tr>
<th></th>
<th>Heat-treated</th>
<th>Non-heat-treated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of platforms</td>
<td>5.5 ± 2.8</td>
<td>4.6 ± 2.4</td>
</tr>
<tr>
<td>N=192</td>
<td>N=155</td>
<td></td>
</tr>
<tr>
<td>Number of flake scar directions</td>
<td>4.9 ± 2.3</td>
<td>4.2 ± 2.0</td>
</tr>
<tr>
<td>N=163</td>
<td>N=150</td>
<td></td>
</tr>
</tbody>
</table>

Table 8.23 t-test results comparing the number of platforms and flake scar directions between heat-treated and non-heat-treated cores, Bui Ceri Uato

<table>
<thead>
<tr>
<th></th>
<th>t</th>
<th>df</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of platforms</td>
<td>-3.096</td>
<td>345</td>
<td>0.181 Not significant</td>
</tr>
<tr>
<td>Number of flake scar directions</td>
<td>-2.949</td>
<td>311</td>
<td>0.112 Not significant</td>
</tr>
</tbody>
</table>

HEAT-TREATMENT AND FLAKE SCARS

Heat-treated cores display slightly higher total number of flake scar counts compared with non-heat-treated counterparts (Figure 8.18 and Table 8.24). However, the difference in flake scar counts between heat-treated and non-heat-treated cores is not statistically significant (Table 8.25).
A more convincing indication of greater reduction of heat-treated cores is depicted by the percentage of non-flaked surface area. Table 8.26 shows a higher proportion of heat-treated cores with low amounts of non-flaked surface area, compared with non-heat-treated counterparts. Chi-square test results show that these proportional differences are statistically significant at the 5% probability level (Table 8.27).

The majority of heat-treated cores are absent of cortex and/or contain less than 21% of cortex as a proportion of their surface area (Table 8.28). In comparison, a greater proportion of non-heat-treated cores display higher amounts of cortex. Furthermore, the differences in the proportion of heat-treated and non-heat-treated cores with varying amounts of cortex are statistically significant (Table 8.29). As mentioned previously in this chapter, the amount of cortex is a less reliable indicator of the extent/length of reduction compared with other morphological attributes adopted in this study. Consequently, it is more reasonable to speculate that these statistically significant differences in cortex are reflective of physical characteristic preferences adopted by humans in selecting chert nodules for heat-treatment rather than differences in the extent/length of reduction between heat-treated and non heat-treated cores. That is, these patterns may indicate that chert nodules with naturally lower amounts of cortex were preferentially selected for heat-treatment by humans occupying Bui Ceri Uato.
Figure 8.18 The total number of flake scars and heat-treatment, Bui Ceri Uato cores

Table 8.24 Total number of flake scars on heat-treated and non-heat-treated cores, Bui Ceri Uato

<table>
<thead>
<tr>
<th></th>
<th>Mean, standard deviation and sample size</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Heat-treated</td>
</tr>
<tr>
<td>Total number of flake scars</td>
<td>15.8 ± 8.0</td>
</tr>
<tr>
<td>N</td>
<td>163</td>
</tr>
</tbody>
</table>

Table 8.25 t-test results comparing the total number of flake scars between heat-treated and non-heat-treated cores, Bui Ceri Uato

<table>
<thead>
<tr>
<th></th>
<th>t</th>
<th>df</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total number of flake scars</td>
<td>-2.567</td>
<td>311</td>
<td>0.887 Not significant</td>
</tr>
</tbody>
</table>
Table 8.26 Percentage of non-flaked surface area on heat-treated and non-heat-treated cores, Bui Ceri Uato

<table>
<thead>
<tr>
<th>% n-f sa</th>
<th>0</th>
<th>1-10</th>
<th>11-20</th>
<th>21-30</th>
<th>31-40</th>
<th>41-50</th>
<th>51-60</th>
<th>61-70</th>
<th>71-80</th>
<th>81-90</th>
<th>91-&lt;100</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>H-t</td>
<td>9 (5.5)</td>
<td>53 (32.5)</td>
<td>19 (11.7)</td>
<td>23 (14.1)</td>
<td>20 (12.3)</td>
<td>14 (8.6)</td>
<td>6 (3.7)</td>
<td>8 (4.9)</td>
<td>5 (3.1)</td>
<td>4 (2.5)</td>
<td>2 (1.2)</td>
<td>163</td>
</tr>
<tr>
<td>Not h-t</td>
<td>1 (0.7)</td>
<td>19 (12.7)</td>
<td>19 (12.7)</td>
<td>21 (14.0)</td>
<td>23 (15.3)</td>
<td>15 (10.0)</td>
<td>6 (4.0)</td>
<td>9 (6.0)</td>
<td>12 (8.0)</td>
<td>13 (8.7)</td>
<td>12 (8.0)</td>
<td>150</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>313</td>
</tr>
</tbody>
</table>

Table 8.27 Chi-square statistics for differences in the percentage of non-flaked surface area between heat-treated and non-heat-treated cores, Bui Ceri Uato

<table>
<thead>
<tr>
<th>Percentage of non-flaked surface area</th>
<th>$\chi^2$</th>
<th>df</th>
<th>Significance</th>
<th>Cramer's V</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heat-treated – Non-heat-treated</td>
<td>37.163</td>
<td>10</td>
<td>0.001</td>
<td>0.345</td>
</tr>
</tbody>
</table>

Table 8.28 Amount of cortex on heat-treated and non-heat-treated cores, Bui Ceri Uato

<table>
<thead>
<tr>
<th>Amount of cortex (%)</th>
<th>0</th>
<th>1-20</th>
<th>21-30</th>
<th>41-&lt;100</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heat-treated</td>
<td>127 (62.6)</td>
<td>52 (25.6)</td>
<td>18 (8.9)</td>
<td>6 (3.0)</td>
<td>203 (100)</td>
</tr>
<tr>
<td>Non-heat-treated</td>
<td>75 (46.9)</td>
<td>36 (22.5)</td>
<td>31 (19.4)</td>
<td>18 (11.3)</td>
<td>160 (100)</td>
</tr>
<tr>
<td>Total</td>
<td>363</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 8.29 Chi-square statistics for differences in the amount of cortex between heat-treated and non-heat-treated cores, Bui Ceri Uato

<table>
<thead>
<tr>
<th>Amount of cortex (%)</th>
<th>$\chi^2$</th>
<th>df</th>
<th>Significance</th>
<th>Cramer's V</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heat-treated – Non-heat-treated</td>
<td>20.944</td>
<td>3</td>
<td>0.001</td>
<td>0.240</td>
</tr>
</tbody>
</table>
HEAT-TREATMENT AND CORE REDUCTION

There is a tendency for heat-treated cores to be smaller than their non heat-treated counterparts, to be more rotated and have lower amounts of non-flaked surfaces. These morphological indicators of the extent/length of reduction were not in most cases sufficiently different between heat-treated and non-heat-treated cores to be statistically significant at the 5% level of probability. For instance, only volume and surface area (as measures of core size) and percentage of cortex as well as non-flaked surface area were statistically different at the 5% level of probability. However, when considered within the 20% level of probability the overwhelming majority of morphological indicators of the extent/length of reduction display a statistical difference in the reduction of heat-treated compared with non heat-treated cores. These include weight, length, number of platforms and flake scar directions. In addition, is the quantitatively unknown level of responsiveness/sensitivity of these morphological indicators of core reduction and at progressive stages of reduction. Framed in this context, it is reasonable to interpret the consistently smaller core size, increased rotation and flake scar areas of heat-treated cores in terms of further reduction compared with their non heat-treated counterparts. That is, that heat-treated cores are more reduced compared with their non heat-treated counterparts at Bui Ceri Uato.

The statistically significant difference in the amount of cortex between heat-treated and non heat-treated cores may not only be explained by further reduction of the former, but by a physical consideration and preferential selection of nodules free of cortex on the part of humans occupying Bui Ceri Uato in prehistory. For instance,
cortex is absent on the majority of heat-treated cores. Of those heat-treated cores with cortex, less than 21% of their surface area contains cortex. While this may be explained by further core reduction of heat-treated cores, an additional explanation may be the preferential selection of chert nodules with minimal amounts of cortex for heat-treatment.

These assessments show that heat-treatment is a contributing influence on the extent/length of core reduction at Bui Ceri Uato. However, this influence remains comparatively marginal to chert quality which remains the dominant technological factor influencing the extent/length of reduction of cores at the shelter.

**CONCLUSION**

In this chapter, human behavioural decisions involved in the procurement of chert nodules and in the process of core reduction at Bui Ceri Uato were investigated. The quality of chert material and the process of heat-treatment were found to influence the extent/length of reduction of cores at the shelter. It was found that chert quality has a comparatively strong influence on the extent/length to which cores were reduced, and that heat-treatment was a comparatively marginal technological influence on the extent/length of core reduction undertaken by humans occupying Bui Ceri Uato in prehistory. In the next chapter, temporal trends in the extent/length of core reduction are investigated.
CHAPTER 9

TEMPORAL TRENDS

Temporal changes in chert core quality, the extent/length of reduction and the occurrence of heat-treated cores at Bui Ceri Uato are investigated. Temporal trends in chert quality may be indicative of relative changes in selection pressure experienced by humans in procuring chert nodules for reduction. Chronological changes in the extent/length of core reduction and the frequency of occurrence of heat-treated cores may provide insight into relative levels of necessity for flaked stone experienced by humans occupying the site. These temporal trends are assessed spanning the earliest human occupation of the shelter through to the more recent past.

First, the number and proportion of chert cores assigned to each subgroup are provided, followed by a cautionary note of the limitations of subgroups in the detection of temporal changes to core morphology at Bui Ceri Uato.

SUBGROUPS

Chert cores are combined into Subgroups 1, 2, 3 and 4 in order to assess temporal trends in stone material quality, the extent/length of core reduction and the frequency occurrence of heat-treated chert cores at Bui Ceri Uato.

The number and proportion of chert cores in each subgroup are presented in Table 9.1. Subgroups are arranged with Subgroup 1 at the base of the trench, and extend through to Subgroup 4 at the trench surface. Subgroup 1 is dated to the comparatively earlier Pleistocene and contains 38 chert cores or 10.0% of the
total chert core artefact assemblage at Bui Ceri Uato. Subgroup 2 dates to the
terminal Pleistocene and contains 211 cores or 55.7% of the chert core
assemblage. Subgroup 3 is dated to the early Holocene and contains 50 cores or
13.2% of the core assemblage. Subgroup 4 spans the Holocene and contains 80
cores or 21.1% of chert cores. The number of chert cores in each subgroup is
sufficiently large to be amenable to statistical testing.

<table>
<thead>
<tr>
<th>Subgroup</th>
<th>Broad timeframe</th>
<th>Number of cores</th>
<th>% of chert cores</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>Holocene</td>
<td>80</td>
<td>21.1</td>
</tr>
<tr>
<td>3</td>
<td>Early Holocene</td>
<td>50</td>
<td>13.2</td>
</tr>
<tr>
<td>2</td>
<td>Terminal Pleistocene</td>
<td>211</td>
<td>55.7</td>
</tr>
<tr>
<td>1</td>
<td>Comparatively earlier Pleistocene</td>
<td>38</td>
<td>10.0</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>379</td>
<td>100</td>
</tr>
</tbody>
</table>

A major consideration affecting observations of temporal trends in core
morphology at Bui Ceri Uato is that subgroups are arbitrary constructs, created
where the author divided the cultural deposits at Bui Ceri Uato based on the
rationale outlined in Chapter 6. Subgroups 1, 2, 3 and 4 do not represent naturally
occurring divides in the range of variation displayed by cores from the base to
the surface of the trench. The way in which deposits were excavated, combined
into horizons (see Chapter 3) and subsequently subgroups very likely resulted in
inter-mixing and to dilute observable temporal changes in core morphology (see
Chapter 6). This is a real and serious consideration. For this reason, not
significant statistical test results comparing cores in each subgroup are not
strictly and singularly adhered to in observations/interpretations of temporal
changes of the cores at Bui Ceri Uato.
TEMPORAL TRENDS IN CHERT QUALITY

Temporal trends in the quality of the chert comprising cores at Bui Ceri Uato are assessed and may be indicative of relative changes in chert material selection pressure spanning the period of earliest human occupation of the site through to the more recent past.

Quality assessments of the chert include homogeneity, texture and grade (see Appendix A). The presence/absence of macroscopically visible cracks as an indicator of chert quality is omitted, as the present study was unable to differentiate between cracks inherent to the raw material versus those caused from taphonomic impacts such as thermal damage (see Chapter 8 and also Appendix A). Quality assessments and associated chi-square tests are presented in Tables 9.2, 9.3, 9.4, 9.5, 9.6 and 9.7.

Broad comparisons suggest that cores in Subgroup 1 generally contained comparatively higher proportions of cores of lower quality chert, whereas those in Subgroup 3 contained comparatively higher proportions of cores of higher quality chert. However, these temporal trends in chert quality are not statistically significant. Yet, given the problem of dilution of temporal trends in core morphology faced by subgroups in dividing the deposit of the shelter these broad comparisons in subgroup chert quality are interpreted in terms of subtle changes in the stone material selection pressure spanning human occupation at the site.

Subgroup 1 consists of higher proportions of lower quality chert compared with Subgroups 2, 3 and 4. This is displayed by consistently lower percentages of cores of homogenous and ‘good’ grade chert and higher percentages of cores with ‘rough’ textured flaked surfaces (Tables 9.2, 9.4 and 9.6). While these proportional differences are not statistically significant (Tables
9.3, 9.5, 9.7) the broadly inter-mixed nature of subgroups across the deposit may act to obscure temporal trends in core morphology, particularly if these trends are subtle.

The comparatively higher proportions of ‘good’ quality chert comprising cores in Subgroups 3 and, along with Subgroup 4, of cores of homogenous chert and of ‘smooth’ flaked surfaces, may indicate that there was greater selection pressure in the procurement of stone material by humans at Bui Ceri Uato in the Holocene. This may suggest that humans may have been comparatively more selective in procuring quality chert nodules for knapping during the early Holocene than other periods of occupation of the shelter.

Table 9.2 Homogeneity and subgroups, Bui Ceri Uato cores

<table>
<thead>
<tr>
<th>Subgroup</th>
<th>Homogenous</th>
<th>Not-homogenous</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>39 (48.8)</td>
<td>41 (51.3)</td>
<td>80 (100)</td>
</tr>
<tr>
<td>3</td>
<td>24 (48.0)</td>
<td>26 (52.0)</td>
<td>50 (100)</td>
</tr>
<tr>
<td>2</td>
<td>98 (46.4)</td>
<td>113 (53.6)</td>
<td>211 (100)</td>
</tr>
<tr>
<td>1</td>
<td>13 (34.2)</td>
<td>25 (65.8)</td>
<td>38 (100)</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td>379</td>
</tr>
</tbody>
</table>

Table 9.3 Chi-square statistics comparing homogeneity between subgroups, Bui Ceri Uato cores

<table>
<thead>
<tr>
<th>Homogeneity and subgroups</th>
<th>$X^2$</th>
<th>df</th>
<th>Significance</th>
<th>Cramer’s V</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2.467</td>
<td>3</td>
<td>0.481 Not significant</td>
<td>0.081</td>
</tr>
</tbody>
</table>

Table 9.4 Texture of flake scar surfaces and subgroups, Bui Ceri Uato cores

<table>
<thead>
<tr>
<th>Subgroup</th>
<th>Smooth</th>
<th>Rough</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>77 (96.3)</td>
<td>3 (3.8)</td>
<td>80 (100)</td>
</tr>
<tr>
<td>3</td>
<td>48 (96.0)</td>
<td>2 (4.0)</td>
<td>50 (100)</td>
</tr>
<tr>
<td>2</td>
<td>194 (91.9)</td>
<td>17 (8.1)</td>
<td>211 (100)</td>
</tr>
<tr>
<td>1</td>
<td>34 (89.5)</td>
<td>4 (10.5)</td>
<td>38 (100)</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td>379</td>
</tr>
</tbody>
</table>

Table 9.5 Chi-square statistics comparing the texture of flake scar surfaces between subgroups, Bui Ceri Uato cores

<table>
<thead>
<tr>
<th>Texture of flake scar surfaces and subgroups</th>
<th>$X^2$</th>
<th>df</th>
<th>Significance</th>
<th>Cramer’s V</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3.124</td>
<td>3</td>
<td>0.373 Not significant</td>
<td>0.091</td>
</tr>
</tbody>
</table>
Table 9.6 Grade of quality chert and subgroups, Bui Ceri Uato

<table>
<thead>
<tr>
<th>Subgroup</th>
<th>Good</th>
<th>Medium</th>
<th>Poor</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>53 (66.3)</td>
<td>22 (27.5)</td>
<td>5 (6.3)</td>
<td>80 (100)</td>
</tr>
<tr>
<td>3</td>
<td>35 (70.0)</td>
<td>11 (22.0)</td>
<td>4 (8.0)</td>
<td>50 (100)</td>
</tr>
<tr>
<td>2</td>
<td>136 (64.5)</td>
<td>64 (30.3)</td>
<td>11 (5.2)</td>
<td>211 (100)</td>
</tr>
<tr>
<td>1</td>
<td>25 (65.8)</td>
<td>8 (21.1)</td>
<td>5 (13.2)</td>
<td>38 (100)</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td></td>
<td>379</td>
</tr>
</tbody>
</table>

Table 9.7 Chi-square statistics comparing the grades of quality chert between subgroups, Bui Ceri Uato cores

<table>
<thead>
<tr>
<th>Texture of flake scar surfaces and subgroups</th>
<th>$X^2$</th>
<th>df</th>
<th>Significance</th>
<th>Cramer's V</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>5.171</td>
<td>6</td>
<td>0.522 Not significant</td>
<td>0.083</td>
</tr>
</tbody>
</table>

TEMPORAL TRENDS IN CORE REDUCTION

The extent/length of reduction of cores in Subgroups 1, 2, 3 and 4 are compared in order to determine any temporal trends in reduction. This includes comparisons of core size, core rotation and flake scars as indicators of the extent/length of reduction (see Table 8.2 and also Appendix A). Cores with taphonomic damage to morphological recordings were omitted from these comparisons (see Table 8.1). In this way, biases created by taphonomic impacts were excluded from assessments of the extent of core reduction.

TEMPORAL TRENDS IN CORE SIZE

The size of cores shows a unidirectional and continuous decline from Subgroup 1 through to Subgroups 2 and 3. This trend reverses in Subgroup 4, where core size increases. Cores in Subgroup 1 are larger, cores decline in size in Subgroup 2 and decline even further in Subgroup 3 (which contains the smallest sized cores deposited at Bui Ceri Uato). Cores in Subgroup 4 display an increase in size and are larger than cores in Subgroups 2 and 3 but smaller than those in Subgroup 1. These trends in core size can be observed in Figures 9.1, 9.2, 9.3, 9.4, 9.5 and Table 9.8, where comparisons between weight, length, surface area,
volume and surface area to weight ratio between cores in each subgroup can be compared. While differences in core size between each subgroup are not sufficiently different to be statistically significant at the 5% level of probability (Table 9.9), these trends are interpreted as evidence of subtle temporal change in the size of cores at Bui Ceri Uato over time.

**The problem of interpretation**

The overwhelming majority of comparisons of the average size of cores between subgroups are not statistically significant (Table 9.9). Consequently, the most parsimonious interpretation of these results is that there is no difference between the size of cores in Subgroups 1, 2, 3 and 4 and, hence, no evidence of change in the extent/length of core reduction at Bui Ceri Uato over time. However, there are two main reasons why this interpretation was not adopted. The first, is the limited integrity of subgroups as units of analysis. The second, as outlined in Chapter 8, there is an absence of information from quantitative experiments objectively delineating the technological responsiveness/sensitivity between the morphological indicators of core reduction adopted in this study (size, platforms and flake scars) with core reduction. Since we are unable to objectively know the technological sensitivity/responsiveness of size with core reduction, and given that subgroups likely act to dilute temporal changes in core morphology, it is feasible not to *completely* rely on these statistical significance outcomes in interpreting observed trends.

**Temporal trends in the extent of core reduction on the basis of size**

The results suggest that cores in Subgroup 1 are comparatively little reduced, cores in Subgroup 2 are further reduced, core reduction peaks in
Subgroup 3, and is followed by a decline in the extent/length of core reduction in Subgroup 4. For instance, the size of cores in Subgroup 1 tends to be greater than those in Subgroups 2, 3 and 4. This is indicated by the inter-quartile range (shown by the box, which contains the middle 50% of values in the distribution curve), which extends to higher values in weight, length, volume and surface area than cores in Subgroups 2, 3 and 4 (Figures 9.1, 9.2 and 9.3). The mean of weight, length, volume and surface area of Subgroup 1 cores are greater than those in the remaining subgroups (Table 9.8). On the basis of size, these trends suggest that cores in Subgroup 1 (deposited in the earlier Pleistocene) may be less reduced than those in Subgroups 2, 3 and 4 (deposited at the terminal Pleistocene and in the Holocene). However, the average size of cores in Subgroup 1 is not statistically significantly different compared with Subgroups 2, 3 and 4, as indicated by t-test results presented in Table 9.9.

There is a tendency for cores in Subgroup 3 to be smaller in size than those in Subgroups 1, 2 and 4. For instance, cores in Subgroup 3 have the smallest mean values of weight, length, volume and surface area than cores in the remaining subgroups (Table 9.8). The inter-quartile range of the surface area to weight ratio of cores in Subgroup 3 tends to be more confined to upper values than those displayed by cores in the remaining subgroups (Figure 9.5). There are statistically significant differences in volume and surface area to weight ratios between cores in Subgroup 3 with those in Subgroups 1, 2 and 4 (Table 9.9). On the basis of size, these trends may indicate that cores in Subgroup 3 (deposited in the early Holocene) tend to be more reduced than those in Subgroups 1, 2 and 4 (deposited in the earlier Pleistocene, terminal Pleistocene and spanning the majority of the Holocene).
Cores in Subgroup 4 show a reversal of this trend and increase in size compared with cores in Subgroups 2 and 3. This is indicated by an increase in values of weight, length, volume and surface area, and lower surface area to weight ratios, compared with cores in Subgroups 2 and 3 (Figures 9.1, 9.2, 9.3, 9.4, 9.5 and Table 9.8). On the basis of core size, this may indicate that cores in Subgroup 4 (in deposits containing pottery and exotic fauna) show a comparative decline in the extent/length of core reduction.

Figure 9.1 Weight and subgroups, Bui Ceri Uato cores
Figure 9.2 Length and subgroups, Bui Ceri Uato cores

Figure 9.3 Volume and subgroups, Bui Ceri Uato cores
Figure 9.4 Surface area and subgroups, Bui Ceri Uato cores

Figure 9.5 Surface area to weight ratio and subgroups, Bui Ceri Uato cores
Table 9.8 Size of ‘good’ grade quality chert cores in each subgroup, Bui Ceri Uato

<table>
<thead>
<tr>
<th>Subgroup</th>
<th>Weight (grms)</th>
<th>Length (mm)</th>
<th>Volume (cm³)</th>
<th>Surface area (mm²)</th>
<th>Surface area to weight ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean ± SD</td>
<td>Mean ± SD</td>
<td>Mean ± SD</td>
<td>Mean ± SD</td>
<td>Mean ± SD</td>
</tr>
<tr>
<td></td>
<td>N=46</td>
<td>N=73</td>
<td>N=73</td>
<td>N=73</td>
<td>N=46</td>
</tr>
<tr>
<td>4</td>
<td>23.8 ± 31.2</td>
<td>22.3 ± 9.1</td>
<td>1,102.2 ± 1,5000.0</td>
<td>1,812.7 ± 1,980.6</td>
<td>121.5 ± 57.9</td>
</tr>
<tr>
<td></td>
<td>17.4 ± 17.5</td>
<td>21.8 ± 7.1</td>
<td>826.6 ± 631.0</td>
<td>1,650.8 ± 1,154.1</td>
<td>117.7 ± 44.6</td>
</tr>
<tr>
<td>2</td>
<td>22.9 ± 40.5</td>
<td>23.3 ± 8.3</td>
<td>1,067.3 ± 1,516.5</td>
<td>1,924.3 ± 1,716.3</td>
<td>117.3 ± 57.7</td>
</tr>
<tr>
<td></td>
<td>34.3 ± 30.1</td>
<td>27.8 ± 7.6</td>
<td>1,522.2 ± 1,257.9</td>
<td>2,606.4 ± 1,552.4</td>
<td>100.2 ± 48.4</td>
</tr>
</tbody>
</table>

Table 9.9 t-test results comparing differences in size between cores in each subgroup, Bui Ceri Uato

<table>
<thead>
<tr>
<th>Weight</th>
<th>t</th>
<th>df</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-2</td>
<td>1.468</td>
<td>183</td>
<td>0.588 Not significant</td>
</tr>
<tr>
<td>1-3</td>
<td>2.755</td>
<td>61</td>
<td>0.125 Not significant</td>
</tr>
<tr>
<td>1-4</td>
<td>1.448</td>
<td>74</td>
<td>0.953 Not significant</td>
</tr>
<tr>
<td>2-3</td>
<td>0.760</td>
<td>186</td>
<td>0.609 Not significant</td>
</tr>
<tr>
<td>2-4</td>
<td>-0.150</td>
<td>199</td>
<td>0.551 Not significant</td>
</tr>
<tr>
<td>3-4</td>
<td>-1.070</td>
<td>77</td>
<td>0.149 Not significant</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Length</th>
<th>t</th>
<th>df</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-2</td>
<td>3.009</td>
<td>227</td>
<td>0.966 Not significant</td>
</tr>
<tr>
<td>1-3</td>
<td>3.722</td>
<td>83</td>
<td>0.622 Not significant</td>
</tr>
<tr>
<td>1-4</td>
<td>3.153</td>
<td>107</td>
<td>0.932 Not significant</td>
</tr>
<tr>
<td>2-3</td>
<td>1.158</td>
<td>240</td>
<td>0.542 Not significant</td>
</tr>
<tr>
<td>2-4</td>
<td>0.889</td>
<td>264</td>
<td>0.856 Not significant</td>
</tr>
<tr>
<td>3-4</td>
<td>-0.297</td>
<td>120</td>
<td>0.729 Not significant</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Volume</th>
<th>t</th>
<th>df</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-2</td>
<td>1.693</td>
<td>227</td>
<td>0.451 Not significant</td>
</tr>
<tr>
<td>1-3</td>
<td>3.345</td>
<td>83</td>
<td>0.010 Significant</td>
</tr>
<tr>
<td>1-4</td>
<td>1.447</td>
<td>107</td>
<td>0.947 Not significant</td>
</tr>
<tr>
<td>2-3</td>
<td>1.087</td>
<td>240</td>
<td>0.262 Not significant</td>
</tr>
<tr>
<td>2-4</td>
<td>-0.168</td>
<td>264</td>
<td>0.287 Not significant</td>
</tr>
<tr>
<td>3-4</td>
<td>-1.215</td>
<td>120</td>
<td>0.025 Significant</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Surface area</th>
<th>t</th>
<th>df</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-2</td>
<td>2.220</td>
<td>227</td>
<td>0.615 Not significant</td>
</tr>
<tr>
<td>1-3</td>
<td>3.257</td>
<td>83</td>
<td>0.130 Not significant</td>
</tr>
<tr>
<td>1-4</td>
<td>2.105</td>
<td>107</td>
<td>0.588 Not significant</td>
</tr>
<tr>
<td>2-3</td>
<td>1.056</td>
<td>240</td>
<td>0.377 Not significant</td>
</tr>
<tr>
<td>2-4</td>
<td>0.453</td>
<td>264</td>
<td>0.815 Not significant</td>
</tr>
<tr>
<td>3-4</td>
<td>-0.516</td>
<td>120</td>
<td>0.611 Not significant</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Surface area to weight ratio</th>
<th>t</th>
<th>df</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-2</td>
<td>-1.525</td>
<td>183</td>
<td>0.134 Not significant</td>
</tr>
<tr>
<td>1-3</td>
<td>-1.501</td>
<td>61</td>
<td>0.669 Not significant</td>
</tr>
</tbody>
</table>

253
TEMPORAL TRENDS IN CORE ROTATION

The extent of rotation of cores (indicated by the number of platforms and the number of flake scar directions) at Bui Ceri Uato are presented in Figures 9.6, 9.7 and Table 9.10. On the whole, temporal changes in core rotation are not statistically significant at the 5% level of probability, as indicated by t-test results presented in Table 9.11

Analyses of core rotation (the number of platforms and the number of flake scar directions) are not indicative of temporal changes in the extent/length of reduction of cores at Bui Ceri Uato. The sequence of subgroups from the highest to lowest average rotation differs between the number of platforms compared with the number of flake scar directions (see Table 9.10), and comparisons between subgroups are overwhelmingly not statistically significant. As the sequence of subgroups from the most to least reduced on the basis of number of platforms and flake scar directions are not synchronous, the minor differences in mean core rotation observed between subgroups are best explained by random occurrence.
Figure 9.6 Number of platforms and subgroups, Bui Ceri Uato cores

Figure 9.7 Number of flake scar directions and subgroups, Bui Ceri Uato cores
Table 9.10 Number of platforms, flake scar directions and subgroups, Bui Ceri Uato cores

<table>
<thead>
<tr>
<th>Subgroups</th>
<th>Number of platforms</th>
<th>Number of flake scar directions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>mean ± standard deviation</td>
<td>sample size</td>
</tr>
<tr>
<td>4</td>
<td>5.3 ± 2.9</td>
<td>4.5 ± 2.2</td>
</tr>
<tr>
<td>N=71</td>
<td></td>
<td>N=57</td>
</tr>
<tr>
<td>3</td>
<td>5.2 ± 2.6</td>
<td>3.9 ± 2.4</td>
</tr>
<tr>
<td>N=49</td>
<td></td>
<td>N=44</td>
</tr>
<tr>
<td>2</td>
<td>5.0 ± 2.4</td>
<td>4.5 ± 2.0</td>
</tr>
<tr>
<td>N=189</td>
<td></td>
<td>N=180</td>
</tr>
<tr>
<td>1</td>
<td>4.7 ± 2.8</td>
<td>4.6 ± 2.7</td>
</tr>
<tr>
<td>N=38</td>
<td></td>
<td>N=32</td>
</tr>
</tbody>
</table>

Table 9.11 t-test results comparing the number of platforms and flake scar directions between cores in each subgroup, Bui Ceri Uato

<table>
<thead>
<tr>
<th>Number of platforms</th>
<th>t</th>
<th>df</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-2</td>
<td>-0.730</td>
<td>225</td>
<td>0.175 Not significant</td>
</tr>
<tr>
<td>1-3</td>
<td>-0.893</td>
<td>85</td>
<td>0.712 Not significant</td>
</tr>
<tr>
<td>1-4</td>
<td>-0.935</td>
<td>107</td>
<td>0.652 Not significant</td>
</tr>
<tr>
<td>2-3</td>
<td>-0.526</td>
<td>236</td>
<td>0.308 Not significant</td>
</tr>
<tr>
<td>2-4</td>
<td>-0.610</td>
<td>258</td>
<td>0.013 Significant</td>
</tr>
<tr>
<td>3-4</td>
<td>-0.017</td>
<td>118</td>
<td>0.315 Not significant</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Number of flake scar directions</th>
<th>t</th>
<th>df</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-2</td>
<td>0.161</td>
<td>210</td>
<td>0.100 Not significant</td>
</tr>
<tr>
<td>1-3</td>
<td>-0.577</td>
<td>74</td>
<td>0.654 Not significant</td>
</tr>
<tr>
<td>1-4</td>
<td>0.096</td>
<td>87</td>
<td>0.443 Not significant</td>
</tr>
<tr>
<td>2-3</td>
<td>-1.137</td>
<td>222</td>
<td>0.259 Not significant</td>
</tr>
<tr>
<td>2-4</td>
<td>-0.051</td>
<td>235</td>
<td>0.354 Not significant</td>
</tr>
<tr>
<td>3-4</td>
<td>0.846</td>
<td>99</td>
<td>0.791 Not significant</td>
</tr>
</tbody>
</table>

TEMPORAL TRENDS IN FLAKE SCARS

The total number of flake scars on cores in Subgroups 1, 2, 3 and 4 are presented in Figure 9.8 and Tables 9.12 and 9.13. The percentage of non-flaked surface area, the amount of cortex and associated chi-squared tests are presented in Tables 9.14, 9.15, 9.16 and 9.17. Again, the overwhelming majority of flake scar comparisons are not statistically significant. Given the limitations of subgroups as the unit of analyses, significant assessment outcomes are not entirely relied upon in forwarding observations of temporal changes in the extent/length of core reduction.
The percentage of non-flaked surface area suggests that cores in Subgroup 1 and Subgroup 4 may be less reduced than those in Subgroups 2 and 3 (Table 9.14). For instance, there is a relatively low proportion of cores in Subgroup 1 with less than 20% of non-flaked surface area (a higher percentage range indicates minimal reduction, whereas a lower percentage range indicates greater reduction whereby the surface area of the core is largely flaked, see Appendix A). Conversely, there is a relatively high proportion of cores in Subgroup 1 with 21-60% and 81-<100% non-flaked surface area. There are a relatively low proportion of cores in Subgroup 4 with high flaked surface areas and a correspondingly high proportion with high non-flaked surface areas. While differences in the proportion of cores with varying amounts of non-flaked surface area are not statistically significant (Table 9.15), it is still argued that these comparisons suggest that cores in Subgroups 1 and 4 may be less reduced than those in the remaining subgroups.

The percentage of non-flaked surface area suggests that cores in Subgroup 3 may be further reduced than those in Subgroups 1, 2 and 4 (Table 9.14), despite that differences in the proportion of cores with varying amounts of non-flaked surface area are not statistically significant (Table 9.15). There are a relatively high proportion of cores in Subgroup 3 with high flaked areas and, correspondingly, relatively low proportion with high non-flaked surface areas. This observation of further reduction of cores in Subgroup 3 may also be supported by the amount of cortex. The majority of cores in Subgroup 3 display less than 41% of cortex as a proportion of the surface area of the core (Table 9.16). In contrast, cores in Subgroups 1, 2 and 3 display comparatively higher
amounts of cortex (Table 9.16). These differences, however, are not sufficiently
different to be statistically significant (Table 9.17).

The total number of flake scars displays a unidirectional continuous
increase over time. This is illustrated in Figure 9.8 and Table 9.12, which show
an increase in the number of flake scars on Subgroup 1 cores located in the
lowest levels of the excavation, through to Subgroups 2, 3 and 4 toward the
surface. In some comparisons, this increase in the number of flake scars is
statistically significant (Table 9.13). This unidirectional trend suggests that there
is a continuous increase in the extent/length of reduction of cores at Bui Ceri
Uato from initial human occupation of the site through to the more recent past.
This is in contrast with the trend indicated by the percentage of non-flaked
surface area, which suggests that cores in Subgroup 4 may be less reduced than
those in Subgroups 2 and 3.

The contrasting trends depicted by the percentage of non-flaked surface
area and the total number of flake scars may be explained by flake scar size. For
instance, smaller sized flake scars are confined to a smaller surface area on the
core and thus correspond with larger estimates of non-flaked surface area (see
Figure 8.2). One way to test whether flake scar size may explain the contrasting
trends between the percentage of non-flaked surface area and the total number of
flake scars, is to compare the size of flake scars. One measure of flake scar size is
the length of the longest complete flake scar measured from the last platform
struck before reduction ceased (see Appendix A; another measure is flake scar
width but was not recorded by the present study). The size of the core also needs
to be considered in these comparisons, as core size limits the length of the flake
that can be detached and hence the length of the flake scar that is displayed on
the core face (see Chapter 5). The ratio of the length of the longest complete flake scar (from the last platform) over the length of the core (also measured from the last platform, see Appendix A) standardises core size. In this way, flake scar length relative to core size can be compared between cores in Subgroup 4 with those in Subgroups 1, 2 and 3.

It was found that cores in Subgroup 4 have lower ratios of the length of the longest complete flake scar compared with Subgroups 1, 2 and 3, as illustrated in Figure 9.9 and Table 9.18. This means that cores in Subgroup 4 have shorter flake scars (at least those detached from the last platform) than cores in Subgroups 1, 2 and 3. With the exception of cores in Subgroup 2, the lower ratio displayed by cores in Subgroup 4 are not sufficiently different to be statistically significant at the 5% level of probability (Table 9.19). Nonetheless, these comparatively smaller sized flake scars explain why a relatively high proportion of Subgroup 4 cores have greater than 41% non-flaked surface areas compared with cores in Subgroups 2 and 3 in particular. On the basis of these assessments of the number of flake scars with the percentage of non-flaked surface and flake scars length, cores in Subgroup 4 are not comparatively further reduced than cores in Subgroups 2 and 3.
Figure 9.8 Total number of flake scars and subgroups, Bui Ceri Uato cores

Table 9.12 Total number of flake scars on cores in each subgroup, Bui Ceri Uato

<table>
<thead>
<tr>
<th>Subgroup</th>
<th>Mean, standard deviation and sample size</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>15.7 ± 9.3 N=57</td>
</tr>
<tr>
<td>3</td>
<td>15.6 ± 8.1 N=44</td>
</tr>
<tr>
<td>2</td>
<td>14.3 ± 7.4 N=180</td>
</tr>
<tr>
<td>1</td>
<td>14.2 ± 9.6 N=32</td>
</tr>
</tbody>
</table>

Table 9.13 t-test results comparing the total number of flake scars on cores in each subgroup, Bui Ceri Uato

<table>
<thead>
<tr>
<th>Total number of flake scars</th>
<th>t</th>
<th>df</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-2</td>
<td>-0.072</td>
<td>210</td>
<td>0.044 Significant</td>
</tr>
<tr>
<td>1-3</td>
<td>-0.689</td>
<td>74</td>
<td>0.332 Not significant</td>
</tr>
<tr>
<td>1-4</td>
<td>-0.734</td>
<td>87</td>
<td>0.877 Not significant</td>
</tr>
<tr>
<td>2-3</td>
<td>-1.028</td>
<td>222</td>
<td>0.406 Not significant</td>
</tr>
<tr>
<td>2-4</td>
<td>-1.191</td>
<td>235</td>
<td>0.026 Significant</td>
</tr>
<tr>
<td>3-4</td>
<td>-0.073</td>
<td>99</td>
<td>0.350 Not significant</td>
</tr>
</tbody>
</table>
Table 9.14 Percentage of non-flaked surface area and cores in each subgroup, Bui Ceri Uato

<table>
<thead>
<tr>
<th>Subgroups / % non-flaked surface area</th>
<th>Core counts (%)</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0-20</td>
<td>21-40</td>
<td>41-60</td>
<td>61-80</td>
<td>81-&lt;100</td>
<td>Total</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>19 (33.3)</td>
<td>11 (19.3)</td>
<td>8 (14.0)</td>
<td>10 (17.5)</td>
<td>9 (15.8)</td>
<td>57 (100)</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>21 (47.7)</td>
<td>13 (29.5)</td>
<td>3 (6.8)</td>
<td>4 (9.1)</td>
<td>3 (6.8)</td>
<td>44 (100)</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>71 (39.4)</td>
<td>51 (28.3)</td>
<td>24 (13.3)</td>
<td>19 (10.6)</td>
<td>15 (8.3)</td>
<td>180 (100)</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>9 (28.1)</td>
<td>12 (37.5)</td>
<td>6 (18.8)</td>
<td>1 (3.1)</td>
<td>4 (12.5)</td>
<td>32 (100)</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>313</td>
</tr>
</tbody>
</table>

Table 9.15 Chi-square statistics for differences in the percentage of non-flaked surface area between cores in each subgroup, Bui Ceri Uato

<table>
<thead>
<tr>
<th>Percentage of non-flaked surface area</th>
<th>$X^2$</th>
<th>df</th>
<th>Significance</th>
<th>Cramer's V</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>14.427</td>
<td>12</td>
<td>0.274 Not significant</td>
<td>0.124</td>
</tr>
</tbody>
</table>

Table 9.16 Amount of cortex on cores in each subgroup, Bui Ceri Uato

<table>
<thead>
<tr>
<th>Subgroups / Amount of cortex (%)</th>
<th>Core counts (%)</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
<td>1-20</td>
<td>21-40</td>
<td>41-&lt;100</td>
<td>Total</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>41 (53.9)</td>
<td>21 (27.6)</td>
<td>8 (10.5)</td>
<td>6 (7.9)</td>
<td>76 (100)</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>26 (54.2)</td>
<td>14 (29.2)</td>
<td>7 (14.6)</td>
<td>1 (2.1)</td>
<td>48 (100)</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>114 (56.4)</td>
<td>47 (23.3)</td>
<td>26 (12.9)</td>
<td>15 (7.4)</td>
<td>202 (100)</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>21 (56.8)</td>
<td>6 (16.2)</td>
<td>8 (21.6)</td>
<td>2 (5.4)</td>
<td>37 (100)</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>363</td>
</tr>
</tbody>
</table>

Table 9.17 Chi-square statistics for differences in the proportion of cores in each subgroup with varying amounts of cortex, Bui Ceri Uato

<table>
<thead>
<tr>
<th>Amount of cortex (%)</th>
<th>$X^2$</th>
<th>df</th>
<th>Significance</th>
<th>Cramer's V</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>6.360</td>
<td>9</td>
<td>0.703 Not significant</td>
<td>0.076</td>
</tr>
</tbody>
</table>
Table 9.18 Ratio of the length of the longest complete flake scar (from platform 1) over core length, Bui Ceri Uato

<table>
<thead>
<tr>
<th>Subgroup</th>
<th>Ratio</th>
<th>Mean, standard deviation and sample size</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>0.46 ± 0.26</td>
<td>N=73</td>
</tr>
<tr>
<td>3</td>
<td>0.53 ± 0.28</td>
<td>N=49</td>
</tr>
<tr>
<td>2</td>
<td>0.55 ± 0.30</td>
<td>N=193</td>
</tr>
<tr>
<td>1</td>
<td>0.56 ± 0.28</td>
<td>N=36</td>
</tr>
</tbody>
</table>

Table 9.19 t-test results comparing the ratio of the length of the longest complete flake scar from platform 1 over core length between cores in each subgroup, Bui Ceri Uato

<table>
<thead>
<tr>
<th>Ratio</th>
<th>t</th>
<th>df</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-2</td>
<td>0.177</td>
<td>227</td>
<td>0.841 Not significant</td>
</tr>
<tr>
<td>1-3</td>
<td>0.465</td>
<td>83</td>
<td>0.542 Not significant</td>
</tr>
<tr>
<td>1-4</td>
<td>1.897</td>
<td>107</td>
<td>0.189 Not significant</td>
</tr>
<tr>
<td>2-3</td>
<td>0.403</td>
<td>240</td>
<td>0.326 Not significant</td>
</tr>
<tr>
<td>2-4</td>
<td>2.360</td>
<td>264</td>
<td>0.042 Significant</td>
</tr>
<tr>
<td>3-4</td>
<td>1.517</td>
<td>120</td>
<td>0.494 Not significant</td>
</tr>
</tbody>
</table>

TEMPORAL TRENDS IN CORE REDUCTION

Interestingly, core size and the percentage of non-flaked surface area depict similar temporal trends in the extent/length of reduction of cores at Bui
Ceri Uato. Ranked in order from the least reduced through to the most reduced on the basis of core size and flake scars are Subgroups 1, 4, 2 and 3. Core rotation (indicated by the number of platforms and the number of flake scar directions) tended not to show any clear temporal trends in the extent/length of core reduction.

Cores in Subgroup 1 (in deposits dated to the comparatively earlier Pleistocene) are the least reduced and cores in Subgroup 2 (in deposits dated to the terminal Pleistocene) are further reduced, cores in Subgroup 3 (in deposits dated to the early Holocene) are the most reduced, and cores in Subgroup 4 (in deposits containing pottery and exotic fauna) are more reduced than Subgroup 1 cores but less reduced than cores in Subgroups 2 and 3. These temporal trends in the extent/length of core reduction are indicated by morphological indicators of core size and flake scars.

Subgroups 1, 2 and 3 show a trend towards increased core reduction from the comparatively earlier Pleistocene, peaking with cores in Subgroup 3 at the early Holocene. Subgroup 4 cores show the reverse of this trend, with a decline the extent/length of reduction depicted by an increase in size and relatively higher proportions of cores with low flake scar areas on cores spanning the majority of the Holocene. Interestingly, the continuous increase in the core:flake ratio (illustrated in Figure 6.4) cannot be explained by increasing core reduction, as this trend is reversed in Subgroup 4. Other considerations must be involved, and are explored further in the next chapter.

It was established that the extent/length of core reduction has a strong relationship with chert quality (see Chapter 8). Consequently, it is important to
discuss these temporal trends in the extent/length of core reduction with those displayed by chert quality.

**Core reduction and chert quality**

Cores in Subgroup 1 display a comparatively higher proportion of lower quality chert (indicated by homogeneity, texture of flaked surfaces and grade quality) and are the least reduced. This suggests that humans occupying the site in the initial Pleistocene occupation were less selective in regard to the quality of chert nodules procured for knapping and were not reducing cores to the same extent as in subsequent periods.

Cores in Subgroups 3 comprise the highest proportions of 'good' grade quality chert and are the most reduced. This suggests that humans occupying Bui Ceri Uato in the early Holocene were more actively selecting higher quality chert for knapping and that they were reducing cores to a greater extent than in any other period of human occupation of Bui Ceri Uato. The relationship between chert quality and extent/length of reduction is closely related (as investigated in Chapter 8).

In contrast with cores in Subgroups 1 and 3, the relationship between chert quality and reduction cannot explain the comparative extent/length of reduction of cores in Subgroup 4. This is because Subgroup 4 cores display similar proportions of homogenous and smooth textured chert as Subgroup 3 and grades of chert quality with Subgroup 2. This suggests that similar selection levels in procuring quality chert nodules for knapping purposes were adopted by humans in Subgroups 2 and 4 (selection pressure for high quality chert nodules was slightly higher in Subgroup 3, as displayed by higher proportions of 'good' grade quality chert). Yet, cores in Subgroup 4 are not as reduced as those in...
Subgroup 2. Other considerations must be involved in explaining temporal changes in the extent/length of core reduction in the Holocene at Bui Ceri Uato, and are discussed in the next chapter.

In the remaining section, trends in the rate of occurrence of heat-treated cores are assessed.

**THE FREQUENCY OF HEAT-TREATED CORES**

Temporal trends in the occurrence of heat-treated chert cores at Bui Ceri Uato provide an indication of the frequency of the application of the technique by knappers occupying the shelter in the distant past.

The proportion of chert cores in each subgroup that have undergone heat-treatment is calculated and presented in Table 9.20 and associated chi-square test Table 9.21. The frequency of occurrence of heat-treated chert cores in each subgroup is also calculated (in per cubic metre of deposit per 1000 years) and these results are presented in Table 9.22 and Figure 9.10. Calculations are based on the dated shell sequence (see Chapter 6) and standardise differences in the total number of cores, the volume of deposit and the rate of core artefact discard per 1000 years in each subgroup.

There are a relatively low proportion of cores that have undergone the process of heat-treatment in Subgroups 1 and 4 (44.7% and 52.5%, respectively, Table 9.20). In contrast, Subgroup 2 shows a higher proportion of cores that have undergone heat-treatment (58.8%) with a peak in Subgroup 3 (62.0%, Table 9.20). These differences in the proportion of heat-treated cores between Subgroups 1, 2, 3 and 4 are not sufficiently different to be statistically significant (Table 9.21). The proportion of cores discarded at the site that have undergone
heat-treatment are lowest in the earlier Pleistocene (Subgroup 1), increase dramatically at the terminal Pleistocene (Subgroup 2), peak in the early Holocene (Subgroup 3) and are comparatively low spanning the Holocene (Subgroup 4). These trends can be observed in Figure 9.10 framed within rates of core artefact discard calculated in Table 9.22. Of course, these patternings in the rate of core discard and the occurrence of heat-treated cores are viewed at a coarse level of resolution spanning the Pleistocene to the Holocene. Also a consideration, is offsite/onsite transportation of cores may have potentially biased patterning in the proportion of heat-treated and non-heat-treated cores at the site.

Heat-treatment is an optional technique in the manufacture of flaked stone, the main benefit of which is to improve the knappability of the stone material (see Chapter 5). For these reasons, a higher proportion of heat-treated cores may be considered in terms of efforts exhibited by humans to maximise stone material in knapping activities. Interestingly, Subgroup 3 contains the highest proportion of heat-treated cores (Table 9.20). Subgroup 3 also contains a comparatively greater proportion of cores comprising higher quality grade chert and which have experienced comparatively greater core reduction. These synchronous trends of higher proportion of heat-treated cores, greater selection of better quality chert and comparatively greater core reduction indicate that humans occupying the site in the early Holocene were maximising stone resources in their knapping activities. This may be interpreted as indicative of relatively increased levels of pressure for flaked stone experienced by humans occupying Bui Ceri Uato in the early Holocene. One possible explanation for this tendency to maximise stone resources may relate to limited access to chert nodules available immediately on descent of the Baucau Plateau (see Chapter 3).
Such possibilities are discussed further in the next chapter, in context of levels of human occupation at the shelter.

Table 9.20 Heat-treated cores and subgroups, Bui Ceri Uato

<table>
<thead>
<tr>
<th>Subgroup</th>
<th># of heat-treated chert cores</th>
<th>% of heat-treated chert cores in subgroup</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>42</td>
<td>52.5</td>
</tr>
<tr>
<td>3</td>
<td>31</td>
<td>62.0</td>
</tr>
<tr>
<td>2</td>
<td>124</td>
<td>58.8</td>
</tr>
<tr>
<td>1</td>
<td>17</td>
<td>44.7</td>
</tr>
<tr>
<td>Total</td>
<td>214</td>
<td>100</td>
</tr>
</tbody>
</table>

Table 9.21 Chi-square statistics the proportion of heat-treated chert cores between subgroups, Bui Ceri Uato

<table>
<thead>
<tr>
<th>Homogeneity and subgroups</th>
<th>$\chi^2$</th>
<th>df</th>
<th>Significance</th>
<th>Cramer's V</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3.716</td>
<td>3</td>
<td>0.294</td>
<td>0.099</td>
</tr>
</tbody>
</table>

Table 9.22 Rates of occurrence of heat-treated chert cores

<table>
<thead>
<tr>
<th>Subgroup</th>
<th>Duration (years)</th>
<th>Volume (m$^3$)</th>
<th># cores</th>
<th># cores/m$^3$</th>
<th># cores/m$^3$ per 1000 yrs</th>
<th># heat-treated cores/m$^3$ per 1000 yrs</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>9,022-Present (9,022)</td>
<td>4.5</td>
<td>80</td>
<td>17.8</td>
<td>2.0</td>
<td>1.1</td>
</tr>
<tr>
<td>3</td>
<td>10,383-9,022 (1,361)</td>
<td>1.0</td>
<td>50</td>
<td>50.0</td>
<td>36.7</td>
<td>22.8</td>
</tr>
<tr>
<td>2</td>
<td>12,990-10,383 (2,607)</td>
<td>2.7</td>
<td>211</td>
<td>78.1</td>
<td>30.0</td>
<td>17.6</td>
</tr>
<tr>
<td>1</td>
<td>29,930-12,990 (16,940)</td>
<td>0.5</td>
<td>38</td>
<td>76.0</td>
<td>4.5</td>
<td>2.0</td>
</tr>
</tbody>
</table>

Figure 9.10 Frequency of occurrence of (heat-treated) chert cores in subgroups, Bui Ceri Uato
CONCLUSION

Temporal trends indicate that chert cores manufactured in the early Holocene (Subgroup 3) were more selectively procured, more likely to have undergone heat-treatment and were also further reduced than cores discarded at Bui Ceri Uato during any other period of human occupation of the shelter. In contrast, cores in the earlier Pleistocene (Subgroup 1) and spanning the majority of the Holocene (Subgroup 4) were not as reduced as those manufactured at the terminal Pleistocene (Subgroups 2) and early Holocene (Subgroup 3) and contained correspondingly low proportions of heat-treated cores. These temporal trends reflect subtle changes to core morphology at Bui Ceri as reflected by subgroups. It is argued that while the majority of these comparisons between subgroups are statistically not significant at the 5% level of probability, the nature of subgroups as unit of analysis broadly and arbitrarily dividing the cultural deposits of the shelter likely resulted in diluting temporal patterns in core morphology (see Chapters 3, 6 and earlier in this chapter). For this reason, statistical significant assessment outcomes were not completely relied upon when forwarding observations of temporal trends in core morphology. It was found that only minor adjustments to the extent/length of core reduction can be observed rather than radical alterations to core morphology. It is unsurprising, therefore, that Glover (1986) failed to detect major changes in core technology at the site.

In the following chapter, inter-relationships and temporal trends in chert quality, core reduction and heat-treatment are outlined along with indices of levels of human occupation at Bui Ceri Uato shelter (refer to Chapters 6, 7 and 8). Outcomes are discussed in the context of broader processes such as
palaeoenvironmental conditions in the region and changes in sea levels as well as major changes in human subsistence/settlement changes in the prehistory of East Timor (Chapter 2). These multiple strands of evidence provide a basis to form interpretations of human behaviour at the site.
CHAPTER 10

SYNTHESIS AND CONCLUSION

Humans occupying Bui Ceri Uato were more responsive to stone quality than any other factor influencing the lithic system (refer to Chapter 1). The extent/length of reduction of cores at the site is largely explained by stone material quality, whereby cores of better quality chert were further reduced than those of poorer quality (see Chapter 8). Only subtle changes in the extent/length of reduction of cores were perceived spanning the duration of human occupation at the site (see Chapter 9).

Subtle trends indicate that the extent of core reduction is lowest at the initial Pleistocene phase of occupation (Subgroup 1), increases at the terminal Pleistocene (Subgroup 2) and peak in early Holocene (Subgroup 3). This trend of further core reduction reverses spanning the majority of the Holocene (Subgroup 4). Differences in core morphology between subgroups (size and flake scars) indicative of core reduction are, on the whole, insufficiently different to be statistically significant at the 5% level of probability. The most parsimonious interpretation of this result is that there is no change in the extent/length of reduction of cores at Bui Ceri Uato. This outcome may be symptomatic of human subsistence or settlement being unresponsive in lithic assemblages whereby it is actually technological constraints (in this case chert quality) that strongly influence the nature of lithic assemblages (e.g. Hiscock, 1988). An alternative factor that likely contributed to the subtly of
observed temporal trends is the arbitrary division of the cultural contents of the excavation into subgroups, which would have acted to dilute temporal changes in core morphology given the nature of the excavation (see Chapters 3, 6 and 9). Of further consideration, is our limited understanding of the relationship between the morphological indicators of core reduction adopted in this study (size, platforms and flake scars) with core reduction. In consideration of these two factors (the diluting influence of subgroups in the detection of temporal trends in core morphology and our limited understanding of the technological sensitivity/responsiveness of these morphological indicators with progressive stages of core reduction), this study did not to completely rely on statistical significance outcomes in interpreting observed trends. Rather, the approach adopted is that the perceived temporal trends in the extent/length of core reduction are not random but reflect real changes in stone knapping.

Subtle trends in the extent/length of core reduction are examined alongside trends in relative levels of human occupation of the site (indicated by sedimentation and flaked stone discard rates and cores with thermal damage) in the context of broader changes such as palaeoenvironmental conditions in the region and the transition towards more controlled food production and the establishment of village communities in East Timor (refer to Chapter 2). These factors form the basis of a synthesis of interpretations of the nature of human behaviour at Bui Ceri Uato shelter.
CORE REDUCTION

THE COMPARATIVELY EARLIER PLEISTOCENE

The extent/length of reduction of cores at Bui Ceri Uato is lowest in Subgroup 1, which is dated from initial Pleistocene occupation through to the terminal Pleistocene (29,930-12,990 cal. BP, see Table 6.1). This period spanned the Last Glacial Maximum with cold and more arid conditions and lower sea levels (see Chapter 2).

A basal date of 26,520 ± 340 (ANU-11738) which is provisionally calibrated between 30,660-29,200 BP at two sigma, represents the earliest known occupation of Bui Ceri Uato, presumably by humans with a hunter-gatherer subsistence strategy (see Chapters 2 and 6 and Appendix E). Occupation of the shelter was, at best, sporadic until about the terminal Pleistocene. This is indicated by relatively low sedimentation and flaked stone artefact discard rates and frequency of occurrence of cores with thermal damage (see Chapters 6 and 7). Indeed, this period most likely represents an early phase of human occupation followed by complete abandonment of the site until the terminal Pleistocene.

This initial phase of Pleistocene occupation (Subgroup 1) represents a period where people could procure chert nodules from the surrounding Bobonaro Scaly Clays without the need to economise on stone material in knapping activities (see Chapters 1 and 3). In comparison with cores in the remaining deposit those in Subgroup 1 were least reduced, contained higher proportions of poor quality chert and comparatively low rates of occurrence of heat-treatment (see Chapter 9). These multiple strands of evidence suggest that there was comparatively little pressure for
flaked stone as a resource at Bui Ceri Uato in the early phase of occupation in the Pleistocene, presumably when mobility of hunter-gather groups was relatively high and stone materials for knapping activities could easily be replenished.

**THE TERMINAL PLEISTOCENE**

The extent/length of reduction of cores at Bui Ceri Uato increases in Subgroup 2, in deposits dated to the terminal Pleistocene (12,990-10,383 cal BP, see Table 6.1). The terminal Pleistocene represents relatively high sedimentation and flaked stone discard rates as well as a relatively high frequency of occurrence of cores with thermal damage at the site (see Chapters 6 and 7). These trends indicate relatively intensive human occupation of the shelter, in a period where climatic conditions had ameliorated (from the cold and drier conditions of the LGM) and also one of rising sea levels (see Chapter 2). There is a noticeable increase in the proportion of cores that have undergone heat-treatment in Subgroup 2, as well as an increase in proportion of higher quality chert procured for core reduction at the terminal Pleistocene (see Chapter 9). Combined with a relative increase in the extent/length of reduction of cores (Chapter 9), these trends are suggestive of an increase in pressure for flaked stone resources experienced by humans at the shelter in this period.

**THE EARLY HOLOCENE**

The extent/length of core reduction at Bui Ceri Uato peaks in Subgroup 3, dated to the early Holocene (10,383-9,022 cal. BP). Sedimentation and flaked stone discard rates peak in this period, as does the frequency of occurrence of cores with
thermal damage (see Chapters 6 and 7). These synchronous trends suggest even more intense occupation of Bui Ceri Uato in the early Holocene.

Cores in Subgroup 3 are the most reduced and there is a focus on stone material quality in this period, as evidenced by the tendency towards the selection of better quality chert material and the highest proportion of heat-treated cores in the early Holocene (see Chapter 9). There is a strong positive relationship at Bui Ceri Uato between chert stone material quality with core reduction (see Chapter 8). These subtle trends towards increased core reduction, preferential selection of better quality chert and an increase in occurrence of the technique of heat-treatment (see Chapter 9) suggest an even greater increase in pressure on flaked stone resources in the early Holocene.

THE HOLOCENE

The extent/length of reduction of cores at Bui Ceri Uato declines in Subgroup 4, dated to the Holocene (younger than 9,022 cal. BP). This subtle decline in the extent of core reduction occurs in levels presumed to reflect changes in human subsistence/settlement in the prehistory of East Timor (such as the eventual adoption of animal husbandry, some sort of agricultural practices and the establishment of village communities, see Chapter 2). There is also a decline in relative levels of human occupation of the shelter in the Holocene, as indicated by a sharp drop in sedimentation and flaked stone discard rates and the frequency of occurrence of cores with thermal damage (see Chapters 6 and 7). While these trends may be accentuated by the possibility of partial removal of Holocene-aged deposits (see
Chapter 6), these comparisons suggest that levels of human occupation at Bui Ceri Uato spanning the majority of the Holocene were slightly higher than in the initial phase of Pleistocene occupation.

The extent of core reduction in Subgroup 4 is relatively low, but higher than cores in Subgroup 1 in the comparatively earlier Pleistocene (see Chapter 9). The proportion of cores with heat-treatment is also comparatively low, as is the selection of quality chert (but remains higher than in the earlier Pleistocene occupation) (see Chapter 9). These trends suggest that humans occupying Bui Ceri Uato spanning the majority of duration of the Holocene experienced little pressure in acquiring flaked stone.

The core:flake ratio peaks in Subgroup 4, which indicates that there are more flakes for each core in the Holocene than in any other period of human occupation of the shelter (see Chapter 6). This manufacture of flakes cannot be sourced to cores, as the extent/length of reduction of cores in Subgroup 4 declines to slightly above that observed in the comparatively earlier Pleistocene (see Chapter 9). There are two likely scenarios to explain this increase in the core:flake ratio with a decline in the extent/length of core reduction: the source of the majority of these flakes derived from retouched flakes and/or there was offsite movement of cores. A quantitative assessment of the flake component of the lithic technology at the site may indicate an increase in occurrence of retouched flakes, which would suggest that flakes themselves became the focus of knapping activities at the site. If this is not the case, then the alternative explanation of the transportation of cores away from the site would seem likely. An additional complication is the likelihood of contemporary
practices of partial removal of Holocene-aged deposits from the shelter (see Chapter 6).

Interestingly, Bui Ceri Uato displays synchronous trends of relatively high levels of intensity of human occupation associated with the increased pressure for flaked stone at the terminal Pleistocene and, more particularly, in the early Holocene. During initial occupation of the site and spanning the majority of the Holocene the reverse is the case, whereby relatively low levels of human occupation are associated with low pressure for flaked stone. These associations require further discussion.

SYNTHESIS: CHANGING OCCUPATION AT BUI CERI UATO

Indices indicative of intensive levels of human occupation at Bui Ceri Uato (such as relatively high sedimentation rates, flaked stone artefact discard rates and frequency of cores with thermal damage) may be interpreted in terms of:

1. prolonged periods of human occupation at the shelter, and/or;
2. more frequent human occupation of the shelter, and/or;
3. a greater number of people occupying the shelter at any given time, and/or;
4. broader processes such as an increasing populations on the Baucau Plateau at the terminal Pleistocene and early Holocene.

It is difficult, if not impossible, to differentiate which of these above factors may have been the prime contributor characterising the deposits at the shelter in these periods of relatively intensive occupation. More likely, these factors were not
isolated and intensive levels of occupation (whether a combination of prolonged occupation, increased number of people occupying the shelter and/or an increase in the frequency of occupation of the shelter) were probably associated with broader processes such as population increase on the Baucau Plateau. However, it seems reasonable to propose that intensive levels of occupation at the terminal Pleistocene/early Holocene may be indicative of more sedentary occupation of Bui Ceri Uato by human groups. This could be reflected by lower residential mobility and more prolonged occupation. The extremely dramatic rates of sedimentation and accumulation of cultural materials (whereby the majority of deposits at the shelter date to between the terminal Pleistocene and early Holocene), coupled with high levels of hearth use at the shelter (indicated by relatively high frequencies of cores with thermal damage) are strong indicators of more prolonged human occupation of the shelter in this period. Subtle trends in levels of core reduction can thus be related to differences in group mobility and the intensity of human occupation at Bui Ceri Uato.

Prolonged human occupation at Bui Ceri Uato at the terminal Pleistocene/early Holocene, perhaps by more sedentary groups, conflicts with interpretations made by Glover (1986) (see also Veth et al, 2005: 190), where he suggests that all his excavated sites in East Timor were used only as temporary camps and were never at any time permanently occupied shelters (see Chapter 4). However, Glover (1986) was not able to obtain satisfactory radiocarbon dates and build a chronological sequence upon which to calculate reliable sedimentation and flaked stone artefact discard rates at Bui Ceri Uato. Instead, he was reliant on
correlations with the nearby site of Lie Siri to provide an estimate of the age of Bui Ceri Uato deposits (see Chapter 3). Indices of levels of human occupation at the shelter calculated on the basis of a dated chronological sequence (see Chapter 6) provide grounds to refute Glover's (1986) interpretations of human use at the site (see Chapter 4). Bui Ceri Uato may be distinguished from the other sites excavated by Glover (1986) in East Timor in that intensive levels of human occupation at the shelter in the terminal Pleistocene/early Holocene may represent relatively sedentary groups of hunter-gatherers in this period, perhaps with a focus on the nearby freshwater spring (see Chapter 3).

Synchronous trends of intensive levels of human occupation and relatively higher levels of pressure for flaked stone at the terminal Pleistocene/early Holocene are in accordance with the model proposed by others (e.g. Hiscock, 1994, 1996, 2003; Holdaway, 2000; Shiner et al, 2005), whereby higher sedentism (lower residential mobility of human groups) and/or intense levels of human occupation at a site are associated with attempts to conserve or maximise stone materials in knapping activities (see Chapter 1). Conservation of stone materials can be observed at Bui Ceri Uato in the late Pleistocene/early Holocene with preferential selection of better quality chert nodules and an increase in the occurrence of heat-treatment, which allowed superior manipulation of the stone material and control of knapping outcomes and the further reduction of cores (see Chapter 5 and Appendix A).

Unlike sites in North America described by Parry and Kelly (1987) (see Chapter 1), Bui Ceri Uato does not show a change in core morphology associated with provisioning as a means of overcoming immediate shortages of raw stone
material linked with increased sedentism. The main indication that lithic provisioning was not commonly practised by humans occupying the shelter is shown by the relationship between levels of human occupation and pressure for flaked stone resources (see above). Provisioning at the site would allow wasteful use of stone in knapping activities (i.e. less reduction) with greater intensity of human occupation (Kuhn, 2004: 433). This is not observed at Bui Ceri Uato. Multidirectional cores, the dominant core type throughout the site, are not considered by the present study as wasteful of stone materials: the small size of the cores associated with high proportions of flaked surface area and numerous rotations are suggestive of intensive reduction and thus of maximising the stone resource. This is particularly evident on cores manufactured at the terminal Pleistocene/early Holocene.

The corollary is depicted in deposits dated to the comparatively earlier Pleistocene and spanning the majority of the Holocene, which are characterised by relatively low levels of human occupation and pressure for flaked stone. Relatively low levels of human occupation in the comparatively earlier Pleistocene (provisionally calibrated to 30,660-29,200 cal. BP, ANU-11738; Appendix E) are indicative of populations on the Baucau Plateau prior to the onset of the extreme conditions of the LGM. Humans may have used Bui Ceri Uato extremely sporadically spanning the period of the LGM (between 28,000-18,000 cal. BP), when the site would have been at a greatest vertical distance from the steep coastline of north east Timor in this period of low World Sea Levels (see Chapter 3). Given the paucity of endemic terrestrial resources such as large-sized game on the island
(see Chapter 2), people may have largely concentrated on coastal resources during these more difficult conditions. Excavation of sites at lower altitudes on the north coast of East Timor may be able to test this scenario of human settlement during the LGM. The combination of low levels of human occupation at the shelter with low levels of pressure for flaked stone in the comparatively earlier Pleistocene is suggestive of relatively mobile groups, as chert nodules could easily be replenished from the Bobonaro Scaly Clay source once descended off the Baucau Plateau (see Chapter 3).

The majority of the Holocene similarly display low levels of human occupation of the shelter and low levels of pressure for flaked stone. These trends occur in deposits containing introduced fauna and ceramics and thought by this study to be associated with broader changes in human subsistence/settlement in the prehistory of East Timor such as animal husbandry, agricultural practices and the establishment of village communities (see Chapters 2 and 6). Low indices of human occupation at Bui Ceri Uato in this period suggest that people were not occupying the shelter anywhere near as intensively as hunter-gatherers in the late Pleistocene/early Holocene. Rather, it seems that with the onset of more controlled food production and the establishment of village communities Bui Ceri Uato was used sporadically by agriculturalists. Glover (1986) noted that caves/rock shelters were commonly used by contemporary East Timorese as overnight camps and temporary shelters for hunting parties and/or people travelling to distant gardens (see Chapter 4; and also Veth et al, 2005: 185). It may be that with the onset of more controlled food production that people largely concentrated their activities within
villages and Bui Ceri Uato became marginal to such settlements on the Baucau Plateau. The abundance of pottery collected from the site certainly suggests that people were still utilising the shelter, but this was more likely to be as part of a larger complex of village activities rather than a direct focus of concentration for human occupation (Veth et al, 2005: 181).

This change in the use of Bui Ceri Uato shelter by agriculturalists is also reflected in the lithic technology in this period. As with initial occupation in the Pleistocene, the relatively low pressure for flaked stone in the Holocene is suggestive of occupation of the shelter by relatively more mobile groups, but in the case of this later occupation this role may be attributed to hunting parties or overnight travellers to distant gardens. A main differentiation in the lithic technology observed in the Holocene (compared with the comparatively earlier Pleistocene and at the terminal Pleistocene) is a peak in the core:flake ratio correlated with a decline in the extent/length of reduction of cores. These contrasting trends suggest that there was a shift to flake technology as a source of generating more flakes and/or that there was a noticeable increase in the offsite removal of cores. Offsite transportation of cores may be suggestive of mobile groups occupying the shelter in this period, whereby flakes were manufactured and generally discarded at the shelter but cores may have tended to have been retained as part of the tool repertoire of humans sheltering at the site and carried away for future use. Of course, the possibility of partial removal of Holocene cultural deposits in contemporary gardening practices adds a layer of complexity to the situation (see Chapter 6).
Further discussion of change in deposits dated to the Holocene involves the issue of technological replacement of stone. Glover (1986) attributed a decline in flaked stone artefacts in upper horizons in his various excavated sites as marking the introduction to metal and/or the introduction/cultivation of bamboo to Timor within the last 3,000-2,000 years (see Chapter 4). The current study has demonstrated that there is an overall decline in the rate of flaked stone artefacts deposited at Bui Ceri Uato shelter after about 9,022 cal. BP. However, the lack of chronological resolution within Holocene-aged deposits does not allow for a more refined and detailed investigation of changes in the lithic technology within the Metal Age (starting *circa* 2,000 BP; see Chapters 3 and 6).

**CONCLUSION**

Temporal trends in levels of human occupation along with levels of pressure for flaked stone (indicated by the extent/length of core reduction) at Bui Ceri Uato allowed interpretations of the nature of human mobility of hunter-gatherers in response to climatic conditions as well as to infer a change in site use by agricultural populations. Variations in extent/length of core reduction were not a product of distance to source (Holdaway, 2000), since the Bobonaro Scaly Clays are likely to have provided the majority of chert material comprising the Bui Ceri Uato lithic assemblage (see Chapter 3). Change occurred in the extent/length to which cores were reduced and can be related to levels of human occupation at Bui Ceri Uato and settlement changes of human groups. In the earliest phase of occupation in the comparatively earlier Pleistocene, groups were relatively mobile. At the terminal Pleistocene/early Holocene there was more sedentary occupation at the shelter. In
the Holocene, with the onset of animal husbandry and agricultural practices, Bui Ceri Uato became peripheral to village activities and was used as an overnight shelter by travelling groups and, at least in more modern times, as a place to parch corn and pen goats (see Chapter 3). This study has contributed to an understanding of cave use in East Timor spanning the transition from hunter-gatherers to agriculturalists, as well as inferring aspects of human behaviour from a lithic assemblage which could be described as morphologically amorphous.

Future research at a regional level may be rewarded with wider settlement pattern information and detailed observations of human behavioural responses in the lithic system of prehistoric populations in East Timor. Temporal changes in the core technology at Bui Ceri Uato were subtle and required sensitive approaches (such as those adopted in this study) to detect change in the lithic technology. This technological approach to lithic analysis has great research potential in Island Southeast Asia, where lithic technologies are not generally conducive to typological frameworks. Quantitative analyses of lithic assemblages (e.g. Hiscock, 2002), as well as measures of lithic reduction such as those adopted with cores (in this study) and retouched flakes elsewhere (e.g. Hiscock and Attenbrow, 2005; Clarkson, 2002a, 2002b; Hiscock and Clarkson, 2005) have provided the means to investigate behavioural responses in lithic technology. In combination with contextual information such as known distances to lithic sources as well as site information measuring levels of human occupation (e.g. rates of sedimentation and artefact discard, taphonomic damage to artefacts), a powerful framework is constructed upon
which interpretations of human behaviour/mobility/settlement in prehistory can be proposed.


288


Cinatti, R. M. G. 1963. As pinturas de Timor. Lisbon: *Coloquio*.


Clarkson, C. 2004. *Technological provisioning and assemblage variation in the Eastern Victoria River Region, Northern Australia: A Darwinian*


296


Hiscock, P. in press. Looking the other way: a materialistic/technological approach to classifying tools and implements, cores and retouched flakes.


Kershaw, P., Keers, van de S., Moss, P., and Wang, S. 2002. Quaternary records of vegetation, biomass burning, climate and possible human impact in the


Spriggs, M. 1998. From Taiwan to the Tuamotus: absolute dating of Austronesian language spread and major sub-groups. In R. Blench and M.


APPENDIX A

ATTRIBUTES AND ATTRIBUTE STATES

This list of attributes and attribute states establishes a body of data with which to assess thermal damage to the core artefacts and the extent/length of reduction of cores at Bui Ceri Uato. Attributes and attribute states recording core artefact morphology are listed, defined and linked to a specific knapping determinant. In this way, human behaviour inferred from the analysis of core artefact morphology are made explicit.

PROVENANCE INFORMATION

The sample of cores identified by the present study at Bui Ceri Uato is different from that of Glover (1986: Table 43), as different criteria were adopted in defining a ‘core’ in flaked stone assemblages (see Chapter 5). For example, the present study identified cores amongst the various ‘flake’ classes established in Glover (1986: Table 41). This consideration to core artefact identification is relevant, because not all classes of flaked stone were allocated identification numbers (ID) or recorded to square and spit of origin. The provenance information of various classes of flaked stone adopted by Glover (1986) is summarised in Table A1.
Table A1 Flaked stone artefact provenance information, Bui Ceri Uato

<table>
<thead>
<tr>
<th>Identification number</th>
<th>Square/Spit</th>
<th>Horizon</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cores and trimming flakes</td>
<td>Yes</td>
<td>Ye</td>
</tr>
<tr>
<td>Flakes with secondary working</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Utilised flakes (including flakes with gloss)</td>
<td>No*</td>
<td>Yes</td>
</tr>
<tr>
<td>Waste flakes</td>
<td>No</td>
<td>No</td>
</tr>
</tbody>
</table>

* A minority of artefacts classed as 'utilised flakes' were allocated with an identification number and are illustrated in Glover (1986: 102). However, the majority of 'utilised flakes' were not provided with an identification number but can still be provenanced to square and spit of origin as they were stored in bags labelled with this relevant information.

1. IDENTIFICATION NUMBER

Flaked stone artefact identification numbers allocated by Glover (1972a: Appendix 8) at Bui Ceri Uato ranged from 2701 to 6425. Some numbers also occurred outside of this range e.g. 6452 (Spit 11 of N6E1, Horizon III).

For the purposes of the present study cores lacking an identification number were provisionally allocated with a unique number and are presented in Appendix J. The numbering system arbitrarily began at 10,000 in order to ensure that there was no overlap with the number range adopted by Glover (1972a: Appendix 8). In this way, each core was allocated a unique number and could be individually identified.

2. SQUARE AND SPIT

The majority of core artefacts identified by the present study at Bui Ceri Uato can be sourced to square and spit of origin. The exception are cores that were classed as 'waste flakes' in Glover (1986: Tables 41 and 42) (Table A1).

The excavation of Bui Ceri Uato comprised eight 1 by 1 metre squares (N7E1, N7E2, N6W1, N6E0, N6E1, N6E2, N5E1, N5E2) and spits ranged from 1 (at the surface) through to 16 (at the trench base) (see Chapter 3).
3. HORIZON

All cores can be provenanced to horizon. There are a total of ten horizons and extend from Horizon X at the floor of the shelter through to Horizon I at the base of the trench.

4. RAW STONE MATERIAL

A total of four raw stone materials are distinguished amongst the cores at Bui Ceri Uato. These include: chert, obsidian, silicified limestone and volcanic (kept at a generic level) (see Chapter 7).

There are two main benefits to recording the type of raw stone material. The first, considers the differing fracture properties of the various raw stone materials in core reduction. For instance, obsidian requires a smaller amount of force to initiate fracture in comparison with chert (Phagan, 1976: 25). All things equal, this means an obsidian core can be reduced to a much smaller mass in comparison to a core manufactured from chert, before inertia finally limits reduction.

Second, the type of raw stone material can be informative of procurement strategies adopted by humans in prehistory. This can be achieved by comparing the composition of stone materials knapped into cores with naturally occurring stone sources suitable for knapping in the surrounding landscape (it is beyond the scope of the present study to undertake quantitative analysis of the composition of raw stone materials in the ‘flake’ classes of stone artefacts at Bui Ceri Uato).

5. COLOUR

The colour of each core artefact is recorded under halogen lighting against Munsell Soil Color Chart (1975 Edition).
Colour is descriptive of the stone material and allows comparisons to be made with naturally occurring stone resources in the surrounding landscape. However, the colour of chert may change upon heat-treatment e.g. turn pink or red, and varies depending on mineral impurities in the material (Luedtke, 1992: 94). This means that until the effects of heat-treatment on the material is recognised, colour is not always a reliable guide in attempting to determine raw material sources (Flenniken and White, 1983: 45).

QUALITY OF THE STONE MATERIAL

In reality, a nodule of suitably fracturing stone is rarely perfectly homogeneous. Not uncommonly, it may contain macroscopic flaws (e.g. pores, inclusions and cracks). The extent of homogeneity of suitably fracturing stone determines its workability (e.g. it may not fracture conchoidally). Cracks and other flaws can arrest fracture propagation and make the stone fracture unpredictably or in undesirable directions (e.g. result in step or hinge terminations) (Cotterell and Kamminga, 1987: 7001; Crabtree, 1972b: 5, 70; Whittaker, 1994: 12 e.g. Volkman, 1983: 148). These features can be used to describe the quality of a mass of stone material suitable for flaking. The quality of a mass of stone material is critical to the level of control the knapper has over the fracture process. For instance, high quality material allows excellent control over knapping outcomes. In contrast, poor quality material may not fracture conchoidally or in a predicable fashion (i.e. there may be little control over fracture).

The quality of the material of each core at Bui Ceri Uato is assessed by recording whether the material is homogeneous, the texture of flake scar surfaces, and the presence/absence of macroscopically visible cracks. An overall
grade of the quality of the material of each core is also made, based on the *extent* to which the material is homogeneous, the *extent* of cracks displayed in the material, and the texture of flaked surfaces.

6. HOMOGENEOUS YES / NO

Material that is 'the same throughout' or physically uniform, is recorded as homogeneous i.e. Yes.

Material that is not of the same substance throughout or contains inclusions of foreign material, is recorded as not homogeneous i.e. No.

Core at Bui Ceri Uato of homogenous material are illustrated in Figure A1, and non-homogenous material in A2.

![Figure A1 Cores of homogenous chert, Bui Ceri Uato](image1)
From left to right, identification number and (Horizon): 5357 (III); 5645 (III); 5378 (III).
(Each square is equal to 1 cm)

![Figure A2 Cores of non-homogenous chert, Bui Ceri Uato](image2)
From left to right, identification number and (Horizon): 5625 (III); 5955 (II); 6337 (I).
(Each square is equal to 1 cm)
7. TEXTURE ‘Smooth / ‘Rough’

By running a fingertip over flaked surfaces, the texture of the stone material is described as either ‘smooth’ or ‘rough’. This simply indicates the ease by which the fracture plane propagated through the material. For instance, ‘smooth’ textured fracture surfaces indicates that the fracture passed through the material with ease and, thus, of relatively high quality stone material. In contrast, ‘rough’ textured flaked surfaces indicate that the fracture passed through the material with comparatively greater difficulty and, thus, is of comparatively lower material quality from knapping perspectives. This description of the texture of flaked surfaces is subjective between analysts, and is also relative in that it is made in context of the material comprising the core artefacts at Bui Ceri Uato.

Core of ‘rough’ textured flaked surfaces at Bui Ceri Uato are illustrated in Figure A3.

Figure A3 Cores of ‘rough’ textured flaked surfaces, Bui Ceri Uato
Left to right, identification number and (Horizon): 6452 (III); 5922 (II).
(Each square is equal to 1 cm)
8. CRACKS YES / NO

Macroscopically visible cracks are observed (includes surface cracks created by crazing) i.e. Yes. This is illustrated in Figure A4.

Macroscopic cracks are not observed i.e. No.

![Figure A4 Cores with cracks, Bui Ceri Uato](image)

Left to right, identification number and (Horizon): 5767 (II); 5510 (III); 10075 (III).
(Each square is equal to 1 cm)

9. GRADE OF STONE MATERIAL QUALITY ‘Good’/ ‘Medium’/ ‘Poor’

Each core evaluated into ‘good’, ‘medium’ or ‘poor’ grades, on the basis of: the extent to which the material is homogeneous (i.e. the size and frequency of inclusions or other heterogeneities in the material), the extent of cracking (i.e. the length and frequency of cracks in the material), and the texture of flaked surfaces (i.e. smooth or rough). For instance:

‘Good’: is indicative of stone material that is most amenable to knapping. That is, it allows the knapper a good degree of control over the path of the fracture. While flaws such as inclusions and cracks may be present in the material, they are low in occurrence and prominence (i.e. inclusions as specks in the material and short, comparatively infrequent cracks). Only
cores with 'smooth' flaked surface texture are placed into this grading. ‘Good’ grade cores are illustrated in Figure A5.

It is reasonable to surmise crazing in combination with other heat fractures superimposed on flaked surfaces, are probably contemporaneous in occurrence i.e. are taphonomic impacts in that they occurred after the core had been reduced and subsequently discarded. In such cases, the stone material may still be graded as ‘Good’. This is an attempt to alleviate taphonomic bias in assessments of the quality of the stone material knapped into cores.

Figure A5 Cores of 'good' grade quality, Bui Ceri Uato
Left to right, identification number and (Horizon): 5395 (III); 5393 (III); 5256 (III).
(Each square is equal to 1 cm)

‘Medium’: (a) reflects material with ‘smooth’ flaked surfaces, but with a comparatively higher incidence/prominence of inclusions and or cracks [than the ‘Good’ category]; or,
(b) material with ‘smooth’ flaked surfaces low in occurrence and prominence of cracks, but may have more sizeable inclusions [than (a)]; or,
(c) material with ‘smooth’ flaked surfaces low in occurrence of inclusions, but with a comparatively higher incidence of short cracks or few but prominent cracks [than (a)]; or,

(d) material with ‘slightly rough’ flaked surfaces, but generally low in occurrence and prominence of cracks and inclusions.

‘Medium’ grade cores are illustrated in Figure A6.

---

Figure A6 Cores of ‘medium’ grade quality, Bui Ceri Uato
Left to right, identification number and (Horizon): 5518 (III); 5386 (III); 5369 (III).
(Each square is equal to 1 cm)

Poor: (e) reflects material with ‘smooth’ flaked surfaces, but with extensive cracking and or with major inclusions [than (a), (b) and (c)]; or,

(f) material with ‘slightly rough’ flaked surfaces with a comparatively higher incidence of cracking and inclusions [than (d)].

‘Poor’ grade cores are illustrated in Figure A7.
These categories are not explicity quantifiable, which means that these assessments of ‘good’, ‘medium’, and ‘poor’ grades are somewhat subjective. This assessment of stone quality is also relative in that it reflects the range in quality of stone material comprising the core artefacts at Bui Ceri Uato.

**EVIDENCE OF HEATING**

There are two distinctions concerning evidence of heating on lithic artefacts. These are controlled heat-treatment, which is distinct from uncontrolled exposure to heat (Mercieca, 2000).

The presence of crazed surfaces, pot lid scars, crenated fracture and/or convoluted surfaces indicate uncontrolled exposure to heating/cooling. This is a result of thermal stresses created by direct or uneven exposure to heat, such as that created from proximity to a campfire. In contrast, glossy flaked surfaces will result only from controlled exposure to heating, whereby a gradual increase in temperature (sufficient to induce changes in the stone material) is followed by slow cooling. Surface lustre with crazing, pot lid scars, crenated fracture and/or convoluted surfaces may indicate either uncontrolled heating events superimposed upon controlled heating events and or controlled heating but uncontrolled cooling (Hiscock, 1988: 364-5).
The present study records whether heat-treatment was part of the technological repertoire adopted by humans in the reduction of cores at Bui Ceri Uato. Heat-treatment is also relevant to the extent/length of core reduction. For instance, heat-treated chert is more brittle than non-heat-treated counterparts and this means that flakes can be detached with less force. All else being the same, heat-treated chert cores can, therefore, be reduced to a smaller mass before inertia limits further flake removal than non-heat-treated counterparts.

The presence of thermal damage such as crazed surfaces, pot lid scars, crenated fracture and/or convoluted surfaces on cores at Bui Ceri Uato may be indicative of fire use (i.e. hearths) in the shelter (Hiscock, 1984: 144-146). Experimental evidence has shown that larger size rocks are more prone to thermal stress and suffer from heat fractures than rocks of smaller size (e.g. Mercieca, 2000). This suggests that larger sized cores would be more prone to heat fractures than smaller sized core. This size bias needs to be considered when making statements of frequency of fire/hearth use on the basis of the frequency of cores with thermal damage.

10. HEAT-TREATED Yes / No

Glossy and smooth flaked surfaces are interpreted by the present study in terms of evidence of heat-treatment. The reliability of this recognition of heat-treatment is dependant on the magnitude of the contrast between flaked and non-flaked surfaces on the same core artefact, as well as contrasts between cores and geological specimens (Collins, 1973: 465). For instance, flaked surfaces are compared against the natural external surface on a core. This provides a contrast on each core artefact. Also, geological samples of chert collected from Bobonero Scaly Clays (i.e. the closest and most likely source of chert to Bui Ceri Uato
shelter) provide another contrast with which to compare flaked surfaces. It was found that freshly knapped surfaces on the geological specimens have a matt lustre and are not as smooth in texture compared with flake scar surfaces on heat-treated chert cores.

On the whole, it was found that comparisons between flake scar surfaces and the natural external surface of the material on each core provided an adequate contrast. Where a suitable external surface was not available on a core (e.g. where the surface comprised only of cortex or of flaked surfaces), familiarity with the material was relied on to make a judgement as to whether flaked surfaces were indicative of heat-treatment. The geological chert provided a contextual framework whereby flaked surfaces on the core could be contrasted with freshly flaked surfaces on the geological specimens (i.e. non-heat-treated chert).

Cores were only recorded as heat-treated if glossy and smooth flaked surfaces contrasted with natural (other than cortex) surfaces on the artefacts and, more broadly, with fresh flaked surfaces on the geological specimens. This method of distinguishing heat-treated and non-heat-treated chert core artefacts remains subjective, but empirical testing of the occurrence of heat-treatment exceeded the restricted confines of this study.

11. CRAZING Presence / Absence

Crazing results when overly rapid heating or cooling occurs such as when stone material is exposed to direct heat (Domanski and Webb, 1992: 603; Purdy, 1973: 138). Crazing can be described as a matrix of macroscopically visible reticulated fractures on the surface of the material, and is illustrated in Figure A8.

The presence or absence of crazed surfaces on each core is recorded.
12. POT LID SCARS Presence / Absence

Pot lid scars result when stone is rapidly raised to high temperatures and results in differential expansion of the rock (Purdy 1973: 136).

Pot lid scars can be described as circular pits or depressions and are illustrated in Figure A9. Usually the deepest part of the scar is at the centre, and there is no initiation. That is, pot lid scars are never associated with a ring crack or any other feature relating to the input of force from a blow (Hiscock and Hall, 1988: 85). This distinguishes pot lid scars from flake scars.

The presence or absence of pot lid scars on each core is recorded.
13. CRENATED FRACTURE Presence / Absence

Crenated fracture occurs when stone is kept at too high a temperature or is cooled too rapidly (Purdy, 1973: 137). Crenated fractures can be described as an undulating or wave-like fracture plane that cleaves through stone material, as illustrated in Figure A10. There is no initiation or evidence of an external blow, no ring crack or bulbar features (Hiscock and Hall, 1988: 85). This distinguishes crenated fractures from flaked surfaces.

The presence or absence of crenated fracture surfaces on each core is recorded.

Figure A10 Cores with crenated fracture, Bui Ceri Uato
Arrows indicate crenated surfaces
Left to right, identification number and (Horizon): 10016 (VI); 6259 (I); 6391 (I).
(Each square is equal to 1 cm)

14. CONVOLUTED SURFACES Presence / Absence

Convoluted fracture surfaces are indicative of extensive heat damage resulting from high or direct exposure to heat. When thermal stresses exceed the elastic limits of the material and it explodes (Purdy, 1973: 136), rough and irregular (i.e. convoluted) surfaces result, as illustrated in Figure A11. Small thin pieces do not explode as readily as larger specimens (Purdy, 1973: 139).
The presence or absence of convoluted heat fractured surfaces on each core is recorded.

Figure A11 Cores with convoluted surfaces, Bui Ceri Uato
Arrows indicate convoluted surfaces
Left to right, identification number and (Horizon): 4103 (V); 5206 (IV); 6022 (II).
(Each square is equal to 1 cm)

SIZE

The present study records core size with two direct measurements: mass (i.e. weight), and length (measured from the surface of platform 1, which is the last platform from which flakes were struck before reduction ceased). Core size is important to statements concerning inertia and the extent/length of reduction. The smaller the core the lower its inertia and the more likely it is to displace rather than detach a flake when a blow is struck. As reduction continues the size of the core diminishes, such that core size may be regarded as one indication of the extent/length of reduction (see Chapter 8).

Recorded values of weight and length may be affected by taphonomic impacts (e.g. heat fractures and/or mechanical breakage), which act to undervalue these measurements. In such cases, recorded values of weight and length do not reflect the original state of the core artefact at the point at which it was discarded (i.e. when core reduction is inferred to have stopped). For this reason, it is important to record when recorded values of weight and length are
taphonomically affected. Core artefacts with weight and/or length
taphonomically affected are indicated by ‘weight affected’ (16) and/or ‘length
affected’ (18), respectively. This controls for taphonomic bias distorting the
recorded core size at Bui Ceri Uato.

15. WEIGHT

The weight of each core is measured on an ISSCO electric top-loading
balance (Model 3000). Weight is recorded to the nearest 0.1 grams, ranging from
0.1 to 3000 grams. This records the mass of each core.

16. WEIGHT AFFECTED Yes / No

This indicates that the mass of a core (15) does not reflect its original
weight at the point when reduction was discontinued. That is, that the recorded
weight (15) is undervalued. Heat fractures (e.g. pot lid scars, crenated fractures,
and convoluted surfaces) and/or mechanical breaks superimposed on flake scar
areas are indicative of taphonomic impacts (in that they occurred after core
reduction ceased). Pot lid scars, crenated fractures, convoluted surfaces and
mechanical breaks act to remove stone material, resulting in a decrease in mass
whereby the recorded weight (15) of the core artefact is undervalued. In this way,
analyses involving core size can control for taphonomic biases influencing
recorded values of weight (15).

17. LENGTH

The length of each core is measured from the horizontal surface of
platform 1 (i.e. the surface from which the last flake scar was struck) to the most
protruding margin/edge at the opposite end of the core. In this way, the length of
the core is the furthest distance perpendicular to the last platform from which
flakes were struck, and is parallel to flake scars deriving from platform 1 on the core face. This is illustrated in Figure A12.

The measurement is taken with electronic display callipers to the nearest millimetre.

![Figure A12 Schematic drawing of a core showing the orientation of the measurement: length of the core measured from platform 1](image)

18. LENGTH TAPHONOMICALLY AFFECTED Yes / No

Indicates that the length of the core measured from platform 1 (17) does not reflect the original length of the core at the point when reduction ceased. That is, the recorded length (17) is undervalued.

This is recorded when platform 1 and/or the distal end of the core opposite platform 1 is removed by taphonomic impacts (such as from mechanical breakage and/or by heat fractures such as pot lids, crenated fracture and/or convoluted surfaces). In this way, taphonomic bias affecting the length of each core artefact at Bui Ceri Uato can be controlled.
SHAPE

Indicators of core shape include dimensions of width and thickness, the average core width and average core thickness, the parallel index, the relative thickness index, and the longitudinal thinness index. These measures and calculations indicate the shape of each core at the point when reduction ceased. Shape may be relevant to the likelihood of occurrence of uncontrolled heat fractures (see Chapter 7).

DIMENSIONS: WIDTH AND THICKNESS

The width and thickness of each core is measured perpendicular to each other at three locations evenly spaced along the length of the core. That is, from:
Platform 1 (the last platform struck, after which reduction ceased);
Midpoint along the length of the core; and
Endpoint of the core (i.e. the distal portion of the core opposite platform 1)

All width (19, 20 and 21) and thickness (22, 23 and 24) measurements are taken at the same perpendicular orientation along the length of the core i.e. in parallel with each other along the length of the core. This is illustrated in Figure A13.
A13 Schematic drawing of a core showing the orientation of the measurements of width at platform 1, midpoint and endpoint, and thickness at platform 1

19. Width of the core at platform 1

The width of the core is recorded at platform 1 by measuring the maximum distance from one margin to the other across the surface of platform 1.

Width is measured with electronic display callipers to the nearest millimetre.

20. Width of the core at midpoint

The width of the core is recorded at the midpoint by measuring the distance from one margin to the other at the mid length of the core. This measurement parallels that of the maximum width of the core at platform 1 (19).

Width is measured with electronic display callipers to the nearest millimetre.
21. Width of the core at endpoint

The width of the core is recorded at the endpoint by measuring the distance from one margin to the other at the distal end of the core (i.e. opposite platform 1). This measurement parallels that of the maximum width of the core at platform 1 (19) and the width of the core at midpoint (20).

Width is measured with electronic display callipers to the nearest millimetre.

22. Thickness of the core at platform 1

The maximum thickness of the core at platform 1 is recorded perpendicular to the maximum width of the core at platform 1 (19), measuring the maximum distance from one margin of the core to the other.

Thickness is measured with electronic display callipers to the nearest millimetre.

23. Thickness of the core at midpoint

The thickness of the core at midpoint is recorded perpendicular to the width of the core at the midpoint (20), measuring the distance from one margin to the other along the midpoint of the core. This measurement parallels the maximum thickness of the core at platform 1 (22).

Thickness is measured with electronic display callipers to the nearest millimetre.

24. Thickness of the core at endpoint

The thickness of the core specimen at the endpoint is recorded perpendicular to the width of the core at endpoint (21), measuring the distance from one margin to the other at the distal end of the core (i.e. opposite platform
1. This measurement parallels that of the maximum thickness of the core at platform 1 (22) and the thickness of the core at midpoint (23).

Thickness is measured with electronic display callipers to the nearest millimetre.

AVERAGE WIDTH AND AVERAGE THICKNESS

These three measures of core width and core thickness (i.e. at platform 1, at the midpoint, and the endpoint) allow average width (25) and average thickness (26) to be calculated on each core.

25. Average Width of the Core

AvgCWidth (the sum of the width of the core at Platform 1, midpoint and endpoint / 3).

The average width of each core is calculated. That is, the sum of the width of the core at platform 1 (19), the width of the core at midpoint (20), and the width at the endpoint (21), is divided by 3.

Values are in millimetres.

26. Average Thickness of the Core

AvgCThick (the sum of the thickness of the core at Platform 1, midpoint and endpoint / 3).

The average thickness of each core is calculated. That is, the sum of the thickness of the core at Platform 1 (22), thickness of the core at midpoint (23), and thickness at the endpoint (24), is divided by 3.

Values are in millimetres.
27. PARALLEL INDEX

Parallel index at midpoint: ParIndMid (width at midpoint / width at platform 1)
Parallel index at endpoint: ParIndEnd (width at endpoint / width at platform 1)

The parallel index is calculated at two locations on each core: at the midpoint and endpoint. The width at the midpoint (20) and the width at the endpoint of the core (21), are divided by the width of the core at platform 1 (19) (see Figure A13).

The parallel index is a measure of the plan shape of each core. A value of 1.0 indicates that the core is square or rectangular in plan shape. Value less than 1.0 indicates that the core contracts along its length away from the platform 1. Values greater than 1.0 indicate that the core expands along its length away from platform 1 (see Hiscock and Hall, 1988: 87, where the parallel index is calculated on flakes).

28. RELATIVE THICKNESS INDEX

Average width of the core / Average thickness of the core)

The relative thickness index is calculated for each core by dividing width by thickness (width / thickness). For instance, the average width of the core (25) is divided by the average thickness of the core (26).

This index provides an indication of the shape of the transverse cross-section of the core. Values of 1.0 indicate that the core is as thick as it is wide. Values less than 1.0 indicate that the core is thicker than it is wide. Values greater than 1.0 indicate that core thickness is small relative to width. The higher the value of the index, the thinner is the core (see Hiscock and Hall, 1988: 87, where the relative thickness index is calculated on flakes).
29. LONGITUDINAL THINNESS INDEX

LTIXMid (thickness at midpoint / thickness of core at Platform 1)
LTIXEnd (thickness at endpoint / thickness of core at Platform 1)

The longitudinal thinness index is calculated for each core, by dividing the thickness of the core at the midpoint (23) and endpoint (24) by the thickness of the core at platform 1 (22).

The longitudinal thinness index provides an indication of the shape of the longitudinal cross-section of the core. A value of 1.0 indicates that the core cross-section is square or rectangular in shape. Values less than 1.0 indicate that the core contracts along its length away from platform 1. Values greater than 1.0 indicate that the core expands along its length away from Platform 1 (see Hiscock and Hall, 1988: 87, where the longitudinal thinness index is calculated on flakes).

CALCULATED SIZE

The size of each core is also indicated by a number of calculations, including: area, volume, surface area and surface area to weight ratio.

CORE AREA

33. Average core area

Average Core Area = average width x average thickness of the core
Av C Area = AvgCWidth x AvgCThick

The average area of the core is equal to the multiplication of the average width (25) and average thickness (26) of the core.

Values are in mm².
CORE VOLUME

34. Average Core Volume

Average Core Volume = Average Core Area x Length of Core at P1

\[ \text{Av C Vol} = \text{Av C Area} \times L \text{ C P1} \]

The average core volume is equal to the average core area (33) multiplied by the length of the core measured from platform 1 (17).

Values are in mm³.

35. CORE SURFACE AREA

The schematised surface area of each core is calculated. The surface area of a sphere is \( \pi D^2 \) (where \( D \) equals the diameter of the sphere). While the shape of each core may not conform to a perfect sphere (i.e., may be more irregular in shape), this formula can still be applied to calculate a standardised surface area. The length of the core measured from platform 1 (17) is applied in this calculation. For instance:

\[ \text{C SA} = \pi \times (\text{the length of the core measured from platform 1})^2 \]

The core surface area is equal to \( \pi \) multiplied by the square of the length of the core measured from platform 1 (17).

Values are in mm².

36. SURFACE AREA TO WEIGHT RATIO

The surface area to weight ratio for each core is calculated. For instance:

The Surface Area to Weight Ratio = Surface Area / Weight

\[ \text{C SA/W} = \text{C SA} / \text{C Weight} \]

The surface area to weight ratio is equal to the surface area (35) divided by the weight of the core (15).
Allometry, it would be expected that smaller cores would have a greater surface area to weight ratio.

**EXTENT/LENGTH OF CORE REDUCTION**

Other morphological indicators of the extent/length of core reduction besides size, include: the percentage of non-flaked surface, the amount of cortex, the number of platforms, the number of flake scar directions of force, and the total number of flake scars. It is recorded when the percentage of non-flaked surface area and amount of cortex is taphonomically affected.

**37. THE PERCENTAGE OF NON-FLAKED SURFACE**

The percentage of natural surface is inversely related to the proportion of the surface area of the core that is flaked. For instance, the surface of a core consists of flaked surfaces and may also have natural surfaces, which are characterised by the rock material from which the core was knapped. That is, the surface of a core consists of flake scar areas and may also have surfaces that are unmodified by humans (this includes weathered surfaces as well as cortex). The proportion of non-flaked surfaces (i.e. natural surfaces) versus flaked surfaces on each core is assessed.

The percentage of the non-flaked (i.e. unmodified) surface is estimated as a percentage of the surface area of the core, based on visual observation i.e. of plan views of the surface of the core. This involves distinguishing flaked from non-flaked surfaces. Ridgelines outline the boundary of flake scar areas, and external surfaces of the rock (from which the core was knapped) are indicated by weathered or patinated surfaces and cortex. In this way, flaked and non-flaked surfaces are differentiated on the core.
The percentage of non-flaked surface on each core is estimated in intervals of 10 (e.g. 0, 1-10, 11-20, 21-30, 31-40 etc.). This system of intervals minimises the level of accuracy in estimating the percentage of non-flaked surface area on each core and is an attempt to avoid a false representation of accuracy. Estimates of the percentage of non-flaked surface may be subject to variation between observers.

The percentage of non-flaked surface is a key indicator of the extent of reduction of a core, given that it represents the outer unmodified surface. Highest values indicate minimal reduction, whereas lower values indicate greater reduction.

38. THE PERCENTAGE OF NON-FLAKED SURFACE AFFECTED Yes / No

Taphonomic damage such as from heat fractures and/or mechanical breakage may have removed a large portion of the original surface of the core, such that it is no longer able to determine if the face of the core was flaked or was a natural surface. In such situations, the percentage of non-flaked surface (37) is recorded as affected (i.e. Yes) and, thus, not a reliable estimate. In this way, taphonomic bias in estimates of the percentage of non-flaked surface is controlled.

39. THE AMOUNT OF CORTEX

Cortex is the rough external surface of a rock. The cortex of chert is often calcareous from the limestone in which the chert formed (Whittaker, 1994: 17).

The proportion of cortex is estimated as a percentage of the total surface area for each core. The percentage of cortex is estimated based on visual observation of plan views of each core and is estimated in intervals of 10 (e.g. 1-
10, 11-20, 21-30, 31-40, etc.). This system of intervals minimises the level of accuracy in estimating the percentage of cortex on each core, and is an attempt to avoid a false representation of accuracy. Estimates of the percentage of cortex on a core are subjective and may vary between observers.

The amount of cortex on a core can be an indication of the extent of reduction (e.g. Coinman, 1997; Cole, 2001). For instance, highest values indicate minimal reduction whereas lower values indicate far greater reduction. However, the amount of cortex is only a reliable indicator of the extent/length of reduction when the entire non-flaked external surface of a core is cortical. This is not always the case of core artefacts at Bui Ceri Uato, as the external surface of some cores consist of natural surfaces (e.g. patinated weathered surfaces).

40. CORTEX REMOVED Yes / No

Cortex may have been partially removed by taphonomic impacts (such as from breakage and/or heat fractures surfaces). It is recorded when the percentage of cortex estimated on a core is affected by taphonomic impacts i.e. Yes. This indicates that the percentage of cortex estimated on a core (39) is underestimated and does not reflect the original amount of cortex on the core at the point when it was discarded (i.e. when core reduction is inferred to have stopped). In this way, taphonomic bias affecting estimates of the amount of cortex on each core artefacts at Bui Ceri Uato is controlled.

41. THE NUMBER OF PLATFORMS

The total number of platforms on each core is determined based on the sequence or order in which platform surfaces were struck (i.e. received a blow in
the removal of flakes from the core face). The order in which surfaces were struck is indicated by the combination of:

1. Superimposition of flake scars on the core face. This demonstrates the order in which flakes were removed or flake scars were created. Flake scar superimpositions are indicated by ridgelines, which outline flake scar boundaries. As flakes are detached from the face of a core material is removed and the shape of the flake detached becomes imprinted onto the core face. In this way, most recent flake scars interrupt ridgelines created by earlier flake removal from the core. By observing the overlapping of flake scar ridgelines on the face of the core the order in which flakes scars were created can be traced.

2. Evidence of initiation (see Chapter 5). The presence of a ring crack with Hertzian initiated fracture locates the point of force application and hence identifies the platform surface. The negative impression of lipping on the proximal margin/edge (i.e. between the platform surface and the flake scar) of bending initiated flake scars indicates the surface directly above the flake scar received the blow. In this way, platform surfaces are identified for Hertzian and bending initiated flake scars on the face of the core.

The point of initiation (characterised by a ring crack, but this does not occur with bending initiations), features such as the negative bulb of percussion (but this does not occur on bending flake scars), termination, flake scar areas (outlined by ridgelines), and the direction of flake scar removal (indicated by ripples on the flake scar area surface) are the main characteristics observed in
determining the order of flake scar super-positioning on the core face and in the recognition of platform surfaces.

The first step in tracing the order in which platform surfaces were struck (from the last platform through to earlier platforms) is to identify the last flake scar created on the core face. The key means of identifying the last flake scar are ridgelines. For instance, the last flake scar is not super-imposed or interrupted by any other flake scar. Furthermore, the last flake scar must be complete whereby the struck surface from which the flake scar was created (i.e. the platform), proximal features (i.e. negative lipping or a negative bulb of percussion) and termination type are retained. The only exception to this (whereby the last flake scar is incomplete) is where taphonomic factors such as breakage and/or thermal damage have partially removed the last flake scar.

The last flake scar indicates the size and shape of the final flake removed from the core face, after which reduction stopped and the core was discarded. The surface from which the last flake scar was created (i.e. the struck surface from which the final flake was detached from the core face) identifies the last platform. This is called platform 1 for the purposes of the present analysis. Observing which flake scars on the core face are superimpositioned by those derived from platform 1 and identifying the surface from hence they were struck, locates platform 2. Repeating this process traces the sequence of platforms on each core from the last to earlier platforms, as illustrated in Figure A14.

The ordering of flake scars on the core face determines the size of individual platforms (i.e. the platform area) and thus the total number of platforms on the core. The method by which platform boundaries are delineated is critical to obtaining consistent and accurate platform counts.
It is not possible in all circumstances to determine the order between particular platforms on a core. This is the case, for example, where flake scars deriving from two alternate platforms do not overlap on the core face. When there is no means of determining the order between particular platforms a random selection between the relevant platforms is made in recording the next platform in the sequence.

Not all platform surfaces on a core are retained. This is because subsequent flake scars deriving from alternate platforms may have removed the platform of previously created scars upon further reduction of the core. Where platform surfaces have been removed (e.g. by subsequent flake scars deriving from an alternate platform) the direction in which the flake was removed (indicated by ripples and undulations on the flake scar surface) and the location of characteristic features within the flake scar area (e.g. the position of the negative bulb of percussion relative to the length of the flake scar on Hertzian initiated fracture) indicates the orientation and approximate distance the struck surface (i.e. the platform) must have been located above the flake scar. These observations are important, as they indicate whether flakes scars without platforms were likely to have been struck from the same platform or were derived from different platforms. This is where consistent and repeatable platforms counts recorded for each core is most susceptible to inter-observer ambiguity and dependent on the level of skill and experience of the lithic analyst.
42. NUMBER OF PLATFORMS AFFECTED Yes / No

This indicates that the total number of platforms recorded on a core is affected by taphonomic impacts (i.e. heat fractures and/or mechanical breakage) and is not a reliable reflection of the morphology of the core at the point when reduction ceased. In other words, this indicates that heat fractures and/or mechanical breakage have modified a core to the extent whereby the total number of platforms recorded is not reliable.

43. THE NUMBER OF FLAKE SCAR DIRECTIONS

Ripples and undulations on the flake scar surface indicate the direction of force as it travelled through the core mass when the flake was detached (Andrefsky, 1998: 18; Wyckoff, 1992: 95). The direction of the force is determined mainly by the stiffness of the flake as it propagates parallel to the surface of the core (Cotterell et al, 1985: 205).
The direction of force is considered for each flake scar created on the core face, such that the number of flake scar directions is counted on each core. The relationship between the total number of platforms and the number of directions of force on a core is closely associated, but does not necessarily directly correspond. This is because a single platform may have more than one direction of force. On the other hand, different platforms on a single core may have flake scars struck along the same direction of force.

There is a continuum of degrees in the direction of force between flake scars as they are orientated on the core face. This continuum may introduce some inter-observer ambiguity in assessments of the number of flake scar directions. For instance, some researchers may be more discrete than others in deciding at which point along this continuum the orientation of the direction of the force is sufficiently altered.

44. THE TOTAL NUMBER OF FLAKE SCARS

The total number of flake scars on each core is counted. For instance:

The Total Number of Flake Scars = the sum of the number of flake scars per platform

\( T \text{ Flakes} = \sum \text{No.Fl.P} \)

The total number of flake scars is equal to the sum of the number of flake scars from each platform.

This count refers to the total number of visible scars on the core face. It bears no resemblance to the total number of flakes that have been removed from the core. It is impossible to estimate the number of flakes that have actually come off any one core and can only be attempted by conjoining in lithic assemblages. Each core depicts the latest flakes removed in the reduction sequence at the point
where knapping ceased and core was discarded. Earlier stages of flaking may be completely eliminated from the face of the core as reduction was continued.

The total number of flake scars can be informative of the extent of reduction. For example, the higher the number of flake scars on a core the more reduction has taken place.

**FLAKE SCAR LENGTH RELATIVE TO SIZE**

45. Ratio of the length of the longest complete flake scar (from platform 1) over the length of the core (from platform 1)

The length of the longest complete flake scar struck from platform 1 is divided by the length of the core measured from platform 1. For instance:

The length of the longest complete flake scar from platform 1 over the length of the core from platform 1 = the length of the longest complete flake scar from platform 1 / length of the core from platform 1

\[ \frac{L_{gCmLCP1}}{L_{ComFP1}} = \frac{L_{gComFP1}}{LCP1} \]

The length of the longest complete flake scar from platform 1 over the length of the core from platform 1 is equal to the length of the longest complete flake platform 1 divided by the length of the core measured from platform 1.

The higher the value, the longer the flake scar relative to the length of the core.
APPENDIX B

STRATIGRAPHIC DETAILS

STRATIGRAPHIC DIFFERENCES ACROSS THE SHELTER

On the whole, Squares N6E1, N6E0 and N6W1 toward the mouth of the shelter followed the main stratigraphic sequence established from Squares N7E2, N6E2 and N5E2 along the rear of the shelter. Yet, stratigraphic differences did occur across the expanse of the shelter and are obvious from the section drawings (see Figures 3.17a and 3.18a).

Prior to outlining stratigraphic differences between squares along the rear with those toward the mouth of the shelter, there are three instances of ambiguity in the identification of particular layers of sediment in the section drawing Figure 3.18a which require clarification. Glover’s text describes Layer 7 as hard packed deposit with many small fragments of limestone (1986: 92), and these are represented in the section drawing of squares N7E2 through to N5E2 along the rear of the shelter (see Figure 3.17a). However, squares N6E1 through to N6W1 towards the mouth of the shelter were not drawn with limestone fragments (see Figure 3.18a), yet generalisations in the description of this layer may lead one to a supposition that a similar abundance of rock fragments also occurred in this part of the trench (Glover, 1986: 92).

In the second instance, Square N6E1 is drawn with two arrows pointing to an enclosed layer about 15 cm below the surface. This layer is enclosed from above by Layer 3 (charcoal, 10YR 4/1) and from below by Layer 4 (light brown, 10YR 6/3).
In the southernmost part of the square (i.e. in the direction toward the rear of the shelter), the arrow pointing to this enclosed layer is labelled 10YR 6/3 (light brown). This enclosed layer extended into the northernmost part of the square (i.e. in the direction toward the mouth of the shelter), where a second arrow is labelled 10YR 5/4 (yellowish brown). The present study interprets these arrows in terms of light brown (10YR 6/3) grading into yellowish brown (10YR 5/4) as this layer extended in the direction toward the mouth of the shelter in N6E1. Speculatively, this instance of ambiguity may have stemmed from a subtle distinction of colour difficult to isolate as a distinct change at any point in the profile.

In the third instance, the layer beneath 10YR 5/2 (grey brown) in N6E1, and which extended into the adjacent N6E0, was not directly labelled in the section drawing (see Figure 3.18a). According to the key, the corresponding infill identifies this layer as either reddish yellow (7.5YR 6/6, 5YR 5/6) or light brown (10YR 6/3). In this instance, ambiguity stems from the application of similar infill, such that the differentiation between these sediments without a direct label is not clear. As reddish/yellow sediments (7.5YR 6/6, 5YR 5/6) are directly labelled in the section drawing (see Figure 3.18a) and also described in the text as being at the base of the trench (Glover, 1986: 92), it seems reasonable to deduce the layer in question, located within the top 30 cm of the trench profile, is light brown in colour (10YR 6/3).

On the basis of these interpretations, the soil profile of Squares N6E1, N6E0 and N6W1 is represented in Table B1.
Table B1 Soil Layers in Squares N6E1, N6EO and N6W1, Bui Ceri Uato

<table>
<thead>
<tr>
<th>SQUARE N6E1</th>
<th>SQUARE N6EO</th>
<th>SQUARE N6W1</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Goat dung (10YR 4/3);</td>
<td>1. Goat dung (10YR 4/3);</td>
<td>1. Goat dung (10YR 4/3);</td>
</tr>
<tr>
<td>2. White ash (7.5 YR 8/0);</td>
<td>2. White ash (7.5 YR 8/0);</td>
<td></td>
</tr>
<tr>
<td>3. Dark grey charcoal rich layer (10YR 4/1);</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Light brown (oxidised soil) (10YR 6/3) / Yellowish brown (10YR 5/4);</td>
<td>4. Light brown (10YR 6/3) / Yellowish Brown (10YR 5/4);</td>
<td>5. Brown (10YR 5/3) (Gradual change);</td>
</tr>
<tr>
<td>Grey brown (10YR 5/2) (Max. thickness approx. 10cm);</td>
<td></td>
<td>Yellowish brown (10YR 5/4)</td>
</tr>
<tr>
<td>4. Light brown (10YR 6/3)</td>
<td></td>
<td>6. Light brownish grey (10YR 6/2)</td>
</tr>
<tr>
<td>7. Yellow red (5YR 5/6)</td>
<td>7. Reddish yellow (7.5YR 6/6) Not excavated to bedrock</td>
<td>7. Reddish yellow (7.5YR 6/6) Not excavated to bedrock</td>
</tr>
</tbody>
</table>

Sourced from Glover, 1986: Fig. 20a.
Bold and numbered identify with layers in the main stratigraphic sequence established from Squares N5E2, N6E2 and N7E2 at the rear of the shelter.
Layers are ordered as they occurred in the soil profile, but are not to scale.
Basal Layer 7 showed slight and gradual variations in colour across the trench.
Yellowish brown (10YR 5/4) and Grey brown (10YR 5/2) did not occur in the stratigraphy at the rear of the shelter. That is to say, yellowish brown (10YR 5/4) and grey brown (10YR 5/2) did not occur in the main stratigraphic sequence constructed at the site.

The following paragraphs outline stratigraphic differences between Squares N7E2 to N5E2 (along the rear of the shelter) and Squares N6E1 to N6W1 (toward the mouth of the shelter), as obvious from the section drawings (see Figures 3.17a and 3.18a).

The set of Layers 2, 3 and 4 (white ash, charcoal rich layer, and pale brown oxidised soil - 10YR 6/3) occurred in deposits along the rear of the shelter (see Figure 3.17a). While Layers 2, 3, and 4 also extended into N6E1, the adjacent N6E0
only contained Layer 2 (white ash), and none of these layers were found in N6W1 at the mouth of the shelter (Table B1). Instead, at the equivalent depth in N6W1, Layer 5 (brown, 10YR 5/3) occurred (see Figure 3.18a). In this way, the sediment profile toward the mouth of the shelter reflected increasing distance from the recent fire event(s) represented by Layers 2, 3 and 4.

Light brown (10YR 6/3) occurred twice in the soil profile of N6E1 (Table B1). The first occurrence was approximately 15 cm from the surface, directly beneath Layers 2 and 3 (ash and charcoal), and can be recognised as oxidised Layer 4 in the main stratigraphic sequence. A second occurrence of light brown (10YR 6/3) directly underlay grey brown (10YR 5/2) and extended across the top 25 cm into the adjacent N6E0 (Table B1). It is uncertain whether this second occurrence of light brown (10YR 6/3) in N6E1 is distinct from that recognised as oxidised Layer 4 in the main stratigraphic sequence. That is, it is uncertain whether these identically coloured sediments contained equivalently deposited materials or, alternatively, were unrelated. This is relevant to the integrity of horizon contents and will be discussed in greater detail later in this chapter.

Two sediment layers occurred outside of the main stratigraphic sequence. The first outlier, a grey brown (10YR 5/2), ranged approximately 10-20 cm below the surface in N6E1 and was likely to have extended into the northeastern portion of the adjacent N6E2 (see Figures 3.17a and 3.18a). Grey brown (10YR 5/2) reached a maximum thickness of about 10 cm and is drawn as a well-defined layer in the sediment profile (see Figure 3.18a). On this basis, it could be reasonable to interpret grey brown (10YR 5/2) in terms of a distinct depositional layer in the stratigraphy.
The second sediment layer outside of the main stratigraphic sequence was yellowish brown (10YR 5/4). This layer occurred as a thin band directly underneath the bed of charcoal in N6E1 and more diffusely within the top 25 cm of N6W1 and the adjacent N6E0 (see Figure 3.18a). It is not certain whether this sediment layer represents fallout from windblown sediments (e.g. in N6E1), or whether its diffuse occurrence across N6E0 and N6W1 toward the mouth of the shelter was a result of post-depositional alteration related to leaching and loss of organics.

Another instance where the stratigraphy differed toward the mouth of the shelter was Layer 5 (brown, 10YR 5/3), which did not occur in N6E1 and N6E0 (Table B1). Instead, Layer 6 (light brownish grey, 10YR 6/2) occurred at the equivalent depth in these squares and was thicker in profile compared to its occurrence at the rear of the shelter (compare Figures 3.17a and 3.18a). This is probably best explained by the accelerated rates of leaching in operation toward the mouth of the shelter.
APPENDIX C

EVIDENCE OF POST-DEPOSITIONAL MOVEMENT

Relevant to describing the cultural contents of Bui Ceri Uato shelter and assessing the integrity of deposits is evidence of post-depositional movement of materials in the trench. This is investigated on the basis of information recorded by Glover (1986), as it is beyond the limited scope of the present study to conduct a more comprehensive analysis. Evidence of post-depositional movement of materials in the trench is primarily restricted to the depth modern artefacts reached below the surface in the trench, distances between conjoined pottery sherds, patterning of sherd counts in each spit, and spatial observations of bone of identical faunal species in the trench (no conjoining of flaked stone artefacts has been undertaken at the site).

MODERN ARTEFACTS

Twelve modern (i.e. European) objects were found in the excavated deposits of Bui Ceri Uato shelter. These included one iron nail, nine pieces of bottle glass, and two pieces of glazed pottery (Glover, 1986: 119). Unfortunately, the provenance of these modern objects was not recorded to square and spit of origin, but to the level of horizon only. The pottery, nail, and four glass fragments were in Horizon X (i.e. at the surface of the trench), and four further pieces of glass were in Horizon IX (i.e. about 20 cm below the surface) (see Figures 3.17b and 3.18a) (Glover, 1986: 119). The bottom of a green Dutch gin bottle was found near the base of the filling of a large intrusive posthole about 65 cm from the surface in N6E2 (see Figure 3.17) (Glover, 1986: 119, Plate 26). Apart from this one piece which was from a
recognised disturbance, there was an absence of modern artefacts below Spit 2 (Glover, 1986: 119). Glover considered this as supporting evidence for the integrity of deposits at the shelter (Glover, 1986: 119).

CONJOINED POTTERY SHERDS

Of the 2,559 sherds in the Bui Ceri Uato assemblage (Glover, 1986: Table 50), only 26 sherds were conjoined. These comprised 12 decorated sherds, 2 ring bases, and 12 rim sherds (Glover, 1986: 112-114, Plate 33a, c-m, Tables 50 and 51). These are ranked in the order of most information value in examining evidence of post-depositional movement of pottery in the trench.

Conjoined decorated sherds indicated horizontal movement was greater than vertical displacement of pottery (Glover, 1986: 113). However, vertical distances between conjoined sherds could only be approximated due to the limited section drawing of spit boundaries (see Figure 3.18c). Nine decorated sherds thought to derive from a single vessel were scattered horizontally across four metres (i.e. across Squares N5E2, N6E2, N6E1 and N7E1) and a vertical distance of about 30 cm apart (i.e. from Spits 4 through to 6) (Glover, 1986: 113, Plate 33e-m). Also, a decorated sherd in Spit 3 of N5E1 (Horizon VIII) may have belonged with a piece from Spit 4 of N5E2 (Horizon VII) (Glover, 1986: 113). These pieces were scattered across two metres and a vertical distance of about 20 cm (see Figures 3.16, 3.17). The greatest disparity between two conjoined decorated sherds occurred between the surface of N6W1 (Horizon X), and Spit 5 of N5E2 (Horizon VII). These pieces were at opposite ends of the trench (i.e. scattered across four metres) and a vertical distance
of approximately 45 cm apart (see Figures 3.16, 3.17, and 3.18) (Glover, 1986: 113, Plate 33a).

One ring base in Spit 1 of N6E0 (Horizon X) conjoined with another in the underlying Spit 2 of the same square (Horizon IX) (Glover, 1986: Plate 33q). This would have required a vertical movement of only about 5 cm in the trench (see Figure 3.18c).

While six rim sherds were conjoined, the distances between the conjoined sherds in the trench are unavailable. This is because the provenance of rim sherds in the trench was not recorded. Consequently, conjoined rim sherds are of little value in assessing post-depositional movement of pottery.

Conjoining of sherds in the Bui Ceri Uato assemblage was severely restricted in scope and undermined by limited recording of provenance of sherds during excavation. As a result, conjoining outcomes were not able to determine the overall extent to which post-depositional movement of pottery sherds was common in the trench and of little value in assessing the integrity of pottery containing deposits at the site.

SHERD COUNTS

In investigating evidence of post-depositional movement of materials in the deposits of Bui Ceri Uato shelter, it is useful to observe sherd counts in each spit. Plain body sherds are the most abundant pottery types at the site (Glover, 1986: Table 50). Unfortunately, these were not provenanced to square and spit of origin (Glover, 1972a: Appendix 8). Consequently, dominant pottery distribution patterns cannot be observed at the site.
Pottery types recorded to square and spit of origin are limited to rim and decorated sherds. However, these comprise only a fraction of the pottery in the Bui Ceri Uato assemblage (Glover, 1986: Table 50). Despite the small sample, combined rim and decorated sherds counts are presented in Table D1. This comprises a limited means of investigating post depositional movement of pottery at the site.

Table D1 Combined rim and decorated sherd counts, Bui Ceri Uato

<table>
<thead>
<tr>
<th>Square/ Spit</th>
<th>Horizon</th>
<th>N6W1</th>
<th>N6E0</th>
<th>N6E1</th>
<th>N6E2*</th>
<th>N7E2</th>
<th>N7E1</th>
<th>N5E2</th>
<th>N5E1</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>X</td>
<td>7</td>
<td>2</td>
<td>2</td>
<td>8</td>
<td>4</td>
<td>7</td>
<td>11</td>
<td></td>
<td>41</td>
</tr>
<tr>
<td>2</td>
<td>IX</td>
<td>7</td>
<td>5</td>
<td></td>
<td>2</td>
<td>9</td>
<td>8</td>
<td></td>
<td></td>
<td>31</td>
</tr>
<tr>
<td>3</td>
<td>VIII</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>10</td>
<td>8</td>
<td>2</td>
<td>3</td>
<td>8</td>
<td>38</td>
</tr>
<tr>
<td>4</td>
<td>VII</td>
<td>7</td>
<td>1</td>
<td>6</td>
<td>7</td>
<td>25</td>
<td>4</td>
<td>18</td>
<td>7</td>
<td>75</td>
</tr>
<tr>
<td>5</td>
<td></td>
<td></td>
<td></td>
<td>4</td>
<td>17</td>
<td></td>
<td></td>
<td></td>
<td>13</td>
<td>34</td>
</tr>
<tr>
<td>6</td>
<td>VI</td>
<td>2</td>
<td>2</td>
<td>20</td>
<td></td>
<td></td>
<td></td>
<td>5</td>
<td></td>
<td>29</td>
</tr>
<tr>
<td>7</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>7</td>
</tr>
<tr>
<td>8</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>9</td>
<td>V</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>24</td>
<td>12</td>
<td>16</td>
<td>70</td>
<td>39</td>
<td>15</td>
<td>55</td>
<td>26</td>
<td>257</td>
</tr>
</tbody>
</table>


The total number of sherds catalogued to spit i.e. 257, is greater than the total of 221 calculated from Glover, 1986: Table 50; included rims, incised and impressed sherds, paddle stamped sherds, burnished body sherds and angular shoulders. I have no forthcoming explanation for this difference of 36 sherds.

Spits without rims or decorated sherds (e.g. Spit 2 of N6E1, N6E2, N5E1 etc.) may still contain pottery, such as plain body sherds.

Spits in adjacent squares may not correspond with absolute precision to equivalent depths in the trench (e.g. Glover, 1986: Fig.20c), and are only presented as such for simplicity.

*N6E2 was the location of major disturbance caused by a protruding posthole.

- Indicates the limit of spits dug in the trench i.e. unexcavated deposit.
Combined rim and decorated sherd counts depict a trickling effect with increasing depth in Squares N6E0, N6E2 and N5E2 (Table D1). This is indicative of post-depositional vertical movement of pottery in the deposit (Spriggs, 1999: 17-18). Square N6E2 was the location of major disturbance caused by a protruding posthole, which extended about 65 cm below the surface (see Figure 3.17) (Glover, 1986: 92). Not surprisingly, this square coincided with the greatest penetration of pottery into the deposit (Table D1).

Pottery bottoms out in Spit 4 in Squares N6W1, N7E2, N7E1 and N5E1 (Table D1). On a preliminary basis, may suggest pottery-containing deposits in these squares may be least impacted by post-depositional disturbances (i.e. compared to pottery-containing deposits in the remainder of the excavation).

In essence, however, rim and decorated sherds comprised were sufficient in number to gauge the extent of post-depositional movements of pottery.

**FAUNAL MATERIAL**

Spatial observations of bone of identical faunal species in the trench can indicate whether post-depositional movement of bone occurred and provides another independent means of assessing the integrity of deposits at Bui Ceri Uato. Unfortunately, the majority of bone was not recorded to square and spit of origin, but only provenanced to the level of horizon (Glover, 1986: 119-122, 214-217). This severely restricts the spatial observations that can be made between bones of identical species in the trench. For instance, it is not possible to make spatial observations of bone of identical species between individual spits, or observe displacement of bone horizontally across the trench. Basically, spatial observation of
bones of the same species is limited to vertical displacement across horizon boundaries, only.

Evidence of vertical movement of faunal material in the trench includes two bones of *Capra/Ovis*. While the majority of *Capra/Ovis* bone occurred in Horizons X, IX, and VIII (Glover, 1986: 216-217), two bones were collected lower in the trench in Horizons IV and II (Glover, 1986: Table 57). The bone in Horizon VI derived from Spit 9 of N7E1 (about 60 cm from the trench surface) and was a fragment of a radius identified as ‘probably’ *Capra/Ovis*. The magnum in Horizon II was collected from Spit 13 of N6E0. As this was the last spit dug in this square, it is possible this bone may have been displaced from overlying deposits during excavation (see Figure 3.18c) (Glover, 1986: Table 37). Glover suspected these two bones at these depths resulted from unrecognised disturbance, and were unlikely to reflect an early arrival of *Capra/Ovis* to eastern Timor (Glover, 1986: 122).

Relevant to the vertical displacement of bone in the deposits of the shelter, is whether bone of identical species but found in adjacent horizons were likely to have derived from the same individual. Glover (1986) counted bone of identical species in different horizons as separate individuals, and this was preferred over the likelihood of disarticulation followed by vertical displacement of individuals in the deposits of the shelter. For example, dog bone occurred in Horizons X, IX, VIII, VII and VI, but there were never more than two dog bones in any one horizon (Glover, 1986: 121). While Glover recognised that some dog bone in different horizons could have belonged to the same individual, he argued against any extensive disturbance of the deposit and that multiple individuals were represented (1986: 121). Similarly, bovid
and monkey bone were distributed across Horizons VIII, VII and VI, and Horizons IX and VIII, respectively, and were counted by Glover as separate individuals in each horizon (1986: Table 57, Appendix 1). Specialist faunal analysis is required to determine the likelihood such bone of dog, bovid and monkey in the relevant horizons may have derived from individual animals distributed in the trench. This would provide empirical evidence of post-depositional vertical movement of bone material and one means of assessing the overall integrity of deposits in the shelter. Until such specialist examination, the distribution of dog, bovid and monkey bone in Horizons X through to VI should be treated with caution and, contrary to Glover (1986: 121), most likely represents vertical movement of individual animal bones within the deposits of the shelter.

In summary, the depth of modern artefacts in Bui Ceri Uato shelter did not indicate disturbed deposits near the surface of the trench. Although severely limited in sample size, preliminary evidence from spatial observations of pottery and bone are suggestive of some post-depositional movement of these materials within the deposits of the shelter. Further investigation is required to determine the extent to which post-depositional movement affects materials in the trench and levels of disturbance, as well as the overall integrity of the site. This is crucial, as it necessarily underpins the accuracy of statements/interpretations regarding human behaviour based on materials excavated from the shelter.
## APPENDIX D

**RADIOCARBON DATES WITH DELTA CONCENTRATIONS**

Appendix D presents a complete list of radiocarbon dates obtained by this study at Bui Ceri Uato shelter. Physical and chemical pre-treatment information of the samples and carbon determinations are as provided by the Australian National University Radiocarbon Dating Laboratory.

<table>
<thead>
<tr>
<th>Laboratory code</th>
<th>Submitter's code</th>
<th>Sample material</th>
<th>Physical pretreatment</th>
<th>Chemical pretreatment</th>
<th>$d^{14}C$ (per mil)</th>
<th>$\delta^{13}C$ (per mil)</th>
<th>$D^{14}C$ (per mil)</th>
<th>Conventional age (years bp)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ANU-11739</td>
<td>AM3</td>
<td>Marine shell</td>
<td>Surfaces cleaned with a dental drill. Sample was washed in an ultrasound bath, rinsed and dried.</td>
<td>None</td>
<td>-469.2 ± 3.7</td>
<td>0.9 ± 0.2</td>
<td>-496.7 ± 3.5</td>
<td>5520 ± 60</td>
</tr>
<tr>
<td>ANU-11878</td>
<td>AM8</td>
<td>Marine shell</td>
<td>Surfaces cleaned with a dental drill. Sample was washed in an ultrasound bath, rinsed and dried.</td>
<td>None</td>
<td>-751.3 ± 2.4</td>
<td>0.0 ± 2.0</td>
<td>-763.7 ± 2.5</td>
<td>11590 ± 90</td>
</tr>
<tr>
<td>ANU-11879</td>
<td>AM9</td>
<td>Marine shell</td>
<td>Surfaces cleaned with a dental drill. Sample was washed in an ultrasound bath, rinsed and dried.</td>
<td>None</td>
<td>-681.3 ± 2.7</td>
<td>0.0 ± 2.0</td>
<td>-697.3 ± 2.9</td>
<td>9600 ± 80</td>
</tr>
<tr>
<td>ANU-11877</td>
<td>AM7</td>
<td>Marine shell</td>
<td>Surfaces cleaned with a dental drill. Sample was washed in an ultrasound bath, rinsed and dried.</td>
<td>None</td>
<td>-744.8 ± 2.5</td>
<td>0.0 ± 2.0</td>
<td>-757.6 ± 2.5</td>
<td>11380 ± 90</td>
</tr>
<tr>
<td>ANU-11737</td>
<td>AM1</td>
<td>Marine shell</td>
<td>Surfaces cleaned with a dental drill. Sample was washed in an ultrasound bath, rinsed and dried.</td>
<td>None</td>
<td>-714.0 ± 3.5</td>
<td>1.2 ± 0.2</td>
<td>-729.0 ± 3.3</td>
<td>10490 ± 100</td>
</tr>
<tr>
<td>ANU-11738</td>
<td>AM2</td>
<td>Marine shell</td>
<td>Surfaces cleaned with a dental drill. Sample was washed in an ultrasound bath, rinsed and dried.</td>
<td>None</td>
<td>-961.1 ± 1.6</td>
<td>1.4 ± 0.2</td>
<td>-963.2 ± 1.5</td>
<td>26520 ± 340</td>
</tr>
<tr>
<td>ANU-11740</td>
<td>AM4</td>
<td>Marine shell</td>
<td>Surfaces cleaned with a dental drill. Sample was washed in an ultrasound bath, rinsed and dried.</td>
<td>None</td>
<td>-632.7 ± 3.0</td>
<td>1.7 ± 0.2</td>
<td>-652.3 ± 2.8</td>
<td>8490 ± 70</td>
</tr>
<tr>
<td>Sample ID</td>
<td>Type</td>
<td>Preparation Method</td>
<td>Treatment</td>
<td>Zn (mg/kg)</td>
<td>Pb (mg/kg)</td>
<td>U (mg/kg)</td>
<td>Radioactivity (Bq/L)</td>
<td></td>
</tr>
<tr>
<td>-----------</td>
<td>------</td>
<td>------------------------------------------------------------------------------------</td>
<td>-----------</td>
<td>------------</td>
<td>------------</td>
<td>-----------</td>
<td>----------------------</td>
<td></td>
</tr>
<tr>
<td>ANU-11741</td>
<td>AM5</td>
<td>Marine shell</td>
<td>None</td>
<td>-536.3 ± 5.5</td>
<td>1.0 ± 0.2</td>
<td>-560.4 ± 5.2</td>
<td>6600 ± 100</td>
<td></td>
</tr>
<tr>
<td>ANU-11742</td>
<td>AM6</td>
<td>Charcoal</td>
<td>Sample was washed in hot 10% ABA, rinsed and dried.</td>
<td>-45.2 ± 6.8</td>
<td>-26.8 ± 0.2</td>
<td>-41.7 ± 6.8</td>
<td>340 ± 60</td>
<td></td>
</tr>
</tbody>
</table>
## APPENDIX E

### RADIOCARBON DETERMINATIONS AND CAL. YEARS BP

<table>
<thead>
<tr>
<th>Lab Code</th>
<th>Horizon</th>
<th>Horizon depth below surface (cm)</th>
<th>Overlap between adjacent Horizons (cm)</th>
<th>Sample Material</th>
<th>Weight (grms)</th>
<th>Conventional radiocarbon age (years BP)</th>
<th>Cal. years BP (two sigma)</th>
</tr>
</thead>
<tbody>
<tr>
<td>11741</td>
<td>VIII</td>
<td>20-30</td>
<td>X-IX=0; IX-VIII=0; VIII-VII=10</td>
<td>Lambis lambis</td>
<td>37</td>
<td>6,600 ± 100</td>
<td>7,260-6,783</td>
</tr>
<tr>
<td>11740</td>
<td>VII</td>
<td>20-50</td>
<td>VII-VI=5</td>
<td>Trochus maculatus</td>
<td>38</td>
<td>8,490 ± 70</td>
<td>9,256-8,788</td>
</tr>
<tr>
<td>11739</td>
<td>VI</td>
<td>45-70</td>
<td>VI-V=5-10</td>
<td>Lambis lambis</td>
<td>32</td>
<td>5,520 ± 60; 340 ± 60</td>
<td>5,967-5,661-505-297</td>
</tr>
<tr>
<td>11742</td>
<td></td>
<td>45-55</td>
<td></td>
<td>Charcoal (N6E1 Spit 7)</td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11879</td>
<td>V</td>
<td>60-90</td>
<td>V-IV=10-15; IV-III=5-20; III-II=5-15</td>
<td>Turbo marmoratus</td>
<td>76</td>
<td>9,600 ± 80</td>
<td>10,549-10,216</td>
</tr>
<tr>
<td>11878</td>
<td>IV</td>
<td>75-100</td>
<td></td>
<td>Turbo marmoratus</td>
<td>88</td>
<td>11,590 ± 90</td>
<td>13,191-12,886</td>
</tr>
<tr>
<td>11877</td>
<td>III</td>
<td>80-110</td>
<td></td>
<td>Turbo marmoratus</td>
<td>61</td>
<td>11,380 ± 90</td>
<td>13,059-12,789</td>
</tr>
<tr>
<td>11737</td>
<td>II</td>
<td>95-130</td>
<td></td>
<td>Trochus maculatus</td>
<td>269</td>
<td>10,490 ± 100; 26,520 ± 340</td>
<td>11,912-11,219; 30,660-29,200 (provisional)</td>
</tr>
<tr>
<td>11738</td>
<td>I</td>
<td>120-145</td>
<td>I-II=10</td>
<td>Strombus sp. (2 specimens)</td>
<td>51 (in total)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Horizon depths below the surface and the depth overlap between adjacent horizon boundaries are approximated and derive from Table 3.4. Ages are calibrated to calendar years using CALIB 5.0 (Stuiver and Reimer, 1993) with a regional deltaR correction factor of the northwestern Australia/Java region (AR = 67 ± 24; P. J. Stuiver, pers. comm. 2006; Marine Reservoir Correction Database).

The ANU-11739 calibration should be considered provisional, calibrated with a program developed by Richard Gillespie (R. Gillespie, pers. comm.)
APPENDIX F
RECRYSTALLIZATION

ANU-11878 (Brown)

ANU-11878 (White)

368
ANU-11878

97.4 % Aragonite
2.6 % Calcite
APPENDIX G
AGE/DEPTH CALCULATIONS

<table>
<thead>
<tr>
<th>Lab Code</th>
<th>Horizon</th>
<th>Horizon depth below surface (cm)</th>
<th>Calendar years (two sigma) (BP)</th>
<th>Assumed depth adopted for age/depth curve (cm)</th>
<th>Assumed midpoint for age/depth curve (cal. BP)</th>
</tr>
</thead>
<tbody>
<tr>
<td>X</td>
<td>0-5</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IX</td>
<td>5-20</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ANU-11741</td>
<td>VIII</td>
<td>20-30</td>
<td>7,260-6,783</td>
<td>25</td>
<td>7,022</td>
</tr>
<tr>
<td>ANU-11740</td>
<td>VII</td>
<td>20-50</td>
<td>9,256-8,788</td>
<td>35</td>
<td>9,022</td>
</tr>
<tr>
<td>ANU-11879</td>
<td>V</td>
<td>60-90</td>
<td>10,549-10,216</td>
<td>75</td>
<td>10,383</td>
</tr>
<tr>
<td>ANU-11878</td>
<td>IV</td>
<td>75-100</td>
<td>13,191-12,886</td>
<td>103</td>
<td>12,990</td>
</tr>
<tr>
<td>ANU-11877</td>
<td>III</td>
<td>80-110</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ANU-11738</td>
<td>I</td>
<td>95-130</td>
<td>13,059-12,789</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>120-145</td>
<td>30,660-29,200</td>
<td>133</td>
<td>29,930</td>
</tr>
</tbody>
</table>

Bui Ceri Uato shell cal. BP and lab code, horizon depth ranges, the assumed depth of the dated shell samples and cal. BP midpoint adopted in the construction of the age/depth curve. The depth below the surface of each horizon are approximates and derive from Table 3.4 based on section drawings of Squares N7E2, N6E2, N5E2 and N6W1, N6E0, N6E1 (see Figures 3.17 and 3.18). Squares N7E1 and N5E1 could not be included. Samples ANU-11737, -11739 and -11742 were excluded from the construction of the age/depth curve because the present study considers these samples as not representative of the age of the majority of deposits at equivalent depths (see Chapter 6).
## APPENDIX H

### FLAKED STONE ARTEFACT DISCARD CALCULATIONS

Subgroups and flaked stone artefact discard rate calculations, Bui Ceri Uato

<table>
<thead>
<tr>
<th>Subgroup</th>
<th>cal. BP (duration)</th>
<th>Volume (m³)</th>
<th>Total # flaked stone</th>
<th>Total # of flaked stone/m³</th>
<th>Total # flaked stone/m³/100 yrs</th>
<th># cores/m³</th>
<th># cores/m³/100 yrs</th>
<th>Total number of flakes</th>
<th>Core:Flake ratio m³/100 yrs</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>9,022-Present (9,022)</td>
<td>4.5</td>
<td>14,821</td>
<td>3,293.6</td>
<td>36.5</td>
<td>19.8</td>
<td>0.2</td>
<td>14,732</td>
<td>1:181.4</td>
</tr>
<tr>
<td>3</td>
<td>10,383-9,022 (1,361)</td>
<td>1.0</td>
<td>6,161</td>
<td>6,161.0</td>
<td>452.7</td>
<td>55.0</td>
<td>4.0</td>
<td>6,106</td>
<td>1:112.2</td>
</tr>
<tr>
<td>2</td>
<td>12,990-10,383 (2,607)</td>
<td>2.7</td>
<td>16,630</td>
<td>6,159.3</td>
<td>236.3</td>
<td>78.9</td>
<td>3.0</td>
<td>16,417</td>
<td>1:77.7</td>
</tr>
<tr>
<td>1</td>
<td>29,930-12,990 (16,940)</td>
<td>0.5</td>
<td>1,967</td>
<td>3,934.0</td>
<td>23.2</td>
<td>76.0</td>
<td>0.4</td>
<td>1,929</td>
<td>1:56.9</td>
</tr>
</tbody>
</table>

Volume is derived from Glover (1986: Table 38).
The total number of flaked stone artefacts are derived from Glover (1986: Table 41), minus six non-artefactual specimens identified by the present study (Appendix I).
The total number of flakes derive from Glover 1986: Table 41), minus six non-artefactual specimens (Appendix I) and cores (see Table 6.1).
**APPENDIX I**

Cores identified by the present study contrasted with Glover’s (1986) lithic classification at Bui Ceri Uato

Of those classed by Glover as cores, the present study identified:

<table>
<thead>
<tr>
<th>Horizon/Glover’s class of flaked stone artefact</th>
<th>Retouched flakes</th>
<th>Flakes</th>
<th>Trimming flakes</th>
<th>Not artefactual</th>
<th>Waste flakes</th>
<th>Miscellaneous and irregular flakes</th>
<th>Scrapers</th>
<th>Trimming flakes</th>
<th>Utilised flake</th>
</tr>
</thead>
<tbody>
<tr>
<td>X</td>
<td>2</td>
<td></td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IX</td>
<td>21</td>
<td>3</td>
<td></td>
<td></td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VIII</td>
<td>35</td>
<td>10</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VII</td>
<td>65</td>
<td>8</td>
<td></td>
<td></td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VI</td>
<td>84</td>
<td>4</td>
<td></td>
<td></td>
<td>5</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>V</td>
<td>63</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td>8</td>
<td>2</td>
<td>2</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>IV</td>
<td>65</td>
<td>1</td>
<td></td>
<td>8</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>III</td>
<td>64</td>
<td>1</td>
<td>1</td>
<td>8</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>II</td>
<td>60</td>
<td>7</td>
<td>1</td>
<td>6</td>
<td>2</td>
<td>3</td>
<td>1</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>I</td>
<td>22</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td></td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td><strong>Totals</strong></td>
<td><strong>481</strong></td>
<td><strong>39</strong></td>
<td><strong>1</strong></td>
<td><strong>6</strong></td>
<td><strong>33</strong></td>
<td><strong>11</strong></td>
<td><strong>7</strong></td>
<td><strong>7</strong></td>
<td><strong>5</strong></td>
</tr>
</tbody>
</table>

527 63

372
### APPENDIX J

Cores originally classed in flake categories in Glover (1986) and provisionally allocated an identification number by the present study, Bui Ceri Uato

ID numbers begin at 10,000 in order not to overlap with flaked stone ID numbers allocated by Glover (1972: Appendix 8).

<table>
<thead>
<tr>
<th>ID Number</th>
<th>Horizon</th>
<th>Glover's classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 000</td>
<td>IX</td>
<td>Waste flake</td>
</tr>
<tr>
<td>10 001</td>
<td>VIII</td>
<td>utilised fl N5E2/3</td>
</tr>
<tr>
<td>10 010</td>
<td>VII</td>
<td>Waste flake</td>
</tr>
<tr>
<td>10 016</td>
<td>VI</td>
<td>Waste flake</td>
</tr>
<tr>
<td>10 017</td>
<td>VI</td>
<td>Core (ID number erased)</td>
</tr>
<tr>
<td>10 018</td>
<td>VI</td>
<td>Waste flakes</td>
</tr>
<tr>
<td>10 021-22</td>
<td>VI</td>
<td>Waste flakes</td>
</tr>
<tr>
<td>10 033</td>
<td>VI</td>
<td>Waste Flakes</td>
</tr>
<tr>
<td>10 037</td>
<td>V</td>
<td>Waste Flakes</td>
</tr>
<tr>
<td>10 038-39</td>
<td>V</td>
<td>Waste Flakes</td>
</tr>
<tr>
<td>10 041</td>
<td>V</td>
<td>Waste Flakes</td>
</tr>
<tr>
<td>10 045</td>
<td>IV</td>
<td>Waste Flakes</td>
</tr>
<tr>
<td>10 046</td>
<td>IV</td>
<td>Waste Flakes</td>
</tr>
<tr>
<td>10 047</td>
<td>IV</td>
<td>Waste Flakes</td>
</tr>
<tr>
<td>10 048</td>
<td>IV</td>
<td>Waste Flakes</td>
</tr>
<tr>
<td>10 050</td>
<td>IV</td>
<td>Waste Flakes</td>
</tr>
<tr>
<td>10 053-55</td>
<td>IV</td>
<td>Waste Flakes</td>
</tr>
<tr>
<td>10 056-59</td>
<td>III</td>
<td>Waste Flakes</td>
</tr>
<tr>
<td>10 073-76</td>
<td>III</td>
<td>Waste Flakes</td>
</tr>
</tbody>
</table>

| 10 062    | II      | Utilised flake N7E1/11  |
| 10 063    | II      | Utilised flake N6E1/12  |
| 10 064    | II      | Utilised flake N6E2/12  |
| 10 066-68 | II      | Waste Flakes            |
| 100 70-72 | II      | Waste Flakes            |
| 10 078    | I       | Waste Flake             |