

https://dspace.org/

Assessing core reduction strategies in the Early Acheulean of East and South Africa

Moll, Rosa Matsileng

2024

https://hdl.handle.net/10539/37507

Downloaded from a DSpace repository. https://dspace.org/

Assessing core reduction strategies in the Early Acheulean of East and South Africa

Rosa Matsileng Moll

Student number: 558026

Supervisors:

Prof Kathleen Kuman

Prof Ignacio De la Torre

Prof Dominic Stratford



A thesis submitted to the School of Geography, Archaeology and Environmental Studies, Faculty of Science, University of the Witwatersrand, Johannesburg, in fulfilment of the requirements for the degree of Doctor of Philosophy.

December 2022

Declaration

I declare that this thesis is my own, unaided work. It is being submitted for the Degree of Doctor of Philosophy at the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination at any other University.



(Signature of candidate)

9th day of December 2022 at Johannesburg

Abstract

The earliest phase of the Acheulean technocomplex is represented in archaeological sites across East and South Africa. Typologically, there is some similarity between these regions, but little is known about how lithic technological strategies compare. If archaeological assemblages in East and South Africa compare, it could provide some detail into the regional technological evolution and how that is linked to hominid behaviour. Through a technological analysis of the core and Large Cutting Tool (LCT) assemblages from three South African sites (Sterkfontein M5W in the Cradle of Humankind, two layers from Pit 6 in Canteen Kopje, and two pits at Rietputs 15) and EF-HR, in Olduvai Gorge, Tanzania, comparable reduction strategies appear to have been practiced. At each site, the LCT and core flaking strategies are distinct processes, but in both cases the edge management sequences are similar (bifacial, alternating, and unifacial). Blank shape and edge angles are shown to be more relevant to reduction strategies than the size or raw material type of the blank.

Throughout the earliest phase of the Acheulean technocomplex >1.5 Ma there appears to be a progressive change in core reduction strategies. In the earliest assemblages, cores are generally exploited along multiple surfaces with no structured organisation of flake scars. In slightly younger deposits at EF-HR, the Organised Core Technology layer and Canteen Kopje, and Pits 5 at Rietputs 15, ca 1.3 Ma, there is a shift to structured flaking of a core edge or surface, as well as continuous, intensive, organised and sometimes hierarchal reduction strategies. These reduction patterns are precursors to later technological developments such as the Victoria West prepared core industry.

LCTs were primarily shaped using bifacial means, both traditional and alternating. The shape of the blank was more important for edge management, as acute angles required fewer flake scars to manipulate. These sequences reveal forethought about artefact production, which is comparable to continuous and structured core reduction sequences. Like cores, work needs to be done to understand if there are progressive changes in LCT production during the early Acheulean.

Dedication

I dedicate this thesis to two of the best teachers and mentors I have ever had:

My grandfather, Théo Schneider

and

My other mother, Kathy Kuman

Acknowledgements

There are many thanks to be given for this thesis. Firstly, I want to thank the funders, Genus Palaeo and the Leakey Foundation, for awarding me the Baldwin Fellowship. Without their support, this research would not have been possible.

Thanks need to go to my supervisors for their support and mentorship. Kathy, I will never not learn from you, and I cherish being guided by you. Ignacio, you have taught me so much and given me opportunities I will carry for my entire career. Dominic, thank you for giving me the trust to grow as a researcher and laughing with me.

To my family, Ian, Margie, Megan, Slo, Helen, Karin, Lucy, Sheila, Nicci, Oli, Tasnim, Philippe, Robin, Rina, Barry, Jodie, Leslie, Jacques, Brigitte, and Coralie. I cannot put into words what you have done for me. Especially thanks to my nephew Aloïs for being born and giving me a happy distraction.

My friends have stuck by me through all the chaos and for that I am eternally indebted. Robyn, Geeta, Tamara, Vedhant, Nick, Dan, Lamisa, Nadine, Lee, Bevin, Caitlin, Louise, Gabi, Lucille, Ahmed, Makha, Cassey, and Natalie. To my dear friends who are PhD candidates and colleagues, Philippe, Kelita, Pamela, David, Iris, Carmen, Caitlin, Adela, Silindo, Mpumi, Recognise, Matt, Steph, and Abenicia. To my Partner Zwelakhe, thank you for your love.

I can honestly say this thesis would not have happened without all of your unwavering support. I will be contacting you all to give my specific thanks as these acknowledgements are not enough.

To all the technicians and staff at Sterkfontein, the McGregor Museum, and Olduvai Gorge, our research would not be possible without you all. Thank you for dealing with us PhD students who are lost and confused.

Finally, thank you to my examiners for their thoughtful comments, and for taking the time to review my thesis in a time when the world is chaotic and overwhelming.

Contents

Declaration ..... **i**

Abstract ..... **ii**

Dedication ..... **iii**

Acknowledgements ..... **iv**

Contents ..... **v**

List of Figures ..... **xi**

List of Tables ..... **xx**

Abbreviations ..... **xxi**

Chapter 1: Introduction **1**

1.1 Research questions 2

1.2 Hypothesis 3

1.3 Aims 3

1.4 Rationale 4

1.5 Organisation of thesis 4

Chapter 2: Literature Review **5**

2.1 Introduction 5

2.2 Earlier Stone Age 5

2.2.1 Nomenclature: Technocomplex 6

2.2.2 The Lomekwian and the Oldowan 7

2.3 Acheulean 12

2.3.1 The Acheulean technocomplex 12

2.3.2 ‘Organised’ core technology 14

2.3.3 Progression in core reduction 17

2.3.4 Knapping skill in the ESA 17

2.4 The question of transitions for the Earlier Stone Age 18

2.4.1 Developed Oldowan 18

2.4.2 Acheulean sites with few LCTs 19

2.5 Who made the Earlier Stone Age? 21
2.5.1 Hominids associated with the Acheulean 22
2.6 Approaches to lithic analysis in the ESA 23
2.6.1 Typological approach 24
2.6.2 Technological approach 25
2.6.3 Theories of technological approaches 26
2.6.4 Technological analysis in the ESA 27
2.6.5 The focus on large cutting tools 29
2.7 The influence of raw material on core reduction strategies 31
Chapter 3: Materials and Methods 33
3.1 Materials 33
3.1.1 The early Acheulean sites used in this thesis 35
3.2 Methods 50
3.2.1 Core reduction strategies 50
3.2.2 Attribute analysis 55
3.2.3 Large cutting tools 58
3.2.4 Refinement Index 60
3.2.5 Diacritical analysis 60
3.2.6 Statistical analysis 61
3.2.7 Early Acheulean in Africa 62
Chapter 4: Results: Sterkfontein Caves 63
4.1 General observations 63
4.2 Raw material 63
4.3 Cores 64
4.3.1 Raw material 64
4.3.2 Core reduction strategies 65
4.3.3 Cores with multiple core edge management strategies 67
4.3.4 Core weights and dimensions 69
4.3.5 Flake scars 70

4.3.6 Core reduction schemes and weight 71
4.3.7 Core blanks 73
4.3.8 Largest flake scars 75
4.3.9 Diacritical analyses of cores 77
4.4 Large cutting tools 87
4.4.1 Raw materials 87
4.4.2 Weight and dimensions 88
4.4.3 Refinement Index 89
4.4.4 Flake scars 90
4.4.5 Large cutting tool blanks 90
4.4.6 Shaping strategies 91
4.4.7 Diacritical analyses of LCTs 93
4.5 Technological trends at Sterkfontein 101
Chapter 5: Results: Rietputs 15 103
5.1 General observations 103
5.2 Cores 103
5.2.1 Raw material 103
5.2.2 Idealised core reduction schemes 104
5.2.3 Weight and dimensions of cores 106
5.2.4 Flake scars 107
5.2.5 Core reduction schemes and weight 108
5.2.6 Remaining cortex 109
5.2.7 Blanks 110
5.2.8 Largest flake scars 111
5.2.9 Diacritical analyses of cores 114
5.3 Large cutting tools 120
5.3.1 Raw material 121
5.3.2 Weight and dimensions of LCTs 121
5.3.3 Refinement Index 124

5.3.4 Blanks 124
5.3.5 Shaping strategies 124
5.3.6 Flake scars 127
5.3.7 Diacritical analyses of LCTs 129
5.4 Comparing the core reduction strategies and LCT production 135
5.5 Technological trends at Rietputs 15 135
Chapter 6: Results: Canteen Kopje 137
6.1 General observations 137
6.2 Raw material 138
6.3 Cores 138
6.3.1 Idealised core reduction schemes 138
6.3.2 Cores with multiple idealised schemes 140
6.3.3 Raw material distribution by idealised scheme 140
6.3.4 Dimensions 141
6.3.5 Core weight and idealised schemes 144
6.3.6 Flake scars 145
6.3.7 Core blanks 146
6.3.8 Largest flake scars 149
6.3.9 Diacritical analyses of cores 152
6.4 LCTs 161
6.4.1 Raw material 161
6.4.2 Weight and dimensions of LCTs 161
6.4.3 Refinement Index 164
6.4.4 LCT blanks 164
6.4.5 Flake scars and shaping strategies 165
6.4.6 Diacritical analyses of LCTs 166
6.5 The core reduction strategies and LCT production 171
6.6 Technological trends at Canteen Kopje 171
Chapter 7: Results: EF-HR 172

7.1 General observations 172
7.2 Raw material 172
7.3 Cores 173
7.3.1 Size and weight of cores 176
7.3.2 Weight and flake scars 177
7.3.3 Core reduction strategies and weight 178
7.3.4 Remaining cortex 180
7.3.5 Core blanks 180
7.3.6 Largest flake scars 182
7.3.7 Diacritical analyses of cores 185
7.4 Large cutting tools 195
7.4.1 Raw material 195
7.4.2 Size and weight dimensions 195
7.4.3 Refinement Index 197
7.4.4 Shaping strategies and edge management 198
7.4.5 Flake scars 199
7.4.6 Blanks 200
7.4.7 Scars and flips 201
7.4.8 Diacritical analyses of LCTs 201
7.5 Technological trends at EF-HR 210
Chapter 8: Comparison between sites 212
8.1 Cores 212
8.1.1 Raw material and blank types 212
8.1.2 Flake scars 214
8.1.3 Organised core reduction strategies 214
8.1.4 Cores with multiple idealised schemes 215
8.1.5 Reduction intensity 216
8.1.6 Bipolar reduction 217
8.1.7 Principal component and correspondence analysis 217

8.2 Large cutting tools 221
8.2.1 Raw material 222
8.2.2 LCT blanks 222
8.2.3 Shaping strategies 223
8.2.4 Refinement Index 223
8.2.5 Shaping scars and flipping 225
8.2.6 Principal component and correspondence analysis 225
8.3 Summary 227
Chapter 9: Discussion and conclusion 228
9.1 Discussion 228
9.1.1 Idealised schemes of core reduction strategies 228
9.1.2 Technological behaviours identified in the core assemblages 229
9.1.3 LCT shaping strategies 232
9.2 The early Acheulean in East and South Africa 234
9.3 Conclusion 238
Reference list 241
Appendix 1: Wentworth (1922) Scale 266
Appendix 2: Leader 2014 Table 5.2.2 267
Appendix 3: Refinement Indices for Africa 268
Appendix 4: Weight ranges of idealised schemes of core reduction 269
Appendix 5: PCA of LCTs with Canteen Kopje assemblages 272

List of Figures

Figure 1.1: A map of the sites studied within South and East Africa 3
Figure 2.1: The definition and breakdown of a technocomplex used in this thesis (from Lombard et al. 2012) 7
Figure 2.2: Schematic representation of freehand core reduction strategies as presented in Diez-Martín et al. (2009) 29
Figure 3.1: The location of the Sterkfontein Caves within the Cradle of Humankind and in South Africa (image from Stratford et al. 2012) 38
Figure 3.2: Aerial photo of the excavation site at Sterkfontein Caves (Photo courtesy of Dominic Stratford) 38
Figure 3.3: Map of Members 4 and 5 from Sterkfontein Caves (Image from Couzens 2021) 39
Figure 3.4: Oldowan cores from Sterkfontein Caves (from Kuman 1994) 40
Figure 3.5: Early Acheulean cores from Sterkfontein Caves (from Field 1999). 41
Figure 3.6: A list of the LCTs from Sterkfontein Caves (from Kuman and Gibbon 2018). 43
Figure 3.7: Map of Rietputs 15 (Image from Leader et al. 2018). 44
Figure 3.8: A profile view of the stratigraphy of Rietputs 15 Pit 5 (A) and the stratigraphic layers of Pit 5 and the relevant depths (B) (images from Leader 2009). 45
Figure 3.9: Map of Canteen Kopje site (image from Leader 2014) 46
Figure 3.10: A bird's eye view of EF-HR, with the locations of the various trenches (image take from de la Torre and Mora 2018b) 49
Figure 3.11: The excavated T2-Main Trench and T9 from EF-HR (image taken from de la Torre and Mora 2018b) 49
Figure 3.12: An example of cores from the EF-HR assemblage (from de la Torre and Mora 2018b) 50
Figure 3.13: Idealised schemes of free-hand core reduction 54
Figure 3.14: The blank types from Field (1999: 39). 58
Figure 3.15: Idealised schemes of LCT shaping sequences (image created by R. Moll). 59
Figure 3.16: Idealised scheme of a ‘rhomboid’ shaping sequence (the dotted lines indicate the opposite side and edge of the piece) (image created by R. Moll). 59
Figure 4.1: Raw material distributions from the early Acheulean core and LCT assemblages 64
Figure 4.2: Raw material distribution in cores 64
Figure 4.3: Core reduction strategies 65
Figure 4.4: Percentage of raw material in the reduction strategies 66
Figure 4.5: Cores with multiple idealised schemes 68

Figure 4.6: Box and whisker plots of the weight (g) (A) and the dimensions (mm) of the core assemblage (B) 69
Figure 4.7: Weight classes of cores (g) 70
Figure 4.8: Correlation between weight (g) and number of flake scars 71
Figure 4.9: Weight ranges for core reduction strategies 72
Figure 4.10: Remaining cortex 73
Figure 4.11: Core blank types. The term ‘pebble’ here follows the size category from the Wentworth scale (1929, Appendix 1) 74
Figure 4.12: Percentage of blank types in core reduction strategies 75
Figure 4.13: Largest flake scar terminations of freehand cores. 76
Figure 4.14: Percentage of largest flake scar terminations by core reduction strategies 76
Figure 4.15: LFS terminations distributed by raw material 77
Figure 4.16: Artefact 1409 78
Figure 4.17: Artefact 9459 78
Figure 4.18: Artefact 443 79
Figure 4.19: Artefact SEA 40 79
Figure 4.20: Artefact 1420 80
Figure 4.21: Artefact SEA 65 81
Figure 4.22: Artefact 334 81
Figure 4.23: Artefact 9698 82
Figure 4.24: Artefact 9619 82
Figure 4.25: Artefact SEA 152 83
Figure 4.26: Artefact 10039 83
Figure 4.27: Artefact 222 84
Figure 4.28: Artefact 9662 85
Figure 4.29: Artefact 9479 85
Figure 4.30: Artefact Stk13-7 86
Figure 4.31: Artefact 1410 87
Figure 4.32: A: Weight ranges (g) and B: maximum length, width, and thickness (mm) of LCTs 88
Figure 4.33: Correlation between weight (g) and maximum length, width, and thickness (mm) 89
Figure 4.34: Number of scars on LCTs (A), and correlation between number of scars and weight (g) (B) 90
Figure 4.35: LCT blank types 90
Figure 4.36: Range of scar numbers by blank types 91
Figure 4.37: Shaping strategies 92

Figure 4.38: Number of flake scars by shaping strategy 92
Figure 4.39: Artefact 2373 93
Figure 4.40: Artefact 10120 94
Figure 4.41: Artefact 10363 95
Figure 4.42: Artefact 9690 95
Figure 4.43: Artefact 6612 96
Figure 4.44: Artefact 2060 97
Figure 4.45: Artefact 2054 97
Figure 4.46: Artefact 2066 (Image from Kuman and Gibbon 2018) 98
Figure 4.47: Artefact 10016 98
Figure 4.48: Artefact 9481 99
Figure 4.49: Artefact Stk13-11 100
Figure 4.50: Artefact 5860 100
Figure 5.1: Raw material in the ACP core assemblage, by both number and percentage. 104
Figure 5.2: Idealised core reduction schemes 105
Figure 5.3: Percentages of raw material by idealised core scheme 106
Figure 5.4: A: Weight (g) and B: maximum length, width, and thickness (mm) of cores 106
Figure 5.5: Weight (g) ranges of cores 107
Figure 5.6: Correlation between the weight (g) and the number of scars on cores 108
Figure 5.7: Weight ranges of core reduction strategy groups 109
Figure 5.8: Number of cores with amount of remaining cortex (%) 110
Figure 5.9: Blank types of cores 110
Figure 5.10: Percentage of core blank types in the core reduction strategies 111
Figure 5.11: Largest flake scar types on cores 112
Figure 5.12: Percentages of largest flake scar types in idealised core reduction schemes 113
Figure 5.13: Percentage of LFS types in the blank types 113
Figure 5.14: Correlation of maximum length and width (mm) of largest flake scars (LFS) . 114
Figure 5.15: Correlation between the maximum length (mm) and weight (g) of LFS 114
Figure 5.16: Artefact Vaal 218 115
Figure 5.17: Artefact Vaal 285 116
Figure 5.18: Artefact Vaal 011 116
Figure 5.19: Artefact Vaal 330 117
Figure 5.20: Artefact Vaal 314 118
Figure 5.21: Artefact Vaal 145 118
Figure 5.22: Artefact Vaal 242 119
Figure 5.23: Artefact Vaal 274 119
Figure 5.24: Artefact Vaal 271 120

Figure 5.25: Raw material types in the ACP (A), and (B) Pit 5 at Rietputs 15 121
Figure 5.26: Weight (g) range (A), and range of maximum length, width, and thickness (mm) (B) of LCTs from the ACP 122
Figure 5.27: Weight (g) range (A), and range of maximum length, width, and thickness (mm) (B) of LCTs from Pit 5 122
Figure 5.28: Correlation between weight (g) and maximum length, width, and thickness (mm) in ACP 123
Figure 5.29: Correlation between weight (g) and maximum length, width, and thickness (mm) of the LCTs in Pit 5 123
Figure 5.30: Blank types of LCTs in ACP and Pit 5 combined 124
Figure 5.31: Shaping strategies of LCTs in the ACP and Pit 5 combined. ('bif alt' stands for 'bifacial alternating'; 'indet' stands for 'indeterminate') 125
Figure 5.32: Percentage of raw material in shaping strategies in LCTs of ACP ('bif alt' stands for 'bifacial alternating') 126
Figure 5.33: Percentage of raw material in the shaping strategies of the LCTs in Pit 5 ('bif' alt stands for 'bifacial alternating') 126
Figure 5.34: Blank types and shaping strategy on the LCTs from the ACP ('bif alt' stands for 'bifacial alternating') 127
Figure 5.35: Blank type and shaping strategy on the LCTs from Pit 5 ('bif alt' stands for 'bifacial alternating') 127
Figure 5.36: Number of flake scars on the LCTs from the ACP and Pit 5 128
Figure 5.37: Correlation of weight (g) and number of scars on LCTs from the ACP (A)and Pit 5 (B) 129
Figure 5.38: Artefact Vaal 318 129
Figure 5.39: Artefact Vaal 463 130
Figure 5.40: Artefact Vaal 347 131
Figure 5.41: Artefact Vaal 061 131
Figure 5.42: Artefact Vaal 460 132
Figure 5.43: Artefact Riet 723 132
Figure 5.44: Artefact Riet 805 133
Figure 5.45: Artefact Riet 388 133
Figure 5.46: Artefact Riet 108 134
Figure 5.47: Artefact Riet 879 134
Figure 6.1: Raw material distributions of the A: Basal Early Acheulean layer, and B: the Organised Core Technology layer 138
Figure 6.2: Idealised core reduction schemes by layer 139

Figure 6.3: Raw material in the Basal Early Acheulean layer idealised schemes of core reduction 140
Figure 6.4: Organised Core Technology layer raw material frequency by idealised scheme 141
Figure 6.5: Weight (g) ranges of the Basal Early Acheulean (A) and the Organised Core Technology (B) layers 142
Figure 6.6: Range of maximum length, width, and thickness (mm) of the Basal Early Acheulean layer (A) and the Organised Core Technology layer (B) 142
Figure 6.7: Correlation between the Basal Early Acheulean layer weight (g) and the maximum length, width, and thickness (mm) of cores 143
Figure 6.8: Correlation between the Organised Core Technology layer weight (g) and the maximum length, width, and thickness (mm) of cores 143
Figure 6.9: Basal Early Acheulean layer weight ranges of core reduction strategies 144
Figure 6.10: Organised Core Technology layer weight ranges of idealised schemes 145
Figure 6.11: Correlation between the weight (g) and number of flake scars for the Basal Early Acheulean layer (A) and the Organised Core Technology layer (B) 146
Figure 6.12: Core blanks for Basal Early Acheulean and Organised Core Technology layers 147
Figure 6.13: Raw material distribution by blank type for Basal Early Acheulean and Organised Core Technology layers combined 147
Figure 6.14: Percentage of blank types in the core reduction strategies in the Basal Early Acheulean layer 148
Figure 6.15: Percentage of blank types in the core reduction strategies in the Organised Core Technology layer 148
Figure 6.16: Frequency of largest flake scar types in the Basal Early Acheulean layer (A) and Organised Core Technology layer (B) 149
Figure 6.17: Distribution of the largest flake scar by idealised scheme in the Basal Early Acheulean layer 150
Figure 6.18: Distribution of the largest flake scar by idealised scheme in the Organised Core Technology layer 150
Figure 6.19: Largest flake scar types by raw material for the Basal Early Acheulean layer 151
Figure 6.20: Largest flake scar types by raw material for the Organised Core Technology layer 151
Figure 6.21: Correlation between the maximum length and width (mm) of the largest flake scars for the Basal Early Acheulean layer (A) and Organised Core Technology layer (B) . 152
Figure 6.22: Artefact CK 14705 152
Figure 6.23: Artefact CK 14883 153

Figure 6.24: Artefact CK 15274 153
Figure 6.25: Artefact CK 14615 154
Figure 6.26: Artefact CK 14979 154
Figure 6.27: Artefact CK 15327 155
Figure 6.28: Artefact CK 12247 156
Figure 6.29: Artefact CK 8096 156
Figure 6.30: Artefact CK 13479 157
Figure 6.31: Artefact CK 11973 157
Figure 6.32: Artefact CK 12305 158
Figure 6.33: Artefact CK 11506 159
Figure 6.34: Artefact CK 12132 159
Figure 6.35: Artefact CK 13481 160
Figure 6.36: Raw material representation in the LCT assemblages for the Basal Early Acheulean layer (A) and the Organised Core Technology layer (B) 161
Figure 6.37: Box and whisker graph of the weight (g) range of LCTs in the Basal Early Acheulean and Organised Core Technology layers 162
Figure 6.38: Box and whisker graph of the maximum length, width, and thickness (mm) of LCTs in the Basal Early Acheulean layer (A) and the Organised Core Technology layer (B) 163
Figure 6.39: Correlation between weight (g) and maximum length, width, and thickness (mm) of LCTs in the Basal Early Acheulean layer 163
Figure 6.40: Correlation between weight (g) and maximum length, width, and thickness (mm) of LCTs in the Organised Core Technology layer 164
Figure 6.41: The blank types for LCTs in the Basal Early Acheulean and Organised Core Technology layers ('Indet' means ‘indeterminate’) 165
Figure 6.42: Percentages of raw material by blank types in the Basal Early Acheulean layer (A) and the Organised Core Technology layer (B) ('Indet' means ‘indeterminate’) 165
Figure 6.43: Artefact CK 14830 166
Figure 6.44: Artefacts CK 14691 (top) and CK 14659 (bottom) 167
Figure 6.45: Artefact CK 14657 167
Figure 6.46: Artefact CK 15437 168
Figure 6.47: Artefact CK 8846 168
Figure 6.48: Artefact CK 11337 169
Figure 6.49: Artefact CK 11590 170
Figure 6.50: Artefacts CK 11761 (left) and CK 13606 (right) 170
Figure 7.1: The raw material type in the core and LCT assemblage 173
Figure 7.2: Raw material in the cores 173

Figure 7.3: Idealised schemes of core reduction strategies 174
Figure 7.4: Frequency of raw material types by idealised schemes of core reduction strategies 175
Figure 7.5: Weight (g) range (A), and the range of maximum length, width, and thickness (mm) (B) 176
Figure 7.6: Weight classes of cores (g) 177
Figure 7.7: Correlation between weight (g) and number of flake scars 178
Figure 7.8: The weight ranges of idealised schemes (this graph excludes outlier points) 179
Figure 7.9: Amount of remaining cortex on cores ('Indet' stands for 'indeterminate') 180
Figure 7.10: Blank types of cores 181
Figure 7.11: Percentage of raw materials for blank types 182
Figure 7.12: Percentages of blank types in the core reduction strategies 182
Figure 7.13: Largest flake scar types 183
Figure 7.14: Distribution of the largest flake scar by idealised scheme 183
Figure 7.15: Percentage of raw material in the largest flake scar types 184
Figure 7.16: Correlation between the maximum length (mm) and maximum width (mm) of the largest flake scars 184
Figure 7.17: Artefact L2 1887 185
Figure 7.18: Artefact L2 792 186
Figure 7.19: Artefact L2 477 186
Figure 7.20: Artefact L2 2150 187
Figure 7.21: Artefact L2 1348 187
Figure 7.22: Artefact L2 518 188
Figure 7.23: Artefact L2 134 188
Figure 7.24: Artefact L2 1990 189
Figure 7.25: Artefact L2 646 189
Figure 7.26: Artefact L2 725 190
Figure 7.27: Artefact L2 1987 191
Figure 7.28: Artefact L1 123 191
Figure 7.29: Artefact L2 1252 192
Figure 7.30: Artefact L2 1568 192
Figure 7.31: Artefact L2 533 193
Figure 7.32: Artefact L2 744 194
Figure 7.33: Artefact L2 516 194
Figure 7.34: Raw material distribution in LCTs 195
Figure 7.35: Weight range (g) (A), and maximum length, width, and thickness (mm) of LCTs (B) 196

Figure 7.36: Correlation between weight (g) and maximum length, width, and thickness (mm) of LCTs 197
Figure 7.37: Correlation of maximum length (mm) and maximum width and thickness of LCTs (mm) 197
Figure 7.38: Shaping strategies of LCTs ('Bif alt' stands for bifacial alternating, and 'indet' stands for indeterminate) 198
Figure 7.39: Distribution of raw material types for LCTs by shaping strategy 199
Figure 7.40: Range of flake scars by shaping strategy for LCTs 200
Figure 7.41: Blank types of LCTs 200
Figure 7.42: Range of flake scars per blank type for LCTs 201
Figure 7.43: Artefact L2 355 201
Figure 7.44: Artefact L2 36 202
Figure 7.45: Artefact L2 1667 202
Figure 7.46: Artefact L2 5 203
Figure 7.47: Artefact L2 549 204
Figure 7.48: Artefact L2 895 204
Figure 7.49: Artefact L2 53 205
Figure 7.50: Artefact L2 665 205
Figure 7.51: Artefact L2 790 206
Figure 7.52: Artefact L2 1806 207
Figure 7.53: Artefact L2 1673 207
Figure 7.54: Artefact T12 L20 249 208
Figure 7.55: Artefact L2 1461 209
Figure 7.56: Artefact L2 572 209
Figure 7.57: Artefact L2 590 210
Figure 8.1: Examples of quartzite (LCT) from Olduvai Gorge (left), and vein quartz (core) from Sterkfontein Caves in the Cradle of Humankind (right) 213
Figure 8.2: The amounts of remaining cortex in the core assemblages of all the studied sites 216
Figure 8.3: PCA of the core data from all sites 218
Figure 8.4: PCA of core assemblages from Sterkfontein (green), Rietputs 15 ACP (yellow), and EF-HR red) 220
Figure 8.5: Correspondence analysis of core reduction strategies 220
Figure 8.6: Boxplot of the Refinement Indices of LCTs across the sites. 224
Figure 8.7: Principal component analysis of LCTs from Sterkfontein (green), Rietputs 15 ACP (yellow) and Pits 5 (orange), and EF-HR (red) 226

Figure 8.8: Correspondence analysis of LCT edge shaping strategies from Sterkfontein, Rietputs ACP and Pits 5, and EF-HR. 227

List of Tables

Table 3.1: The number of cores and LCTs analysed in this thesis..... 33
Table 3.2: Maximum, minimum, mean, and standard deviation of the length, width and thickness (mm), and weight (g) of all assemblages..... 34
Table 3.3: Attributes of cores and LCTs to be recorded..... 55
Table 8.1: Means of core dimensions, weight and number of scars (‘Max’ stands for maximum)..... 212
Table 8.2: Means of LCT dimensions, critical t-test p-value of number of scars and flips in shaping sequences, and the Refinement Index (‘Max’ stands for ‘maximum’)..... 221

Abbreviations

ESA	Earlier Stone Age
Indet	Indeterminate
LCT	Large cutting tool
Ma	Million years ago
Max	Maximum
MSA	Middle Stone Age

Chapter 1: Introduction

> "Isn't it ironic that in order for a core to be exhausted it must *knap* a lot."
>
> - Ian Moll, a dad

This thesis offers an analysis of the lithic technologies of disparate groups of hominids[1] spread over the eastern and southern regions of Africa who displayed remarkedly similar technological behaviours with regard to both core reduction strategies and the shaping of large cutting tools (LCT) during the earliest phase of the Acheulean technocomplex. While cores are a waste product and LCTs are conceptually shaped and functional tools, these two artefact technologies both provide insights into the similarities in approach shared across distant regions during the early Acheulean. I agree that there is much complexity created by the differing landscapes, raw materials, and site contexts, but I argue that the knappers displayed a common set of reduction strategies in both East and South Africa. This thesis takes this idea and aims to prove, with detailed analyses of core reduction strategies and LCT shaping, that this is true even between vast regions, and that variability is context-specific. I hope, with this small contribution, to add to the story of human and technological evolution.

The Earlier Stone Age (ESA) is the longest spanning archaeological era, with material spanning roughly 3 million years (Ma). The ESA is made up of a series of industrial complexes: the Lomekwian, Oldowan, and Acheulean, each with specific diagnostic markers that indicate the changing and evolving technological behaviour of hominids, many of which contribute to the evolution of modern *Homo sapiens* (Lombard *et al.* 2012). The technocomplex of interest here is the Acheulean, with a current age range of 1.76 Ma to around 300 Ka, which is itself broken down into various phases (Gowlett 1986; Lepre *et al.* 2011; Lombard *et al.* 2012; Harmand *et al.* 2015; Kuman 2016, 2017; Shadrach 2018; Braun *et al.* 2019). The Acheulean technocomplex is one of the longest technological periods in human history, spanning over a million years, and found across the globe in Africa, Europe, and Asia.

The earliest phase of the Acheulean technocomplex, also referred to as the early Acheulean, has historically been defined as the period where clear evidence of tool shaping emerges, such as with the production of heavy-duty tool types like handaxes and cleavers. Recently, established definitions of global linear technological progression have been challenged, with archaeologists describing more detailed and complex technological behaviours, especially regarding the extent of LCT shaping and core reduction strategies at specific sites, and within

[1] The use of the term 'hominid' follows Clarke *et al.* 2021

different landscapes (McNabb *et al.* 2004; de la Torre and Mora 2018b; Shipton 2018; Caruana and Herries 2020; de la Torre and Mora 2020; Hovers *et al.* 2021). Cores and LCTs represent different technological products, but both are characteristic of the period. Overall, these questions about the relationship between the diagnostic features of the technocomplex and site-specific behaviours reflect the need for more nuanced analyses between assemblages.

1.1 Research questions

The research questions of this study are:

1. What are the core reduction strategies evident in the South African early Acheulean assemblages from Sterkfontein caves, Rietputs 15 and Canteen Kopje, and how do they compare to recently excavated material from the early Acheulean type site EF-HR in Olduvai Gorge, Tanzania?
2. Does a comparison of reduction strategies demonstrate a shared technological capacity between the assemblages, and can one identify a chronological shift from simple to more organised[2] reduction strategies in the two regions?
3. What edge shaping strategies were used in the production of large cutting tools (LCTs)?
4. What are the implications of these differences or similarities for hominid behaviour and human evolution?

This study will provide a detailed technological and behavioural comparison of early Acheulean core reduction strategies between major sites in South Africa with the site of EF-HR in Olduvai Gorge, Tanzania (Figure 1.1). Originally, there was an intention to study two more sets of cores (BK from Olduvai, and Pit 5 from Rietputs 15), but the Covid-19 pandemic meant that I was unable to access these assemblages. These types of technological analyses are common in ESA research but have not yet been applied in such a way between South Africa and East Africa. Thus, this study aims to test the usefulness of this type of research when comparing assemblages from distant regions, and whether there is variability in the technological behaviours between these different archaeological locations.

[2] The terms 'simple' and 'organised' used in this thesis follow the definition of Leader (2014), and Kuman and Gibbon (2018), as core reduction strategies with no evidence of preparation.



Figure 1.1: A map of the sites studied within South and East Africa

1.2 Hypothesis

The basic hypothesis presented here is that hominids across East and South Africa during the earliest phase of the Acheulean technocomplex utilised similar reduction strategies, and that variability can be explained largely due to contextual circumstances such as environment and raw material availability.

However, other impactful factors need to be considered, such as hominid cognitive development, complexity, and species. The environment in which hominids lived determined the types and shapes of raw material available to them. This in turn determined the shapes of blanks and could have had an influence on the technological behaviours (Jones 1994; Blumenschine *et al.* 2012).

1.3 Aims

The aims of this study are as follows:

- To apply a technological approach to the analysis of core reduction strategies and LCT shaping in the earliest phase of the Acheulean technocomplex on major assemblages from South Africa and Tanzania.
- To compare the results of the analyses which have used the same methodologies to determine whether archaeologists can glean more nuanced insights into the technological behaviours of hominids.
- To identify any possible variability between sites across the southern and eastern regions of the African continent.

1.4 Rationale

This study provides one of the first technological comparisons of core reduction strategies and LCT manufacture between well-known early Acheulean assemblages from South Africa and Tanzania. The methodological approaches applied here have only been used in a few studies in South Africa (Moll 2017; Lotter and Kuman 2018) and are more well established in East African studies (de la Torre *et al.* 2003; de la Torre 2011; de la Torre and Mora 2018b). Despite the growing popularity of technological studies in South Africa, such comparison between distant regions has not yet been addressed (de la Torre and Mora 2018b), as these are often hindered by the different approaches applied by researchers. By using the same methodological approach for both regions, this will test whether more nuanced conclusions for complexity and variability can be deduced (Moll 2017).

1.5 Organisation of thesis

Chapter 1 of this thesis will introduce the research questions, aims, rationale. and structure of the thesis. Chapter 2, the literature review, will introduce the ESA and early Acheulean technocomplexes across East and South Africa, and the terms used in this thesis will be defined. Relevant literature in the field is explored, interrogating the theoretical frameworks and approaches in which archaeologists work to understand the technological lives of prehistoric peoples. The context in which this thesis fits is described, to identify where it fits within the story of technological and human evolution. Chapter 3 is titled 'Materials and methods', and introduce the specific assemblages studied, the background of research at each site, their relevance to this study and their general characteristics. The methodology used to analyse core reduction strategies is described in full, along with all the recorded metric measurements and the equipment used to do so. The use of diacritical analysis for core and LCTs is explained, including examples. Finally, the statistical and quantitative analytical approaches used are defined. Chapters 4 (Sterkfontein Caves), 5 (Rietputs 15), 6 (Canteen Kopje), and 7 (EF-HR) will present the data and results from my analysis of each assemblage. Chapter 8 will discuss and compare the results and deductions of each site and assess the implications for technological evolution across East and south Africa. The conclusion of the thesis will be given in chapter 9.

Chapter 2: Literature Review

2.1 Introduction

In this chapter, a practical overview of the Earlier Stone Age (ESA) is presented, which is essential for placing data acquired from this study into context. This will include discussion of terminology, followed by a detailed assessment of the Acheulean technocomplex and the stages within it and the concept of change through time, along with information on key relevant sites. Current approaches to study of both intra and inter site variability and the associated theoretical discourse are also presented to contextualise the data analysed in this thesis.

Lithic material is one of the most prominent artefact types used by archaeologists to understand the behavioural and cognitive abilities of our human ancestors. The fact that this discipline is very active demonstrates the vast body of knowledge one can acquire from studying and reanalysing the technological outputs of our hominid ancestors. The discussion presented here aims to clarify the theoretical approaches used by researchers for decades, how these approaches compare, and how they are useful when applied to the study of lithic technology in the ESA. This section focuses more on the framework of how researchers think and apply methodologies to the analysis of stone tools.

2.2 Earlier Stone Age

The Earlier Stone Age is an archaeological period in Africa, dating from ~3.3 Ma to ~0.2/0.15 Ma. The technological evolution of this period correlates with and contributes to our understanding of the complex nature of human evolution (Leakey 1971; Gowlett 1986; Lepre *et al.* 2011; Lombard *et al.* 2012; Harmand *et al.* 2015; Kuman 2014, 2016, 2017; Shadrach 2018; Braun *et al.* 2019). There are three main periods in the ESA: the Lomekwian, the Oldowan, and the Acheulean. Each is defined by their temporal occurrence and specific technological signatures, with more sites and greater artefact densities within sites appearing with each subsequent stage. This becomes especially pronounced during the Acheulean, as there are multiple sites from across Africa, Asia, and Europe.

Recently, the shift in ESA discourse argues for more complexity and flexibility in the technology than was previously appreciated. Technological progressions were not linear, and sometimes a single site can contradict global trends for a technocomplex, meaning that variability can be identified both within and between sites of similar ages, and even regions. This thesis agrees with the view of variability being more complex and nuanced in the ESA. Therefore, the approach used is one that aims to highlight specific technological behaviours

between multiple sites containing assemblages from the earliest phase of the Acheulean technocomplex.

It is through the analysis of these details that we can piece together the possible variability between assemblages within the early Acheulean to consider which patterns are site-specific versus those that may reveal differences in behaviour and cognition. If we can determine similarity between sites in terms of reduction strategies applied, they may differ in how or to what they are applied. If this is the case, then one could argue that hominids in the early Acheulean were able to adapt and manipulate their site-specific raw material blanks to fit into a specific pattern. This would encompass the seemingly contradictory argument that knappers both conformed to raw material shape while simultaneously being able to overcome any natural impediments. It could also be used to demonstrate scenarios where knappers were highly capable of using complex technological strategies but were not always doing so within an assemblage.

2.2.1 Nomenclature: Technocomplex

This thesis aims to compare technological behaviours of knappers between regions and within a similarly defined phase (the earliest phase of the Acheulean technocomplex). This could create problems for defining the period, so the use of the term technocomplex needs to be considered. A technocomplex is defined as being a set of industries that shares common features, and therefore assemblages from different regions, time periods and contexts can belong to the same technocomplex. This definition does not exclude the possibility of variation between sites but follows the idea that knappers successfully adapted to their specific circumstances. This is built on the already established works of Clarke (1968), Sampson (1974) and Deacon (1980), who all generally argued that assemblages could be linked under a single tradition but have context-specific differences. The term ‘industrial complex’ was first defined by in 1965 at the Burg Wartenstein Conference in Austria, along with many other standardised terms used in archaeology (Clark et al. 1966). Based on the work of Lombard *et al.* (2012: 124), the definition grew to also describe the term ‘technocomplex’. The terms ‘industrial complex’ and ‘technocomplex’ are thus used interchangeably in this thesis (see Figure 2.1). While I use the term ‘technocomplex’ to define the entire Acheulean period, in this thesis I focus specifically on the earliest phase of this technocomplex, which is the early Acheulean.

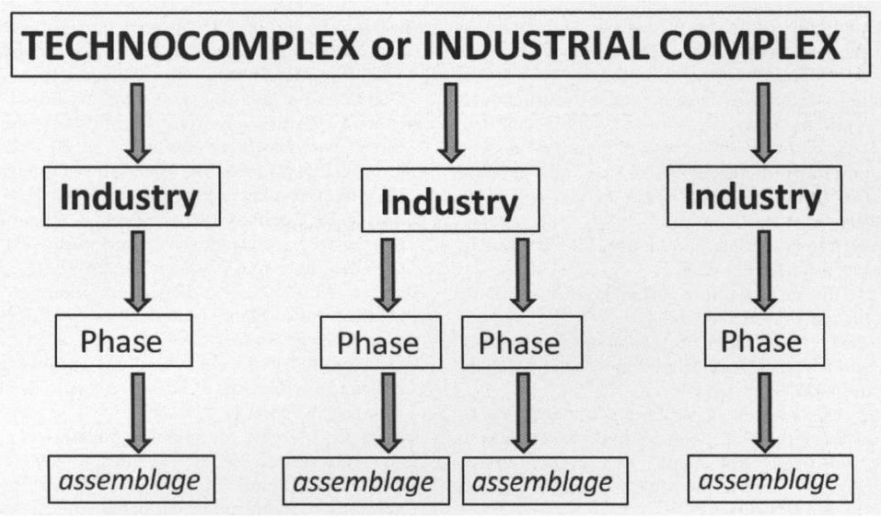


Figure 2.1: The definition and breakdown of a technocomplex used in this thesis (from Lombard et al. 2012)

Archaeologists can fall into a trap of oversimplification when using the term technocomplex, but through consistent, thorough, and repetitive research a more nuanced definition can be achieved. Lombard *et al.* (2012) acknowledge this goal by citing the efficacy of detailed and numerous studies of the Howiesons Poort industry of the South African Middle Stone Age as an example. Therefore, a detailed analysis using a consistent approach of specific technological features to compare sites for core reduction and LCT production strategies is invaluable in creating a high-resolution definition of the early Acheulean.

2.2.2 The Lomekwian and the Oldowan

A discussion of the technocomplexes predating the Acheulean is important to contextualise the changes from one period to another. This thesis does not aim to compare the reduction strategies of these differing complexes but they are presented below as background description for the greater ESA. Therefore, the key technological markers of the Lomekwian and Oldowan are discussed in order to contextualise the early Acheulean within the ESA.

Lomekwian

Currently, there is only one site linked to the Lomekwian industry, Lomekwi 3 (LOM 3) from West Turkana, Kenya. The site dates to 3.3 Ma, roughly 800000 years earlier than the oldest known Oldowan sites from Ledi-Geraru, Ethiopia at >2.58 Ma (Braun *et al.* 2019) and Gona, Ethiopia at 2.53 +- 0.15 Ma (Semaw *et al.* 2003). Harmand *et al.* (2015) published the site as a new industry because it differed considerably to the technologically diagnostic features of the Oldowan. The assemblage consists of 149 artefacts from both in situ deposits and surface collections and represents the earliest stone tool production, whereby sharp flakes were

achieved through passive hammerstone percussion (with the core against an anvil), along with the appearance of bipolar knapping and battering patterns, and a lesser use of freehand flaking (Harmand *et al.* 2015; Lewis and Harmand 2016).

Prior to the publication of Lomekwi 3, there was a consensus in the field that technological innovation and tool use must have predated the Oldowan technocomplex (Panger *et al.* 2002; Kuman 2019), because Oldowan hominids already displayed some good ability with direct percussion and some bifacial techniques in core reduction. The Lomekwian fits well within those parameters.

Cores tend to be large, and with multiple removals in various directions on a single surface, although sometimes cores were rotated and worked on other surfaces. Raw material was sourced from nearby palaeochannels, with a preference for large cobbles of phonolite and basalt (Harmand *et al.* 2015; Gallotti 2018). Despite the evidence of advanced hominid behaviours (raw material selection, knapping techniques, and overall tool use), knappers encountered many flaws, made mistakes in reduction, and did not demonstrate well-structured and continuous core edge management or the reduction of the central volume of the blanks.

Oldowan

To properly understand the emergence of the Acheulean and its importance in technological evolution, one must have an idea of the preceding Oldowan technocomplex and its relevant features. This is because it is the closest technocomplex to the earliest phase of the Acheulean technocomplex, both chronologically and technologically. The technocomplex was first discovered in the 1930s by Louis Leakey (1934) and was named after Olduvai Gorge, Tanzania where the Leakeys worked, with the earliest name being 'Oldoway'. It was described by Mary Leakey (1966). Subsequently, EF-HR, a site from Olduvai Gorge was also used to establish as the type series for the earliest phase of the Acheulean in the third volume of the series (Leakey 1971).

Technologically, the Oldowan saw a development in the technique and skill of knappers over the Lomekwian, with a much greater use of the freehand percussion technique (Leakey 1966, 1971; 1975; Semaw *et al.* 2003; de la Torre and Mora 2005; Semaw 2006; Braun and Hovers 2009; Braun *et al.* 2008a and b; Harmand 2009), with more focus on the manipulation of raw material and a good understanding of fracture mechanics. Currently, there are over 20 known Oldowan sites, with most found in eastern Africa, and others in North Africa and South Africa (Plummer 2004; Sahnouni *et al.* 2019).

The earliest Oldowan sites are Ledi-Geraru at >2.58 Ma, (Braun *et al.* 2019) and Gona, Afar at 2.6 Ma, both in Ethiopia (Semaw *et al.* 2003). Multiple assemblages are found in some site

complexes, such as Olduvai Gorge, Tanzania (the namesake of the Oldowan) (de la Torre and Mora 2018a) and Lokalalei 1 and 2c, Kenya (Delagnes *et al*. 2006). Recently, there have been a few more sites added to the Oldowan, including Nasura Complex in West Turkana, Kenya with dates between 2.3-2.0 Ma (Harmand *et al.* 2016), but sites and data for this time frame for the whole continent are limited. From ca 2.0 Ma onwards, more sites appear, along with innovations in technology, especially in East Africa. Examples of these are the adaptation to high altitude landscapes at ca 1.78 Ma in the Kilombe Caldera, Kenya (Gowlett *et al.* 2022) and the use of obsidian to make small standardised pointed tools at Melka Kunture, Ethiopia ca 1.7 Ma (Gallotti and Mussi 2015).

In South African there are few sites with Oldowan assemblages. Swartkrans and Sterkfontein Caves, from the Cradle of Humankind, represent the oldest archaeological sites with dates of ca. 2.22 Ma and ca. 2.18 Ma, respectively (Kuman and Clarke 2000; Kuman and Field 2009; Sutton 2012; Granger *et al.* 2015; Caruana and Mtshali 2018; Kuman *et al.* 2018; Kuman *et al.* 2021). Wonderwerk Cave in the Northern Cape Province has a small Oldowan assemblage of 65 pieces (Chazan *et al.* 2008; Chazan *et al.* 2012), and Kromdraai B has only two Oldowan aged artefacts (Kuman *et al.* 1997;).

Due to the low number of sites in Africa with Oldowan assemblages, there are some time gaps over the period. Most of the earliest sites in eastern Africa date within the range of 2.6-2.3 Ma, and again from 2.0-1.6 Ma, sometimes coinciding with the emergence of the Acheulean (Diez-Martín *et al.* 2015; de la Torre 2016; de la Torre and Mora 2018b; Gallotti 2018).

According to Mary Leakey (1971), the renowned archaeologist whose work laid the foundation for ESA research, the Oldowan represented an industry of core tools, flakes, and débitage. Artefacts were classified into categories like tool, utilised piece and débitage, with a further breakdown of the tool category based on the size of the piece. The tools category included pices >50mm which were labelled as heavy duty, whereas pieces <50mm were called retouched tools (Leakey 1971). However, subsequent research showed that the primary focus in the Oldowan was to acquire small sharp usable flakes, with cores not necessarily being tools or the desired product (Toth 1982, 1985), and the Oldowan is now largely referred to as a simple core and flake industry. The terms used by Leakey (1971) assumed function based purely on size and morphology, with later researchers opting for terms developed by Isaac (1981, 1984), such as flaked piece, detached piece and pounded piece, which avoided assumptions.

Freehand percussion was clearly an established percussion technique at the start of the Oldowan, but bipolar technique, with the use of an anvil and hammerstone, persisted as a

means of producing stone tools, and to extract bone marrow from carcasses[3] (Blumenschine 1995). There is also evidence of throwing rocks to create platforms and edges for flake production (Kuman 1998; Roche 2000). Knappers at some sites were successful at efficiently exhausting the cores and maximising the numbers of flake removals, although they remained constrained by the natural platforms and surfaces of the raw material blanks (Delagnes and Roche 2005; Gallotti 2018). Unlike the Lomekwian, bipolar knapping was present but was not a dominant percussion technique in all sites, and battering was used for multiple activities along with stone tool production (de la Torre and Mora 2005).

Percussive instruments are found throughout the global archaeological record and are a vital part of the reduction process that provides much information about the technical skill and behaviours of knappers (McGuire 1891; Chavaillon 1979; Leakey 1971; Mora and de la Torre 2005; Goren-Inbar *et al.* 2012; Caruana 2014). Battering activities are common at multiple sites in Olduvai Gorge, Tanzania (Mora and de la Torre 2005; Diez-Martin *et al.* 2010; Santonja *et al.* 2014). In technological studies, battering marks can help indicate the lifecycle of a specific piece, and the variable use of cobbles, blanks and hammerstones in the reduction process. These marks can also be used to understand how hominids adapted to various site contexts and raw materials (Caruana 2017).

Some scholars have argued for a stasis in technological development within the Oldowan (Semaw *et al.* 2000; Hovers 2012; Morgan *et al.* 2015). However, more detailed analyses of assemblages and inter-site variability have shown this to not be the case for the entirety of the period (Semaw 2000; de la Torre 2004; Stout *et al.* 2010; Gallotti and Mussi 2015; Gallotti 2018). Focused research on assemblages and sites provides details of site-specific sophistication and variability in reduction sequences. Some researchers have even argued that the knowledge of fracture mechanics of Oldowan knappers is comparable to that of early Acheulean hominids (Semaw *et al.* 1997; Ludwig and Harris 1998; Roche *et al.* 1999: Semaw 2000).

Lokalalei 2C, Kenya is a well-known Oldowan site at around 2.34 Ma, with evidence of long and exhaustive reduction sequences as seen through refits. At the time of publication, the site was seen as a unique example of technical ability and adaptability of Oldowan knappers. It demonstrated that knapping was not always opportunistic, in the sense that the hominids were able to control the reduction sequences, from blank acquisition to preplanning of core edge

[3] Use wear analysis on Oldowan aged artefacts is difficult, and much of what we know about function comes from experimental and replication work, as well as cutmarks left on fossil bone (Keeley and Toth 1981; Blumenschine 1995; Semaw *et al.* 2003; Plummer 1994).

management (Delagnes and Roche 2005). This counters the argument of stasis in the Oldowan and demonstrates complex cognitive behaviours prior to 2.0 Ma.

Deposits from the Lower Omo Valley which date to ca. 2.32-1.9 Ma, have revealed how Oldowan hominids were able to move about the landscape in search of quality raw material, which they transported back to the area. Delagnes *et al.* (2011) argued that the Lower Omo Valley was ecologically advantageous to hominids, while the raw material choices were poor. The implications are that, even during these early periods, hominids had a good understanding of their extensive landscape and adapted in beneficial ways.

The final phase of the Oldowan and the earliest phase of the Acheulean sometimes overlapped in time and location, meaning that the transition between these technocomplexes was not a linear progression. This challenges the use of techno-typological descriptions to distinguish each period chronologically. The transition between the technocomplexes has long been of interest to archaeologists, both in how and why the shift occurred (Gowlett 1986; Field 1999; Semaw *et al.* 2009; de la Torre and Mora 2018a, b; de la Torre *et al.* 2021; Duke *et al.* 2021). With continuing research, the distinction between late Oldowan and early Acheulean has become more blurred as researchers began to focus more on the specific technological traits between them. Duke *et al.* (2021) have argued that the technological transition between the technocomplexes at Kokiselei, Kenya is not easily separated because of the presence of knapping strategies in the Oldowan that are traditionally associated to the Acheulean, namely bifacial shaping.

Conversely, the separation of Oldowan and early Acheulean can be distinct in some site complexes, such as Olduvai Gorge, where assemblages found in the post-Tuff IB deposits have Oldowan material only (de la Torre *et al.* 2021) (Deino 2012 dates Tuff IB to 1.848±0.003 Ma). However, this does not mean that there are no similarities in core and flake technology between the Oldowan and early Acheulean in the gorge (de la Torre and Mora 2018a, b), because there is a continuity of technological trends across these two stratigraphical units. Thus, one needs to have a good grasp of the Oldowan technocomplex to properly understand the early Acheulean.

It is difficult to pinpoint a specific technologically diagnostic definition for the Oldowan as a whole, without resorting to pure typological categories (critiqued below), as the latter do not give enough detail about the various behaviours of hominids and the relevant evolutionary changes. Therefore, if typological classifications and analyses oversimplify the technological patterns of the Oldowan, the same can be argued for the Acheulean. A discussion of contrasts in these technocomplexes can help to contextualise the progressive evolution of technological behaviour within the ESA, while also describing the ESA overall. The production of sharp

flakes is common in all periods, but they are produced in different ways. The Lomekwian is characterised by passive and bipolar percussion, while freehand percussion becomes dominant in the Oldowan. Hominids continued producing sharp flakes within the Acheulean, but there was the addition of large heavy-duty tools. These changes document how technological progress occurred, and a thesis such as this aims to understand the specifics of those changes.

2.3 Acheulean

The Acheulean technocomplex is part of the ESA and therefore needs to be reviewed in that context. This next section specifically explores the Acheulean because it is the focus of this thesis.

2.3.1 The Acheulean technocomplex

The Acheulean was first discovered and described in the 19th Century at the site of St Acheul in France by Gabriel de Mortillet in 'Époque de St. Acheul" (1872), which gave its name to the tradition characterised by tear drop shaped handaxes. It first appeared during the Lower Pleistocene, with the earliest dated sites at Kokiselei 4, Kenya at 1.76 Ma, and at Konso, Ethiopia at 1.7 Ma (Lepre and Kent 2010; Lepre *et al.* 2011). Assemblages dating to the early phase of the Acheulean technocomplex are also found across the African continent, with well-known major locations in East Africa, for example: Olduvai Gorge, Tanzania (Leakey 1971; de la Torre *et al.* 2011; de la Torre and Mora 2018b; de la Torre and Mora 2020); Konso, Ethiopia (Beyene *et al.* 1997; Beyene 2003; Beyene *et al.* 2003; Beyene *et al.* 2013; Beyene *et al.* 2015); Kokiselei, Kenya (Roche *et al.* 2003; Roche 2005; Lepre *et al.* 2011); Melka Kunture, Ethiopia (Gallotti 2013); and Koobi I, Kenya (Toth 1982; Isaac *et al.* 1997). In South Africa, early Acheulean sites are found in the Cradle of Humankind (Kuman 1994; Field 1999; Kuman and Clarke 2000; Stratford 2008; Moll 2017; Caruana 2020), and in central South Africa (Beaumont and Vogel 2006; Chazan 2015; Kuman and Gibbon 2018; Leader et al. 2018). Outside of Africa there are some sites, with one of the best-known being Ubeidiya, Israel (Gaudzinski 2004; Herzlinger *et al.* 2021).

The Acheulean technocomplex encompasses the archaeological period from around 1.76 Ma, when heavy duty tools such as handaxes began to appear (Lepre *et al.* 2011). New LCT types, such as handaxes, cleavers, picks, and knives, inferred an increase in the cognitive and behavioural capabilities of hominids, going beyond those observed in the Oldowan (Semaw 2000; Lepre *et al.* 2011; Kuman 2019; de la Torre 2016; Toth and Schick 2019). The systematic production of flakes >10cm diagnostically has been used to define the Acheulean, as they were often used as blanks to make LCTs (Mason 1961; Isaac 1969; Wynn 1981; Toth

1982; Kuman 1994; de la Torre and Mora 2005; de la Torre *et al.* 2008). The systematic production of large flakes correlates with cognitive and behavioural changes in knappers (Isaac 1969), but this definition has changed to be less rigid because large flakes have also been used as core blanks, and LCTs have been made on other blank types. While, the systematic production of large flakes correlates with cognitive and behavioural changes in knappers (Isaac 1969), core and flake types similar to that of the Oldowan persisted (Mason 1961; Wynn 1981; Semaw *et al.* 2009; de la Torre 2011; Lepre *et al.* 2011; de la Torre 2016; de la Torre *et al.* 2008; Texier 2018; Kuman 2019).

While historically the definition of the Acheulean thus focused on the appearance of LCTs and flakes larger than 10cm (Kleindienst 1962; Leakey 1971; McPherron 2000; Diez-Martin *et al.* 2015; de la Torre 2016), Isaac (1969) argued that the production of large flakes and blanks indicated a major evolutionary leap in the form of preplanning and cognitive development. This is agreed on by most researchers working in this time period, but further research in the field has shown that there is also development during the Acheulean in core and flake technology, longer LCT shaping sequences, and core reduction strategies that became more consistent and controlled across assemblages (de la Torre 2009; Gallotti 2016; de la Torre and Mora 2020; Semaw *et al.* 2009). Therefore, if we agree that a technocomplex is highly complex, then a study of the specific core reduction strategies, and how they relate to LCT production, is invaluable.

The appearance of the early phase of the Acheulean technocomplex was not sudden at 1.76, but rather there was a progressive emergence of such early sites through to 1.6 / 1.4 Ma. Site complexes such as Olduvai Gorge, Kokiselei 4, Kenya, and Konso, Ethiopia maintained core and flake archaeological assemblages dating to around 1.7-1.4 Mya alongside early Acheulean assemblages (de la Torre 2016). This pattern is also found at Sterkfontein Caves, in the Cradle of Humankind. The Acheulean assemblage from Sterkfontein is estimated to ca. 1.7-1.4 Ma (Kuman and Clarke 2000) and is dominated by core and flake strategies with asymmetrical and crudely made LCTs. Field (1999) described the continuation of similar core reduction strategies from the Oldowan to the Acheulean, and a low number of LCTs, which suggests the transition between the technocomplexes to be slow.

Acheulean assemblages are found throughout Africa with some of the most well-known sites in eastern and southern Africa (de la Torre 2016; de la Torre *et al.* 2018; Kuman 2019). Mary Leakey (1971) used the ~1.6 My old site EF-HR from Olduvai Gorge, Tanzania as the type series for her description of the Acheulean. Subsequently, older Acheulean sites were discovered. In southern Africa, the earliest Acheulean sites are those at Rietputs 15, Northern

Cape at 1.7-1.3 Ma (Gibbon *et al.* 2009; Leader *et al*. 2018; Kuman and Gibbon 2018), Sterkfontein Caves with a relative age ca 1.7-1.4 Ma (Kuman and Clarke 2000), Sundays River Valley (ca. 1.1 - <1.37 Ma), Eastern Cape (Lotter 2016; Lotter and Kuman 2018), Wonderwerk Cave, Northern Cape (ca. 1.6 Ma) (Chazan *et al.* 2008; Chazan 2015), and Canteen Kopje, Northern Cape, with three assemblages >1 Ma (Leader *et al.* in prep.). The Acheulean is therefore present in both eastern and southern Africa from around 1.7-1 Ma (Isaac 1969; Leakey 1971; Klein 2000; Lepre *et al.* 2011; Beyene *et al.* 2013; de la Torre 2016; Beyene *et al.* 2018; Strata *et al.* 2021).

For the oldest early Acheulean sites (>1.5 Ma), there has been little comparative work done to address technological variability across Africa (see discussion in de la Torre and Mora 2018b). Although from ca 1.76 - 1.5 Ma, there is a clear emergence of LCT production and large flakes, (>10cm), there is the continuing manufacture of small flake debitage, albeit with changes in core reduction strategies. Methodological approaches to studies of sites <1.5 Ma tend to be more similar and have allowed for more comparative work between East African sites (de la Torre and Mora 2018a,b). Overall, there is high variability <1.5 Ma in reduction strategies, raw material choices and uses, and representation of LCTs. Core reduction approaches developed during this period with the appearance of simple 'prepared' or 'organised' core strategies (following White *et al.* 2011), which are not always linked to LCT production. There is a common 'know-how' in production between 1.5-1.4 Ma (Gallotti 2016).

Younger than 1.3 Ma, archaeological sites in East Africa become less well understood, often due to a lack of dates. The definition of these younger Acheulean sites has relied heavily on typological traits of handaxes, with minimal technological studies having been performed (Gallotti 2016). However, technological assessments of behavioural complexity can be identified through the changes in LCT manufacture and shape during this time to improve the grip on LCTs, while cores were generally discarded with limited exploitation or reuse (Gallotti 2016). It would be interesting to investigate how this limited knowledge of technological core reduction patterns at the time has constricted the idea of progress between 1.76-1.3 Ma, as explored in my thesis.

2.3.2 'Organised' core technology

The identification and analysis of organised core reduction strategies is an integral part of this thesis. The definition of 'organised' used here follows Leader (2014) and Leader et al. (2018), which was developed to distinguish 'simple' from prepared core technology. Prepared core technology is an umbrella term used to describe strategies that can be loosely defined as flakes removed in a pattern whereby the platform for future removals is created, i.e., 'prepared' (Boëda 1953, 1995). This definition is loose because it encompasses many strategy types,

such as Levallois and strategies such as ‘proto-Levallois’ as used in South Africa (Mourre 2006; Wilkins *et al.* 2010; Gallotti 2013).

Boëda (1953, 1995) defined Levallois as a form of prepared core technology through the study of middle Palaeolithic assemblage in Europe as a reduction strategy that produced preferential flakes through hard hammer percussion from an asymmetrical core. The two surfaces were prepared differently for their purposes of creating knapping surfaces and platforms. Levallois is considered to be a highly complex and advanced core reduction strategy which results in a identifiable morphological core type, and flake type (Van Peer 1992). In the African context, these traits have been identified but the focus of morphology has not always been useful because of factors such as raw material shapes and type (Chazan 1997; Kuman 2001; Wilkins et al. 2010). This is particularly true in the African ESA where there is evidence of core preparation and predetermination, such as the Victoria West, which has been described as ‘proto-Levallois’ (White and Ashton 2003), and for the MSA at Kudu Koppie where the reduction of core volume was akin to Levallois but did not result in the same core morphology (Wilkin et al. 2010). These examples show that it is important to consider prepared core technology, predetermination and potentially Levallois in ESA core reduction.

Nyabusosi in Uganda is an ESA site with evidence of Acheulean core reduction and few LCTs and LCT by-products. Texier (1995) published the material at a time when the oldest dates for the Acheulean were not yet know and concluded that the material was of an Oldowan age but showed the technological signs of an Acheulean assemblage, including prepared core technology. New research into the material published by Mesfin and Texier (2022) has shown that the core reduction strategies are complex and that there is prepared core technology in the form of surface hierarchal control, with bifacial and recurrent edge management and volume reduction. The definition of prepared core technology used by Mesfin and Texier (2022) acknowledges the broad use of the term but argue that the technological behaviour has to be applied across an assemblage for it to be considered an assemblage emblematic of the strategy. Therefore, in cases where there are only a few examples it could be debated that the assemblage is not representative of the industry. The authors consider the vast body of work on these core reduction strategies to define prepared cores as “a core 1) conceptualized as two asymmetrical opposite surfaces, 2) with a well-defined technical role (hierarchised) and 3) a flatter surface being used as the flaking surface thanks to 4) flaking axis parallel to subparallel to the intersection plane and 5) stigmata of core blank preparation” (Mesfin and Texier 2022: 4). As mentioned, this thesis does not aim to define prepared core technology and is therefore using this definition when considering the analysed assemblages.

Some researchers use the term ‘predetermined’ to define core reduction strategies whereby hierarchal platforms are created by previous removals, and this has been applied to ESA assemblages in East Africa (de la Torre *et al,* 2003; Gallotti 2013). ‘Prepared core technology’ and ‘predetermination’ are terms that have been used interchangeably, and so can be confusing when not strictly defined. In South Africa the term ‘prepared core technology’ has been used most to discuss reduction strategies from the MSA, and for similar technological behaviours earlier than the MSA (e.g., Kuman 2001; Wilkins 2008). Hence in this thesis, the term prepared core defines MSA reduction strategies, such as Levallois, while precursors to this are labelled as either early forms, organised, and/or structured. It would be important in the future to assess the use of these terms in a South African context, so as to better compare and contrast similar reduction strategies within the Acheulean technocomplex.

The Victoria West is an early Acheulean industry from South Africa with an early form of core preparation, probably to produce LCT flakes (Jansen 1926; Van Riet Lowe 1945; White and Ashton 2003; Sharon and Beaumont 2006; Leader 2014; Leader *et al.* 2018), which is now confirmed to date to >1 Ma (Leader *et al*. in prep.). Large core blanks were shaped bifacially and asymmetrically to create a preferential surface from which a single large side-struck flake could be removed. The resulting cores were said to have a morphology similar to a chicken’s beak. White *et al.* (2011) argue that the edge working of these cores is like that seen in Middle Palaeolithic prepared cores, whose origins lie in the Acheulean, with one such site being Canteen Kopje, a site of interest in this thesis. Therefore, understanding the core reduction strategies that preceded the Victoria West could help archaeologists better understand technological change through the Acheulean.

Predetermined reduction has been argued to show more structured and continuous core reduction to define strategies that show a more controlled management of flaking patterns. This means that knappers were more able to structure their removals, not only for the acquisition of sharp flakes, but also for the extensive sequence of core edge management. Later strategies, such as prepared core technology, have been argued to emerge out of the Acheulean in Africa (e.g., the Kapthurin Formation in Kenya [Tryon *et al.* 2005] and Bk and SHK Annexe in Olduvai Gorge, Tanzania [Sanchez-Yustus *et al.* 2017]). The strategies, which include ‘Mode 3’ and Levallois, display similar yet more intensive and organised core edge management than seen in the ESA (Van Peer 1992; White *et al.* 2011). Early iterations of prepared core technology, such as the Victoria West industry from South Africa, also display the same control over edge working (Lycett 2008). These stages of development in core reduction strategies, in combination with LCT production, have been used to define the core reduction strategies present in the Acheulean.

The shapes of the core blanks are paramount to consider when analysing core edge management and flaking strategies, especially in regards to understanding organised, prepared, and predetermined technological behaviours. Peninj has been researched for many years, beginning with Mary Leakey and Glynn Isaac in the 1960s (de la Torre and Mora 2008). De la Torre *et al.* (2003) and de la Torre and Mora (2008) described the site as early Acheulean with evidence of varied percussive behaviours, including the transport of quartz clasts to the area for core flaking and hammerstones. They described two *chaînes opératoires* of LCT production and core flaking which had different proportions of raw material types and sources. Cobbles and small clasts were used for core flaking, while large basalt boulders were exploited for large flake blanks that were used for LCTs. They also argued that core reduction strategies constituted an early form of prepared core technology. This is due to the hierarchal and bifacial control of cores to produce recurrent flakes. However, more recent research into the area has shown that the shape of core blanks highly influenced the core flaking strategies, and that the presence of bifacial hierarchal schemes was not the norm. Diez-Martín *et al.* (2018) argued that many core blanks were dome shaped, and this led to an exploitation of the natural edges, which resulted in core that appeared to be bifacial and hierarchal.

2.3.3 Progression in core reduction

As mentioned in section 2.3.2 the description and identification of 'organised' versus 'simple' core reduction strategies has been the subject of much discourse in the ESA. The definition of these two terms as used in this thesis have been taken from Leader *et al*. (2018) and Kuman and Gibbon (2018). Kuman and Gibbon (2018) argue that one can identify chronological shifts in the earliest phase of the Acheulean technocomplex through the progressive changes in core reduction strategies.

Kuman and Gibbon (2018) further argued that the undated ACP assemblage appears to be from an older deposit than Pit 5 at Rietputs 15 where organised core technology, dating to ca. 1.3 Ma, is present, because of the techno-typological differences between these assemblages. Specifically, the ACP had simpler core reduction strategies and fewer LCTs than Pit 5. This hypothesis will be addressed as the same material from Rietputs 15 and CK is reanalysed in the thesis using a more focused technological approach. It is of interest to determine whether there are different in edge management and reduction strategies which correspond the conclusions in Kuman and Gibbon (2018).

2.3.4 Knapping skill in the ESA

Identifying skill in stone tool production has been a question of research for many archaeologists. The Mirriam-Webster dictionary defines skill as the ability to effectively use one's knowledge in doing tasks. Skill has been argued to be represented by progressive,

continuous, and evolved behaviours, both physical and cognitive (Isaac 1987; Pargeter *et al*. 2019). Multiple factors including prediction, standardisation, motor function, cognition, learning, and expertise affect the 'skill' identified (Pargeter *et al*. 2020). It can therefore be complicated to identify 'skill' in the archaeological record, and the technological analysis of core reduction strategies can add to the discourse (Pargeter *et a*l. 2019). This thesis does not actively address whether the knappers were skilled, but what technological behaviours they applied to edge management, a factor that could be used to indicate overall skill.

As mentioned, in an archaeological context, 'skill' could be related to the core reduction strategies and tool production processes identified at sites. Delagnes and Roche (2005) argued that ESA knappers are inherently skilled, even before the advent of the Acheulean technocomplex, which was identified through elaborate, recurrent, and long reduction sequences in the Oldowan core assemblage from Lokalalei 2C, Kenya. However, the complexity and nuance afforded to archaeologists through the assessment of skill is only seen through comparative studies of inter and intra-site variability.

2.4 The question of transitions for the Earlier Stone Age

Archaeologists have long debated the circumstances of transition between technocomplexes of the Stone Age (Hovers and Kuhn 2007), including in ESA research. Presently, the concept of transitions between technocomplexes has been challenged, as there is much more known today about inter and intra site variability and nuance at all stages of the ESA. Long chronological sequences also occurred within the shift, especially with regards to transitional epochs (Leakey 1971; Gowlett 2009; Proffitt 2018; Shadrach 2018), and new sites and dates are constantly changing the narrative of archaeology (Gowlett 1986; Semaw 2000; Lepre *et al.* 2011; Granger *et al.* 2015; Harmand *et al.* 2015; Braun *et al.* 2019). An example of such a debate is the Developed Oldowan, a term defined by Mary Leakey in 1971.

2.4.1 Developed Oldowan

As mentioned, Mary Leakey defined a period between the Oldowan and Acheulean technocomplexes as the Developed Oldowan, which used percentages of artefact representation at sites as proxies for industry assignment. This quantitative classification states that a presence of 40-60% bifaces defines the early Acheulean (Kleindienst 1962; Leakey 1971), and if there was less it was classified as Developed Oldowan B. The value of Mary Leakey's work cannot be underestimated, and these debates persist to some degree, because her classifications revealed that differences in artefact types afford archaeologists with rich and deep research questions (de la Torre 2016; de la Torre 2018; Proffitt 2018). However, it has since been argued and shown by multiple studies that the percentage of LCTs

in early Acheulean assemblages is variable, and there should instead be more focus on core reduction rather than LCT production (de la Torre 2009; Gallotti 2016; de la Torre and Mora 2020; Semaw *et al.* 2020). Diez-Martín *et al.* (2015) argue that separation of certain assemblages in a Developed Oldowan industry underscores diversity and complexity in the early Acheulean, both in the cognitive and behavioural traits of knappers, and the functionality of tools.

Oldowan reduction strategies focused on the production of small flakes, which continues into the Acheulean alongside large flake production (>10cm) at multiple sites (Sharon 2008; Gallotti 2016; de la Torre and Mora 2018b), although in some instances there are few or no actual LCTs present (de la Torre and Mora 2020). Large flakes with minimal presence of LCTs are typical of both East and South African sites between 1.76-1.5 Ma, and fluctuations in representation of these reduction strategies indicate inter- and intra-site variability. Even when the presence of both is identified at a site, the dominant pattern of production can focus on one or the other (Gallotti 2016). Cores are thus an integral part of technological trends and site variability which need to be analysed alongside LCTs to describe the overall technological behaviours at a site (de la Torre and Mora 2018b).

Inter-site variability has long been a point of interest in ESA studies and has led to many debates concerning the relevant discourse to address the differences (Sánchez-Yustos et al. 2017). Mary Leakey coined the term Developed Oldowan to initially address proportional discrepancies in handaxe and LCT representation at sites, but through multiple studies this idea has been challenged and adapted (Sánchez-Yustos *et al*. 2017; Gallotti 2016; Proffitt 2016). In the case of the earliest Acheulean sites in the Cradle of Humankind, South Africa there are generally low numbers of LCTs relative to cores and flakes (Kuman 1994; Field 1999; Moll 2017). The question whether early Acheulean assemblages display similar trends between broad regions in Africa has been only somewhat addressed (Clark and Kurashina 1962; de la Torre 2018 and Mora 2018b).

2.4.2 Acheulean sites with few LCTs

There are multiple sites which belong to the transition from the Oldowan to the earliest phase of the Acheulean that also lack or have few handaxes. Some of these are SHK Annexe in Olduvai Gorge, Tanzania (de la Torre and Mora 2020), Peninj type section, Tanzania (de la Torre and Mora 2008), Nyabusosi, Uganda (Texier 1995), and Chesowanja, Kenya (Gowlett *et al.* 1981).

These sites have demonstrated that researchers can identify early Acheulean sites and/or technological behaviours even when there is a lack of both LCTs and components of LCT production. It also emphasises the need to study core reduction strategies (de la Torre and

Mora 2018b), because “in the absence of handaxes, the presence of structured flaking methods of small débitage has been proposed as an additional technological proxy to track Acheulean innovations” (de la Torre and Mora 2020: 70; also see de la Torre 2009 and 2011).

SHK Annexe, Olduvai Gorge, Tanzania

SHK Annexe yielded a ratio of 6:1 cores to LCTs, and was initially published by Mary Leakey as a Developed Oldowan sites (Leakey 1972) but is now regarded as a site with evidence of the transition into the Acheulean techno-complex at Olduvai Gorge (de la Torre and Mora 2020). There is a lack of flaking debris in the assemblage, but this is argued to be a symptom of collection bias rather than the nature of the assemblage. Out of a total of 492 artefacts in the assemblage, around 57.5% of them relate to core production, while only 2.4% (n=14) relate to LCT production.

The deposit dates to >1.33 Ma (de la Torre and Mora 2018b) and lies in Upper Bed II of the gorge. There are 98 cores from the assemblage, along with 28 core fragments. The collected debris represents mainly cortical flakes with no platform faceting. SHK Annexe stands out from other early Acheulean sites in Olduvai Gorge, such as EF-HR, because highly metamorphosed quartzite dominates. The quartzite selected ranges in size while the lava rock types tend to be more consistent, which influenced the core size range for each.

There is also a presence of battering on the cores, which opposes the knapping surfaces but is not exclusively done before the core is reduced (de la Torre and Mora 2020). One could argue that this was a production site, which focused on structured core and flake technology and has evidence of battering on 37 cores (37.8% of the assemblage). As the sequential pattern of battering and knapping is not consistent but occurs on opposite sides of cores, there is variable use and recycling of hammerstones and cores for multiple purposes.

Nyabusosi, Uganda

Texier (1995) did not assign the archaeological material from Nyabusosi to either the Oldowan or the Acheulean. The assemblage dated to >1.5 Ma but did not match the typological definitions of either period as defined by Leakey (1971), although it was suggested as more advanced than Oldowan assemblages >2Ma (Texier 1995). The technology was described as advanced for the period, but with a lack of LCTs. Core reduction was radial and extensive, with preferential surfaces and platform preparation, and the flakes displayed sharp cutting edges (Mesfin and Texier 2022). With the advancements in dating and investigations into the early Acheulean (Roche 1989; de la Torre and Mora 2020), Texier (1995) argued that this site falls into the early Acheulean and displays the clear technological changes between the two technocomplexes.

Chesowanja, Kenya

Chesowanja, located near Lake Baringo, is known for both archaeological and palaeontological finds. Hominids were argued to repeatedly visit the location over a long period of time, with lithic artefacts found in the in situ excavations and on the surface (Gowlett *et al.* 1984). No LCT or LCT by-products were recovered from the in situ excavations and were only found on the surface. Gowlett *et al.* (1984) dated the in situ sediments to >1.42 ± 0.07 Ma, and suggested the LCT material was younger. At the time of the Gowlett *et al.* (1984) publication, the current oldest dates for the earliest phase of the Acheulean technocomplex were not yet known (See Lepre *et al.* 2011), and the in situ material now falls in that time range. Not much work has been done on the lithic material since, but the shift from assemblages without LCTs to those with them, plus the age range of in situ material, suggests there could be evidence of transition and/or Acheulean material with no LCTs. Chesowanja is a site of further interest regarding the transition into the early Acheulean and the relevant technological features.

Peninj, Tanzania

De la Torre *et al.* (2003) analysed the material from Peninj to be representative of predetermination and planning sequences in core reduction. The site, dated to between 1.6-1.4 Ma, has an assemblage of cores and flakes, with some formal tool such as burins. There are no LCTs, and at the time this was argued to encompass a late Oldowan site with advanced technological behaviours. As with Chesowanja, the dates from Kokiselei 4 indicate that Peninj also falls within the earliest phase of the Acheulean technocomplex and contains evidence of the progressive changes from the Oldowan, especially with regards to core reduction strategies.

2.5 Who made the Earlier Stone Age?

This thesis does not intend to make any arguments about which species were responsible for the production of ESA material, especially within the earliest phase of the Acheulean, but aims to gain an understanding of specific knapping behaviours. However, a brief overview of the hominids is presented.

Historically, there has been debate about which hominids were responsible for the Oldowan industry, especially before the announcement of the Lomekwian industry in 2015. *Homo habilis* was argued to have made the Oldowan, due to size of their brains, their physical attributes, and the fact that their descendants used and made stone tools (Leakey 1971; Plummer 2004). Other evidence suggested that *Parathropus robustus* and/or *Australopithecus*

garhi could also have made Oldowan stone tools. *P. robustus* is said to have exhibited anatomical features, particularly in their hands, that allowed for manual dexterity and manipulation of rocks (Susman 1991), while *A. garhi* had been found in the same stratigraphic horizon as cutmarked bone, indicating tool use. *A. garhi* was also a possible ancestor to the *Homo* genus (Asfaw *et al.* 1999). Despite the associations of these fossils and lithic artefacts, many researchers agreed with the view that *H. habilis* was responsible for producing the Oldowan stone tools (Plummer 2004).

However, with the announcement of the Lomekwian at 3.3 Ma, it became evident that hominids apart from and older than the *Homo* genus were making and using stone tools. The species argued to be associated to the Lomekwi 3 assemblage is *Kenyanthropus platyops* (Harmand *et al.* 2015). Therefore, many hominid species were capable of producing and using the earliest stone tools.

2.5.1 Hominids associated with the Acheulean

The Acheulean technocomplex is argued to be linked to the evolution of the *Homo* genus, and specifically *Homo ergaster* (also referred to as *Homo erectus*). The species was named as a sapient-like *Homo* species by Groves and Mazak (1975) based on the type fossil KNM ER 992 from east Turkana, Kenya, dating to 1.49 Ma. Later the cranium KNM ER 3733, also from east Turkana and dating to 1.78 Ma, was also considered to belong to this species (Clarke 2012). The attribution of these hominids with Acheulean archaeology has been identified in East Africa at Kokiselei 4, Kenya (de la Torre 2011; Lepre *et al.* 2011) and at Konso, Ethiopia (Asfaw *et al.* 1992; Beyene *et al.* 2015). In South Africa, there is a direct association between early Acheulean tools with fossils of *H. ergaster* at Sterkfontein Caves (Kuman and Clarke 2000).

The more advanced physical traits that *Homo ergaster/erectus* possessed would have factored into the development of the Acheulean. The widespread appearance of sites correlates to widespread movement of peoples, which was possible from the modern post-cranial body proportions of *Homo ergaster/erectus.* These body proportions meant they could walk over long distances, and population sizes increased, which in turn increased the number of regions where Acheulean sites were found (Kuman 2019). The pre-frontal cortex of *Homo ergaster/erectus* was larger in size, which has been argued to contribute to the conceptual pre-planning of artefact production, such as seen in LCTs (Stout 2011). In addition to the physically evolved traits of *Homo ergaster/erectus* and increased brain size*,* their more widespread habitats and other factors such as longer maturation rates, sociability and cooperation between groups would have influenced advances in lithic technology (de la Torre

2016). Archaeologically, the ability to migrate further meant an increase in the various raw material types available to knappers, as well as the likelihood of technological innovation to adapt to new environments. It is through a consideration of all these factors that one could infer a broader understanding of human evolution.

At the Sterkfontein Caves, the early Acheulean and the *Homo ergaster* fossil StW 80 are associated stratigraphically in the site, with a cleaver found next to the fossil (Kuman and Clarke 2000). The species is also found elsewhere in the Cradle of Humankind at Swartkrans (e.g., SK 847) (Clarke 2012). The environmental data from the Cradle of Humankind indicates a climatic change at the time of the early Acheulean to more open conditions, which coincides with the expansion of populations and sites (Luyt and Lee Thorp 2003). The presence of archaeological assemblages at Rietputs 15 and Canteen Kopje in the Northern Cape confirms the expansion model, although no fossils have been preserved in these open-air gravel sites. A clear link between *Homo ergaster* and artefact deposits is not always obvious in the eastern African record, although multiple factors show this species is likely responsible for the industry (de la Torre 2016).

2.6 Approaches to lithic analysis in the ESA

Archaeology, like any scientific field, is subject to paradigm shifts and model changes. It is through these changes that cumulative knowledge leads scientists to questions that the existing approaches cannot address. Thus, change and development in a field benefits the progress and knowledge we can acquire. The shift from the dominance of typological to technological approaches in Stone Age archaeology marks a turning point in lithic analysis, in that it has both advantaged and progressed the field. Lithic analysis has been subject to different viewpoints and debates regarding the appropriate methodologies and approaches by which to study stone tools, as well as the theoretical frameworks they fall within. This is not to say that different views are inadequate, but that the archaeologist must understand the frameworks in which they function, as this dictates the questions they ask of the research, as well as the context in which they interpret the results (Tostevin 2011).

For this thesis, I have selected a specific methodological approach by which to analyse the core reduction strategies and will justify this through discussion of the schools of thought in which said methodology was devised, and its usefulness in answering the research questions. This is not to say other methods are not valid or useful, but that it is best suited to a study such as this. The approach used in this thesis has been adopted because of the nuance it affords in studying stone tools. The scheme applied by de la Torre and Mora (2018a) allows the researcher to describe the artefact in terms of how the core edge was managed and how it

corresponds to the volume reduction. This means one could differentiate the specific technological outputs of knappers in regard to how they manipulate their raw material types and blank shapes. This approach will be discussed and described in chapter 3.

Historically, there have been many debates in lithic archaeology originating broadly from the French and USA schools, which permeated all stone age research and maintains a strong legacy to this day (Bordes 1950, 1961, 1968; Bordes and de Sonneville-Borde 1970; Binford and Binford 1968, 1969; Binford and Sabloff 1982; Isaac 1977a,b; Toth 1985; de la Torre and Mora 2009; de la Torre 2011, 2016; Tostevin 2011). This specific debate is not the only standard by which to discuss approaches to lithic analysis, but it can be used as an example of the historical context of the discourse. In very basic terms, the argument can be boiled down to the typological versus technological approaches.

2.6.1 Typological approach

Typological analysis, as developed by Bordes (1961) and applied by many researchers including Leakey (1971), has been the main focus in previous studies of these assemblages (de la Torre 2009). Artefact types based on the morphology of the final lithic product (Krieger 1944; Inizan *et al.* 1999) dominated classification and comparisons in lithic analysis. This methodology created comparable but homogenised morphological types, which archaeologists used for identification and description of industries and the sequencing of sites, as seen with the cultural chronology developed at Olduvai Gorge (Leakey 1971; de la Torre 2009). While these classification (or type) groups can be useful in comparing and separating assemblages and industries, they infer a unilinear view of archaeological change (de la Torre and Mora 2009). The limitations of purely typological analyses are noted among lithic analysts as unable to address variability, which is pigeon-holed into discrete type categories (de la Torre and Mora 2009).

Research focused on technological assessments in the ESA has become more popular over the last decade due to the nuanced interpretations one can ascertain from these studies. Progressive studies have moved from the foundational and highly influential earlier typological analyses to focus more on the core reduction strategies and *Chaîne Opératoire* of stone tool production (Toth 1982; Toth 1985; Tostevin 2011; de la Torre 2016). Regarding typological studies of the Acheulean, morphological variations within artefact types like LCTs were used to define the technocomplex, with changes and progression focused on the standardization of LCT production from the early to later phases of the Acheulean. These changes were used to infer the behaviour of knappers and hominid species. However, more recent technological work has highlighted some of the limitations in these approaches for comparative analysis, especially when comparing the differently defined technological attributes and trends between

assemblages and regions (Shott *et al.* 2011; Couzens 2012; Li *et al.* 2014; de la Torre *et al.* 2018a and b; Caruana 2020).

Comparative studies in archaeological discourse are both commonplace and necessary to define broad ranging technocomplexes such as the early phase of the Acheulean across Africa (Moll 2017; de la Torre *et al.* 2018a, b). However, comparisons can be complicated when researchers use differing definitions for artefact types and attributes (Clarke 1978). In order to create nuanced comparative interpretations, archaeologists need to manage these ideas when producing both practical and theoretical work. Archaeologists need to make a consensus on these must be used across the board. It is because of these differing methodologies and approaches used by various researchers that this study will focus on previously analysed assemblages to illustrate the possible pitfalls encountered in comparative analyses.

2.6.2 Technological approach

Technological studies have aimed to interpret the behaviour of knappers, hopefully to glean insight into their cognitive abilities, but multiple factors need to be considered in this regard such as manufacture, use, and disposal of artefacts, as well as landscape, geology, topography and geography. De la Torre and Mora (2009: 15) define these factors as constituting the 'technological strategies' of knappers. These all play a part in technological decisions, and the further back in the archaeological record one goes, the harder it is to understand these outside elements (Braun and Hovers 2009). Thus, when working in the ESA and early Acheulean, the entire life cycle of production is not present and gaps need to be acknowledged.

Technological approaches to lithic analysis have often abandoned the use of typological classifications of final products because it limits the descriptive analyses of assemblages (Duke *et al.* 2021). It has been argued that these categories infer pre-determined ideas of flaking, in that hominids sought a final product 'type'. For cores, this could mean that flaking strategies can be viewed as inflexible, and that knappers did not demonstrate variable behaviours. The downfall of such an approach is that by focusing simply on the final product, there is little room for nuance and fluctuations in flaking patterns (Tostevin 2011; Duke *et al.* 2021).

The shift from typological to technological approaches has been popular for many decades, However, there is often a lack of consensus with regards to the terminology used to classify various strategies. Therefore, the definitions used by various researchers need to be considered, as they could use the term 'types' differently. Ludwig (1999) acknowledges that cores can demonstrate multiple reduction strategies, but the predominant one will define the

core type. In this case, 'type' is not referring only to the morphology of the piece, but also the technological components.

2.6.3 Theories of technological approaches

Shott *et al.* (2011) and Tostevin (2011) are seminal papers describing and updating the main two schools of thought in lithic analysis – core reduction and *Chaîne Opératoire* (Soressi and Geneste 2011). It is noted by the author that the historical implications and definitions of these schools of thought are vast, and as argued in the papers mentioned, have much overlap. Young researchers can get lost in the literature of the schools of thought as it can often be hard to distinguish the school to which an approach or study can belong. I follow the reasoning of Tostevin (2011) that they are intertwined and can be connected, something that very heavily features in ESA research. Publications on the earliest technological studies do not focus heavily on the theoretical frameworks in which they work, except when distinguishing between typological and technological analyses.

The *Chaîne Opératoire* was developed by archaeologists working in the European Palaeolithic, especially in France, and is translated as the chain of operations (Leroi-Gourhan 1964; Pelegrin 1985, 1990, 1991; Geneste 1985; Sellet 1993; Delagnes and Roche 2005; Tixier 2012). Broadly speaking it can be defined as the study of stone tools through all the life cycles of the artefact, as manipulated by humans. All information, from the acquisition of raw materials to the discard and reuse of tools is used in the interpretation of technological behaviour. The links along the chain investigate various decisions taken by knappers during production. Within each 'link' there is a multitude of information available, such as the core reduction strategies. Each link is then understood in the context of the larger chain of operations. This has been argued to differ from the 'pure' core reduction sequences approach which interprets technological steps prior to implementing them into a larger context (de la Torre and Mora 2005; Shott and Weedman 2006; Tostevin 2011).

Core reduction analysis details the specific decisions made by the knappers within the reduction strategy. It is argued that this allows the researcher access to the thinking of the knapper (Bleed 2001; Shott 2003; Shott *et al.* 2011; Tostevin 2011). Reduction is seen as irreversible, but these specific analyses can potentially reconstruct the sequence, in turn indicating the skill and technological behaviours of knappers (de la Torre and Mora 2005). This means the various factors can be quantified (Braun *et al.* 2008a and 2008b), including "…raw material accessibility, differential transport, patterns of site use, and tool function" (Kuhn 1991: 76), and individual factors could elucidate much information on a sequence (de la Torre and Mora 2005).

Universal processes, as described in *Chaîne Opératoire*, differ with core reduction approaches, which consider variability to manifest in the small details of assemblages and is argued to be the case in ESA studies (Shott 2003; Braun and Hovers 2009; Shott *et al.* 2011). However, Shott *et al.* (2011) argue that the core reduction approach does not assume overarching influences to be inconsequential but rather sees it as a context for the specific traits. I argue that these approaches are inherently asking similar questions about the technological behaviours of knappers. Therefore, the approaches can be used in combination to the benefit of archaeologists (Tostevin 2011).

I do not claim to be an expert on any of the schools of thought, nor the theoretical implications or origins, but think, similarly to Tostevin (2011), that current research needs to consider the implications and benefits of each side. The following discussion comes from my understanding of the literature and experience, and I acknowledge that the debate and flexibility between archaeologists is varied in this regard. This discussion will focus more on the implications for technological studies in general and how these schools of thought have been adapted and used in analyses of the ESA in Africa, with regard to the earliest phase of the Acheulean technocomplex. It will also explore how comparative studies can be conducted in those contexts.

2.6.4 Technological analysis in the ESA

Assemblages from the earliest phase of the Acheulean technocomplex are widespread and appear in many areas around the African continent. Thus are often in vastly different environmental and geological contexts, with variable raw material availability. Core reduction approaches are becoming commonplace in eastern and southern African ESA studies (Tostevin 2011; de la Torre 2016; Presnyakova *et al.* 2015; Caruana 2017; Moll 2017; de la Torre and Mora 2018). However, while technological analyses have successfully been applied to the South African assemblages, the diacritical core reduction approach has only been applied to a few sites, such as Maropeng (Moll 2017) and Penhill in the Sundays River valley (Lotter 2016; Lotter and Kuman 2018).

Despite the variability of site contexts, the results of technological studies have been similar both in terms of morphological artefact types and the manufacture and use of tools (de la Torre 2016; de la Torre and Mora 2018b). Due to these observed similarities, it would be of interest to understand exactly how the production strategies are handled in different sites, which would allow us to determine whether tool makers were technologically adaptable or were dependent on raw material mechanics and/or environments. In other words, if manufacture of stone tools in the ESA is similar, what choices or actions were made to allow for that similarity, and how

did hominids adapt their knapping actions to fit within the context. Reduction strategies refer to the process and pattern of flake removal on a core and include consideration of various factors, like raw material selection and sourcing (de la Torre *et al.* 2003; de la Torre 2011; Shott *et al*. 2011; Tostevin 2011), in order to focus on the physical and cognitive behaviours and skills demonstrated by the knappers through tool production (Kuhn 1991). De la Torre *et al.* (2003) and de la Torre (2011) use a set of diacritical schemes to define patterns of flake scars in relation to flaking direction and edge angles of cores.

Diez-Martín *et al.* (2009) developed a diacritical approach of technological lithic analysis that moved away from typological classification of core reduction. At BK in Olduvai Gorge, cores were categorised by the number of exploited surfaces and their positions relative to each other, and scar directionality, similar to the method used in this thesis. For example, the terms 'multifacial' described cores with at least three faces exploited, in three directions, and would have been classified as 'polyhedrals' under Mary Leakey's core types (1971). The system also cores by the exploitation of surfaces and the preparation of striking platforms for core reduction. Similar to the method from de la Torre and Mora (2018b; described in chapter 3, surface exploitation and directionality are of the utmost importance (Figure 2.2), but the main difference is that Diez-Martin *et al*. (2009) do not consider volume reduction. De la Torre and Mora (2018a) consider volume reduction by adding more categories for core classification. An example of this is the two categories for bifacial alternating edge management that cover the entire circumference of the piece (BALT and discoid, see Figure 3.14), but the invasiveness of flake scars differs between them, with one category removing the central bulk. A systematic comparison of these technological approaches has not been formally published and could be a question this thesis could help answer as a case study. Despite the differences in how these two methodologies consider volume reduction, the general diacritical analysis of surface exploitation is the similar enough for comparison. Thus, in the discussion, the site of BK (Diez-Martín *et al.* 2009) will be used as a comparative site for the data presented in this thesis.

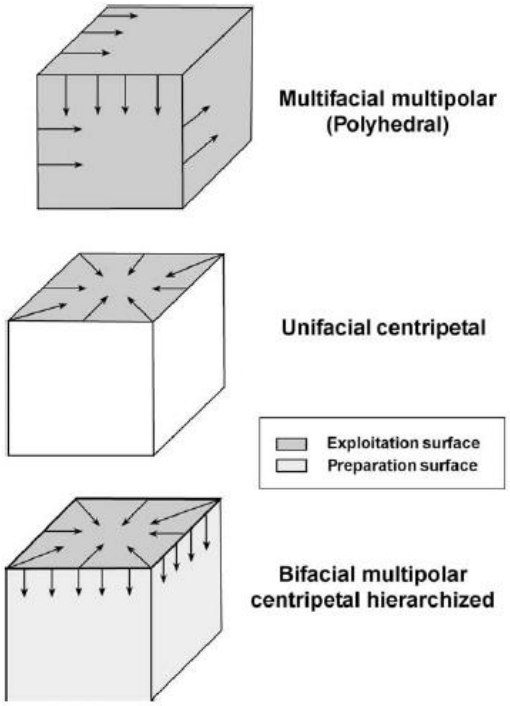


Figure 2.2: Schematic representation of freehand core reduction strategies as presented in Diez-Martín et al. (2009)

2.6.5 The focus on large cutting tools

LCT technology has been at the centre of Acheulean technology, both in the diagnostic descriptions of the technocomplexes and as a focus of research in itself. Handaxes and their teardrop shape have been seen as the morphological standard for the entire technocomplex, but researchers agree that the technology involved can contribute much more intricacy and complexity in understanding the entire archaeological record, as well as the specific pieces (Lycett and Gowlett 2008; Shipton 2018; Wynn and Gowlett 2018; Caruana 2020, 2021, 2022). The connection between LCT and core production has been argued to be separate in some Acheulean assemblages (de la Torre and Mora 2018b) but there is evidence of a connection between these categories, and even the recycling of LCTs as cores and vice versa (Dibble *et al.* 2016; Rosenberg-Yefet *et al.* 2021). Therefore, these artefacts cannot be completely separated when considering the description of reduction strategies.

These artefacts are undoubtedly highly important, as judgements also have to be made concerning shaping in the form of manipulation of blanks, evaluation of outcomes and factors pertinent to the use of working memory in tool production (de la Torre 2016). Bifacial shaping and control over the shaping of a piece became more prominent in the Acheulean, which is a feature related to LCT production along with more structured core edge management (Roche 2005; Shipton 2018; Texier 2018; Caruana 2021). Bifacial knapping did occur in the Oldowan,

but the systematic application of the technique is more pervasive and controlled at Acheulean sites (Duke *et al.* 2021). This control shows the ability of knappers to create specific shapes and tool types through successive removals, which needs to be done in stages. Therefore, hominids had to use forethought while making LCTs to function as tools. Cores were discarded by-products, but because core reduction schematics show a continuous and controlled knapping scheme similar to LCT edge management, the processes for both artefact types had to be understood based on the successive steps to be taken.

Refinement and symmetry of handaxes in the Acheulean is likely due to variability at specific localities rather than a blanket cognitive evolutionary development (McNabb and Cole 2015; Shipton 2018; Caruana 2021). Progression of refinement and symmetry are argued to exist within the Acheulean technocomplex, but to properly determine this there needs to be more assessment of all sites across time and regions (Shipton 2018). Despite refinement being argued by some as a progressive technological trait (Leakey and Roe 1994; Kuman 2007; Wynn and Gowlett 2018), other researchers counter the argument because of the reliance on typological classifications of handaxes required. What is important to remember is not that these ideas of progression are necessarily wrong but that we do not have a large enough and comprehensive dataset to suggest it (McNabb and Cole 2015; Shipton 2018; Caruana 2021).

Reduction strategies can indicate the level of cognitive and behavioural ability through the intensity of problem solving undertaken by the knappers for both cores and LCTs (Roe 1994; Clark 1999; Wynn 2002; Dibble *et al.* 2016; Muller *et al.* 2017; Rosenberg-Yefet *et al.* 2021; Caruana 2022). This argument is relevant in core reduction studies, as the extension of a core's use demonstrates hierarchal organisation and thus good technical ability. In Muller *et al.* (2017) the argument was applied to biface production, among other production types. The authors argue that the imposition of form along with the increased refinement and symmetry in later Acheulean handaxes displays a more developed complexity than that of knappers in the early Acheulean. This conclusion was achieved through an experimental study and shows how general trends in lithic production techniques and industries developed alongside cognitive evolution in humans and their tool making ancestors.

Despite such work as Muller *et al.* (2017) that demonstrates continuous global development in the techniques of stone tool production, recent research and discourse has proven that handaxe shaping does not universally follow the rule of 'crude to refined' (Isaac 1971; McNabb *et al.* 2004; Diez-Martín *et* al. 2015; McNabb and Cole 2015; Shipton 2018; Shipton *et al.* 2019; Caruana 2020). Muller *et al*. (2017) argue for less complex cognition in the early Acheulean as there were fewer steps of organisation in the production of handaxes, hence less hierarchal organisation, and knappers did not prepare platforms, while in the Later

Acheulean, handaxes showed organisation across multiple volumetric planes. However, variability within and between sites through the Acheulean technocomplex has shown that artefacts of all types are also heavily influence by the context in which they are discovered. This means that despite the global trend of refinement throughout the entire Acheulean technocomplex, variability within and between sites can be highly complex (Shipton 2018) and needs to be considered across all artefact types. I assert that is the same for core reductions strategies.

Cognitive archaeology is of interest to consider, as it seeks to understand how our ancestors thought while performing different activities. Stone tools are a useful proxy for accessing the minds of knappers, which in turn gives one an understanding of hominids and their cognitive behaviours (Du and Wood 2020). The ability hominids possessed to conceive of a final product demonstrates their mental forethought of the process by which to achieve said final product. Along with the actual artefacts, researchers need to consider multiple factors to develop a more homogenous idea of the entire lithic production process.

Knappers use a series of decisions while producing a stone tool (Wynn 2002; Du and Wood 2020), which includes a working knowledge of the landscape in which they live, as well as the raw material available, and the properties there within (Du and Wood 2020; Kübler *et al.* 2020). The study of the entire *Chaîne Opératoire* necessitates that knappers were able to "…locate, transport, manipulate and modify" raw material, thus having developed cognitive technological behaviours (Du and Wood 2020: 9).

Other factors to also consider include brain size and cognitive evolution. This is not the determining factor in lithic production, but it is related to the adaptability of hominids across the African continent during the earliest phase of the Acheulean

2.7 The influence of raw material on core reduction strategies

Raw material type, selection, transport, and mechanical properties are important factors in evaluating hominid behaviour, skill, and landscape use. Jones (1994) has argued that cognitive skill and behaviour can be inferred from the knappers' ability to work with a raw material type and to overcome any flaws. Artefacts have been observed to be shaped along the natural constraints of their raw materials, as knappers often rely on local sources for procuring blanks (Isaac 1977a, b; Toth 1985; Jones 1994; Newman 1994; Plummer 2004; Field 1999; Braun *et al.* 2008 a and b; Blumenschine *et al.* 2012; Kuman and Gibbon 2018; Mesfin *et al.* 2021).

The locality of raw material greatly influences the tool types at a site. During the ESA, hominid groups tended to rely on proximal sources but did in some cases travel long distances to

procure desirable raw materials (Jones 1994). However, as discussed for the Oldowan, hominids did transport material long distances, sites such as the Lower Omo Valley, to take advantage of more suitable environments to inhabit (Delagnes *et al.* 2011). Transport of raw material over long distances has been recorded in early archaeological sites, indicating knappers had a good idea of fracture mechanics of various rock types, and the landscape knowledge to move them. In sites where material was imported for tool production, there is often evidence of core rejuvenation and heavy exploitation, whereas knappers more quickly abandoned reduction sequences in sites where raw material was in proximity (Jones 1994; Blumenschine *et al.* 2012).

De la Torre *et al*. (2003) related the differentiation in raw material properties with the resulting artefact types at Peninj, Tanzania to support the hypothesis that hominids were able to variably exploit different rock types. This was further demonstrated at EF-HR where the two production strategies are dominated by different raw materials (de la Torre and Mora 2018b), where trachyte makes up half of the raw material used in the production of LCTs, and core and flake strategies are primarily made on other lavas such as basalt and phonolite.

In South Africa, some raw materials differ with those in East Africa, and it is of interest to determine if they denote vastly different reduction strategies. At Sterkfontein quartzite became more prominent in the Acheulean than the Oldowan and was linked closely to the manufacture of LCT blanks (Field 1999; Kuman and Clarke 2000; Caruana and Mtshali 2018), which is also observed at Maropeng in the Cradle of Humankind (Moll 2017). The increased use of quartzite is also seen in the core and flake components of the industry, suggesting the raw material was generally preferred by knappers. These ideas will be fleshed out in this thesis and the relevant technical data used to determine to what extent raw material types influenced the overall technology. If hominids were able to adapt similar behaviours to different raw materials in a relative way, it could support the idea that there was a shared technological background to early Acheulean assemblages whereby raw material choices were subject to developments in technological ability.

Interestingly, the quartzite found in Olduvai Gorge has been procured from the Naibor Soit Hill and has often been called quartz because it is highly metamorphosed. Richard Hay (1976) described the geological context of Olduvai Gorge and described the nature of the quartzite, which erodes in tabular slabs out of the hill. To maintain consistency in this thesis I will be referring to this raw material as quartzite, following Hay (1976). For this research, it will be discussed in the results how this affects the technology from both regions, and whether the quartzite from Olduvai Gorge and the quartz from the Cradle of Humankind are exploited similarly.

Chapter 3: Materials and Methods

This chapter is divided into two main sections. Firstly, the assemblages from each site that was studied will be presented. Secondly, it will detail the various methods and measurements used in the data collection and analyses, including the statistical analyses used.

3.1 Materials

Core and LCT materials from the assemblages representing the earliest phase of the Acheulean from four sites were studied. In total six assemblages were studied for this thesis (Table 3.1 and 3.2). The analysed material includes the early Acheulean core and LCT assemblages from the South African sites of Sterkfontein caves, in the Cradle of Humankind, and the Artefact Collection Pit assemblage and the Pit 5 LCTs from Rietputs 15. Material from Pit 6 in Canteen Kopje was also analysed, and both sites are located in the Northern Cape. Early Acheulean material published by de la Torre and Mora (2018b) from EF-HR, Olduvai Gorge in Tanzania was also analysed.

Table 3.1: The number of cores and LCTs analysed in this thesis

	Cores	LCTs	Age
Sterkfontein Member 5 West	264	18	Estimated <2 Ma (Leakey 1970; Kuman 1994; Kuman and Clarke 2000)
Canteen Kopje Basal layer	39	33	>1.51 Ma (Leader 2014)
Canteen Kopje Organised Core layer	40	52	1.51 ± 0.8 Ma Leader 2014)
Rietputs 15 Pit 5	0[4]	62	1.31 ± 0.21 to 1.27 ± 0.2 Ma (Gibbon *et al*. 2009; updated in Leader *et al.* 2018)
Rietputs 15 ACP	93	18	Estimated > 1.3-1.5 Ma (Kuman and Gibbon 2018)
EF-HR	128	102	>1.33 Ma (de la Torre and Mora 2018b)
Total	**564**	**285**	

[4] This material is currently mislaid at the McGregor Museum and therefore has not been included in this thesis. Once it is found, the cores will be added to the results for publication.

Table 3.2: Maximum, minimum, mean, and standard deviation of the length, width and thickness (mm), and weight (g) of all assemblages

Sites	Type		Maximum	Minimum	Mean	Standard deviation
Sterkfontein						
	Cores					
		Length	170	33,3	87,2	1,3
		Width	136,4	26,9	73,6	1,1
		Thickness	102,5	18,9	56,4	1
		Weight	2832,1	17,4	422,6	19,2
	LCTs					
		Length	169	92,8	121,6	4,2
		Width	93,4	52,6	75,6	2,3
		Thickness	79,3	27	48,6	2,7
		Weight	892,2	115,5	440,2	43,1
Rietputs 15 ACP						
	Cores					
		Length	133,3	43	69,2	2,1
		Width	92,7	34,9	55,8	1,3
		Thickness	87,7	18,9	37,3	1,2
		Weight	1162,3	41,2	180,6	18,5
	LCTs					
		Length	142,8	66,7	109,6	4,4
		Width	120,5	55,2	75	3,6
		Thickness	52,5	25,2	49	1,7
		Weight	816,6	96,1	362,4	395
Rietputs 15 Pit 5						
	LCTs					
		Length	225	11,4	125,9	3,7
		Width	113,9	55,6	80,6	1,6
		Thickness	98,2	23,8	42,3	1,5
		Weight	1727,6	131,8	485,6	36,1
Canteen Kopje Basal layer						
	Cores					
		Length	387	49,9	226,3	14,3
		Width	278	41,8	164,2	10,3
		Thickness	229	19,7	118,1	8,9
		Weight	23000	56,9	6351,2	885,8
	LCTs					
		Length	182	80	138	3,9
		Width	154,7	52,6	86,4	3,4
		Thickness	64,2	23,3	39,8	1,6
		Weight	2302,5	111,3	592,5	65,9

Canteen Kopje Organised core layer						
	Cores					
		Length	401	15,5	151	15,3
		Width	243	31,5	108,9	9,4
		Thickness	196	18,2	79,6	7,9
		Weight	13499,5	26,3	2740,3	531,4
	LCTs					
		Length	181,5	76,8	129,7	4,1
		Width	125,5	39,7	78	2,7
		Thickness	63,5	20,2	38,3	1,3
		Weight	1327,1	68,9	469,1	41,7
EF-HR						
	Cores					
		Length	185	36,6	83,5	2
		Width	135,3	28,5	701	1,8
		Thickness	113,5	21,2	53	1,5
		Weight	3096	21,8	424,9	36,1
	LCTs					
		Length	195	95,6	145,3	2,1
		Width	110,4	62,4	85,8	1
		Thickness	76,6	20,9	46,9	0,9
		Weight	1121,6	261,5	554,6	17,2

3.1.1 The early Acheulean sites used in this thesis

South Africa

Early Acheulean sites >1 Ma in South Africa are thus far restricted in location and context to the Cradle of Humankind in Gauteng, the interior of the country in the Northern Cape, and the Eastern Cape (Kuman 1994, 2007; Lotter and Kuman 2018). In the Cradle of Humankind, these assemblages are in secondary contexts and include the karst cave sites of Sterkfontein and Swartkrans (Kuman 1994; Field 1999) and the open-air colluvial site of Maropeng (Pollarolo *et al.* 2010; Moll 2017). In the Northern Cape, there are the colluvial and alluvial sites Canteen Kopje and Rietputs 15, as well as the cave site of Wonderwerk Cave (Gibbon *et al.* 2009; Leader 2014; Leader *et al*. 2018; Kuman and Gibbon 2018; Shaar *et al.* 2021). In East Africa there are many well-known areas with early Acheulean archaeology (Kleindienst 1962; Leakey 1971; de la Torre 2009; de la Torre 2011; de la Torre and Mora 2014; de la Torre 2016; Lepre *et al.* 2011; Beyene *et al.* 2013; Presnyakova *et al.* 2018). In this thesis, the site EF-HR in Olduvai Gorge, Tanzania will be used because it was the type series for the Early Acheulean (Leakey 1971).

Sterkfontein Caves

The Sterkfontein caves are located in the Cradle of Humankind, South Africa (Figure 3.1). It is arguably one of the richest and most famous palaeoanthropological sites in the world. The archaeological deposit is important because of its association with hominid fossils in Member 5 West (Field 1999; Kuman and Clarke 2000). The site lies close to other important cradle sites, such as Swartkrans and Kromdraai, as well as the Bloublank River. Some of the most important fossil discoveries from the cave system include the first adult specimen of *Australopithecus africanus*, as well as the skull of Mrs Ples, another *A. africanus* (Kuman and Clarke 2000; Thackeray 2002; Clarke 2013). The most complete *Australopithecus* skeleton was also found here, known as Little Foot, which belongs to the species *Australopithecus Prometheus* (Granger *et al.* 2015; Clarke and Kuman 2019).

Sterkfontein has historically been the best-known Early Acheulean assemblage in South Africa and hence has been used as a reference site for other archaeological analyses in the Cradle of Humankind and elsewhere in the country (Kuman 1994, 1998; Field 1999; Leader *et al.* 2018; Kuman and Gibbon 2018; Moll 2017; Lotter and Kuman 2018). Until recently, the Oldowan from Sterkfontein was the oldest known archaeological assemblage in South Africa, at 2.18 Ma (Granger *et al.* 2015), but a slightly older date of 2.2 Ma for Swartkrans has recently been published (Kuman *et al.* 2020). The Oldowan assemblage from Sterkfontein consists of 3513 pieces, 70% of which are small flaking debris. Compared to the large assemblage of small flaking debris in the Oldowan, the Acheulean assemblage has been heavily winnowed (Field 1999).

The original analyses of the Early Acheulean at Sterkfontein focused on applying a typological analysis to describe the chronological position of the lithics and their context (Kuman 1994, 1998). In a techno-typological study for her MSc titled '*An analytical and comparative study of the Earlier Stone Age archaeology of the Sterkfontein valley*, Annabel Field (1999) described 701 pieces, including 208 manuports (30%), 258 cores (37%), 21 flakes >20mm (3%), and a large collection of chunks (14.55%). The assemblage was recovered from Member 5 West and was produced on local raw materials, mainly quartzite, quartz and chert (Field 1999; Kuman and Clarke 2000). Stratford (2008) added the material from Dump 21 to the original assemblage described by Field (1999) and argued that there is a focus on expedient flake production.

The Sterkfontein cave system has been partially filled with a series of deposits that have been grouped into major units called members (Partridge 1978). Six members are recognised at Sterkfontein, with the bulk of the australopithecine remains yielded from Member 4, in which

no stone tools are found. The archaeological material has been yielded from Member 5 East and West, irregularly divided by an erosional pocket that has been filled with younger (Middle Stone Age-MSA) material. The Oldowan material is found in Member 5 East is overlain by Acheulean in unreliable context due to solution pockets that have admitted some MSA lithics (Kuman 1994; Reynold *et al.* 2007; Ogola 2009). However, Acheulean material found in Member 5 West is considered in good context (Clarke 1994; Kuman 1994; Kuman and Clarke 2000; Stratford *et al.* 2012; Stratford 2017).

Figure 3.3 shows the schematic margins for Member 5 West (M5W, in purple), based on the original grid squares established for the site. The Sterkfontein deposits are complex, and confusion regarding the provenience of some artefacts has occurred because of the mechanical, spit-based excavations conducted in early years. This was partly rectified with the creation of a schematic plan of the members published by Kuman and Clarke (2000). More detailed mapping of the contact between remaining breccias was later undertaken by Ray Couzens (2021). In this thesis, there is a focus on material from the designated Member 5 West infill as defined by Couzens (2021), with the addition of material from the southern Member 5 squares and those west of line 58. This means there has been an additional set of squares added to the analysis conducted by Annabel Field (1999), who focused on squares excavated by John Robinson in the 1950s.

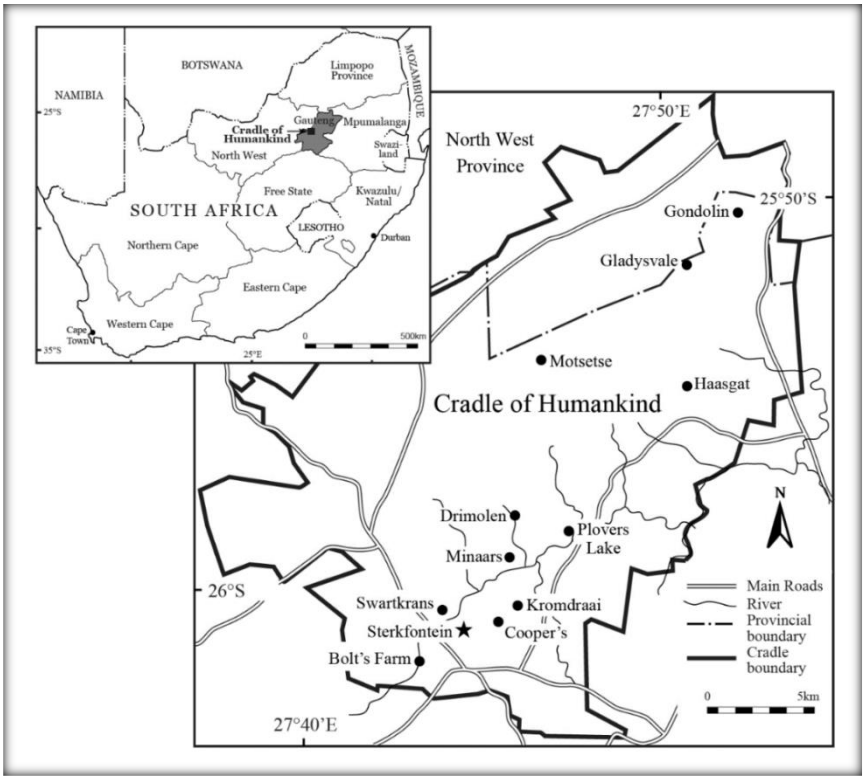


Figure 3.1: The location of the Sterkfontein Caves within the Cradle of Humankind and in South Africa (image from Stratford et al. 2012)



Figure 3.2: Aerial photo of the excavation site at Sterkfontein Caves (Photo courtesy of Dominic Stratford)

One of the problems we encounter with Member 5 West is that there are no absolute dates for the deposit. The Acheulean assemblage was heavily winnowed on the surface prior to being incorporated in the M5W infill, and with such exposure it has, thus far, been difficult to

obtain a cosmogenic burial age for quartz-containing clasts within the deposit. Previously, a date of <2 Ma was suggested based on the faunal remains from the deposit and Mary Leakey's assessment of the archaeological material in 1971 (Leakey 1970; Kuman 1994; Kuman and Clarke 2000). This new project has added 14 cores to the analysis of the Sterkfontein Early Acheulean assemblage and aims to do a more in depth and nuanced analysis between Sterkfontein and the more recently excavated material from EF-HR.

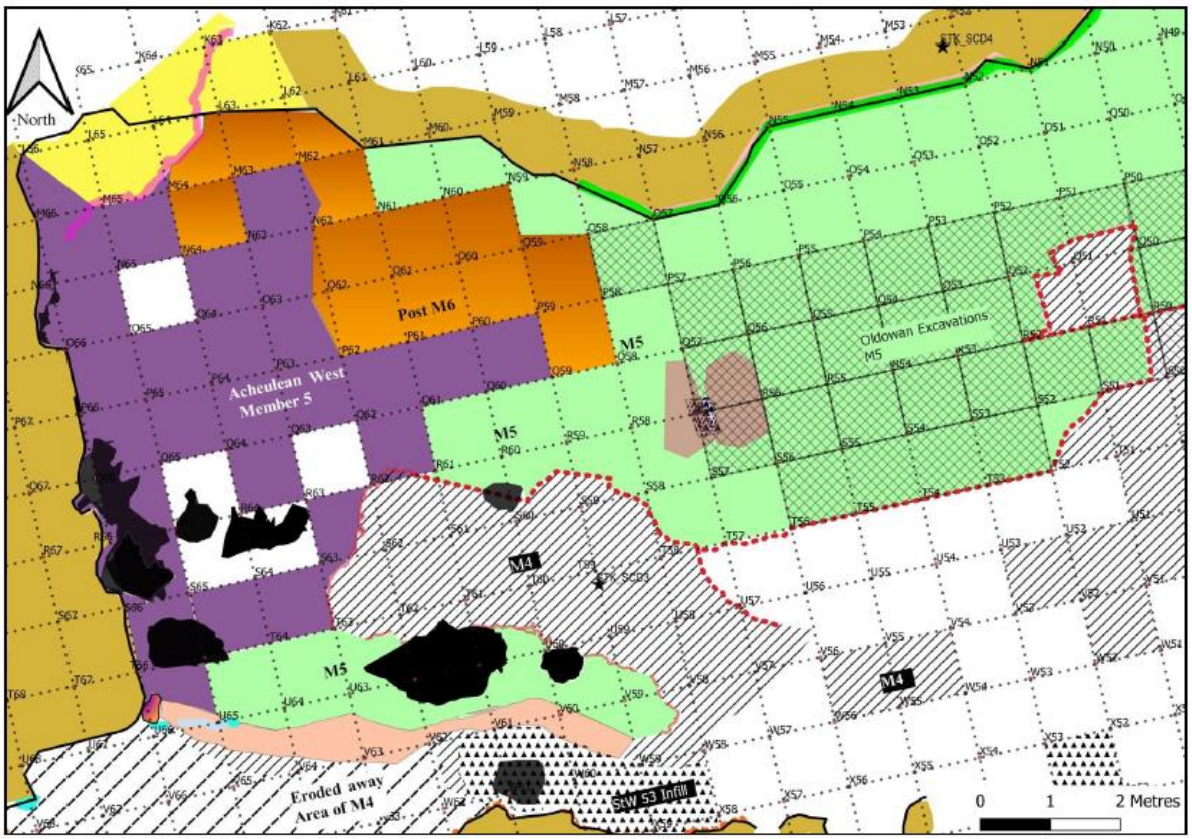


Figure 3.3: Map of Members 4 and 5 from Sterkfontein Caves (Image from Couzens 2021)

There are 264 cores analysed in this new study, out of an assemblage of 707 pieces. There are also 208 (29.4%) manuports and together with the cores these make up more than two thirds of the assemblage. In total, there are only 19 LCT products in the assemblage. Overall, small flaking debris <20 mm in size comprises only 4% of the M5W assemblage due to loss through surface erosion, while larger flakes and cores make up 72% of the assemblage (Field 1999; Stratford 2008). Fine-grained quartzite dominates the core assemblage, and there is a range of 4-16 removals across the cores in the sample studied by Field (1999). Field (1999), Stratford (2008) and Moll (2014) have all argued for limited exploitation of core blanks, with a third of polyhedral cores (as defined by Field 1999) still having flakeable platforms.

This new study aimed to move away from the typological classifications of core technology and study the characteristics of core reduction and LCT shaping. Core reduction strategies were classified using the schematic developed by de la Torre and Mora (2018a) in Olduvai Gorge, while the shaping strategies evident on LCTs were recorded. They also applied this to a recently excavated assemblage from EF-HR, which will be discussed later as the comparative study to Sterkfontein.

The schematic is set up to classify technological strategies based on the intersection of core edge management and volume reduction of a core. Thus, researchers can deduce the behavioural traits of knappers, such as the use of natural platforms and surfaces on raw material blanks. It also describes the steps taken within the reduction sequences, like the rotation of cores and flipping of blanks for bifacial knapping.

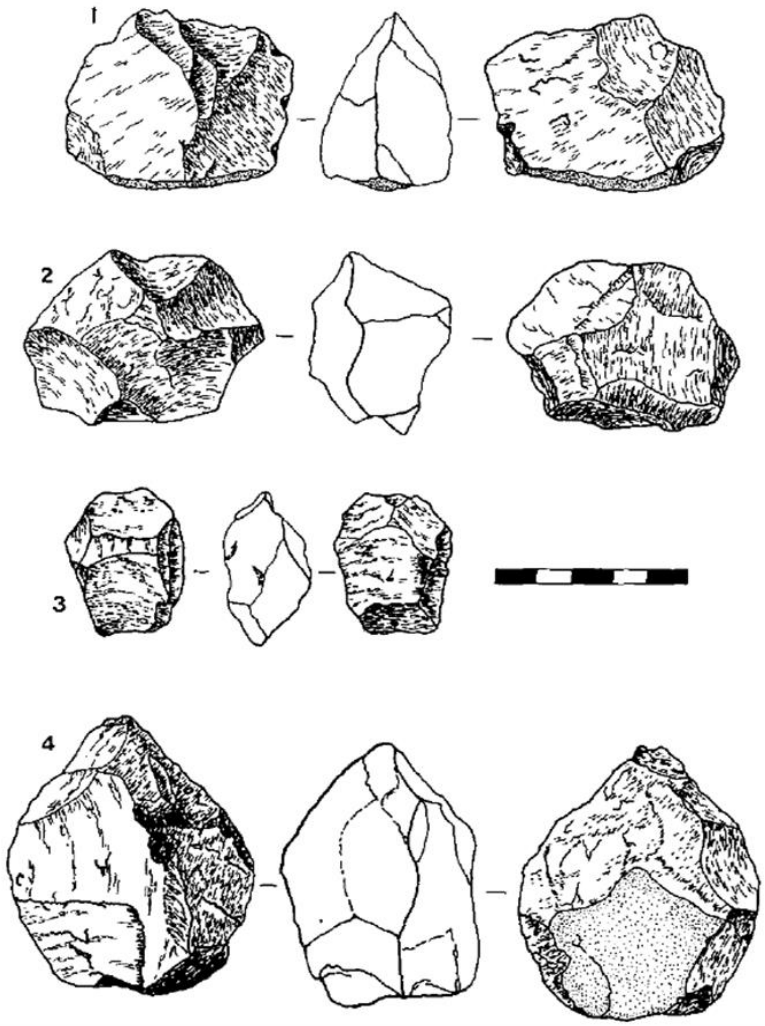


Figure 3.4: Oldowan cores from Sterkfontein Caves (from Kuman 1994)

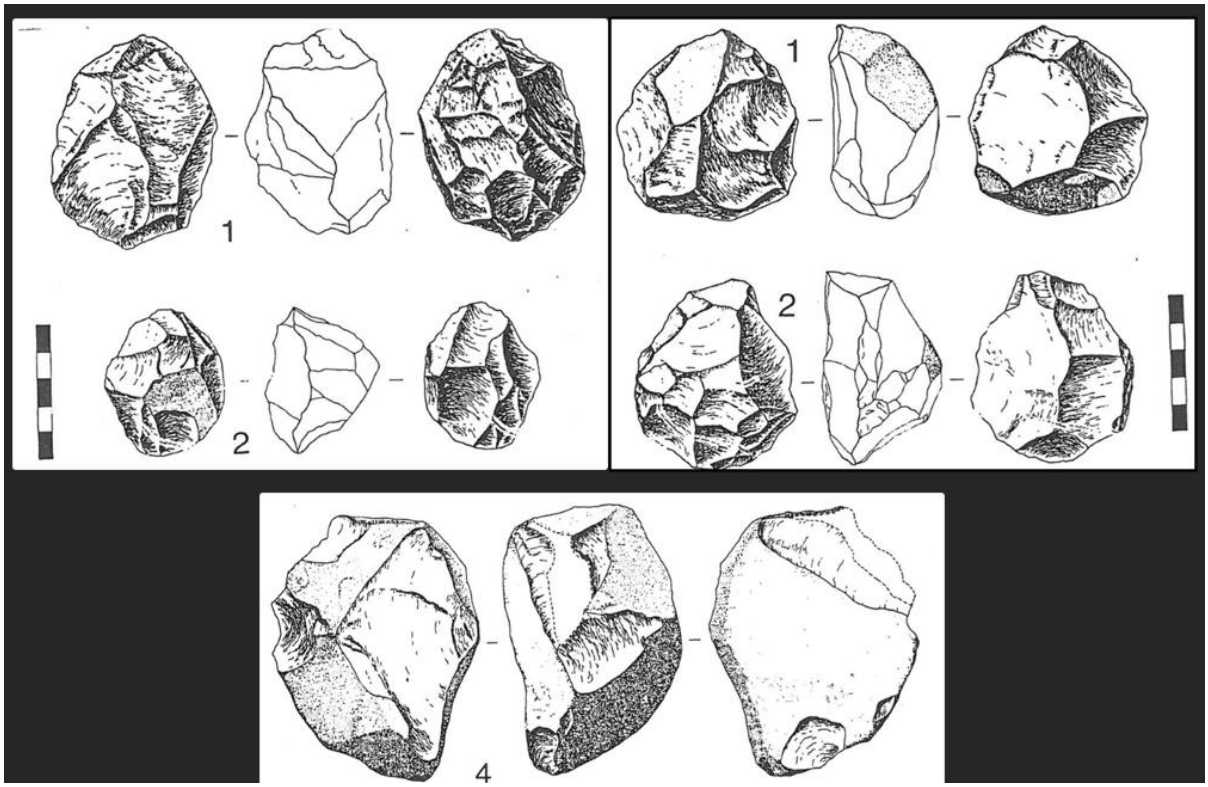


Figure 3.5: Early Acheulean cores from Sterkfontein Caves (from Field 1999).

The impetus to study the Acheulean assemblage from Sterkfontein Caves M5W is based on two main reasons. First is that the assemblage and initial study done by Field (1999) remains unpublished and unrevised since the late 1990s, yet the assemblage has been used for comparison without further detail available on the nature of reduction techniques and strategies (Moll 2017; Kuman and Gibbon 2018). Secondly, the assemblage is important for comparative analyses because its LCTs compare well with the Early Acheulean in East Africa (Kuman 1994) between 1.7 and 1.4 Ma (Leakey 1970; Kuman and Clarke 2000), and a technological study could confirm and/or elaborate on the similarities.

Figure 3.5 shows some examples of cores described in Annabel Field's MSc thesis (Field 1999). These pieces were classified as polyhedral or irregular polyhedral cores. The latter means they were less intensely exploited, sometimes in a casual manner, over multiple surfaces on the core. Field (1999) uses the term casual as cores that were minimally exploited along angular natural platforms. Roughly a third of the core assemblage has remaining cortical surface and further platforms to exploit (see also Moll 2014). For cores classified as discoids, and for heavily exploited polyhedrals (Field 1999), the flaking strategies are defined as intensive, and occurred when further natural platforms were exploited. Overall, the Acheulean is described as opportunistic, influenced by the good availability of raw material and the small representation of intensive reduction.

Other conclusions presented in Field (1999) that need to be considered in this analysis are bipolar flaking techniques, cortex, flake scar size and frequency, as well as the differences between the raw materials. Quartz represented a smaller sample in the core assemblage, but these cores tended to have more flake scars, a fact Field attributes to the properties of quartz to shatter more easily than the quartzite, as seen through experimental knapping. Quartz pieces tended to have less cortex but the overall largest flake scar sizes were consistent between raw materials and cores with differences in scars counts, suggesting that the knappers were consistent in flake production.

While the original classifications describe the general reduction patterns, there is little that can be understood about core edge management, especially regarding the distribution of bifacially and unifacially exploited cores. Thus, comparisons of specific technological behaviours are limited with this data set and EF-HR because of the different analyses.

Sterkfontein LCTs

The LCT assemblage from Sterkfontein is small in relation to the size of the core assemblage, with a ratio of 14:1 representation. This includes pieces which I have reclassified with the help of Prof de la Torre as broken LCTs, or 'rough-out' LCTs, and which will be further expanded upon in the results chapter. The debitage from the deposit has not yet been reanalysed to determine whether any flakes belong to LCT production, which would be of interest for future research.

Notably, all the LCTs or related products are made on quartzite, except for one piece, which is made on chert. Figure 3.6 outlines the specific artefacts and their basic dimension and shaping details as described in Field (1999) and Kuman and Gibbon (2018), but it does not include the added pieces, which are also all made on quartzite. Field (1999) analysed nine pieces classified as heavy-duty tools, including two utilised cobbles, a pick, a cleaver, a handaxe and a 'proto-biface'. Following the method described below, all current LCTs are described based on their respective shaping strategies and blank.

LCTs have similar trends to the cores, in that there was much cortex remaining on the pieces, but demonstrated an increased knapping ability, as large flakes were produced, as argued for the cleaver 10016 (Field 1999). Obviously, the assemblage has grown, and there are now a further ten pieces that can be added to the LCTs (Figure 3.6).

Artefact	Material	No.	Length	Width	Max Th	Mid Th	Blank	Th/W	L/W	Shaping
Sterkfontein										
Cleaver	Quartzite	10,363	117	69	50	40	Cobble	0.72	1.7	Cleaver on cobble with bifacial primary flaking
Cleaver	Quartzite	10,016	127	70	48	42	flake	0.69	1.81	Cleaver on flake with worked base
Cleaver	Quartzite	2060	104	68	32	32	Flake SS	0.47	1.53	Cleaver on flake with platform removal
Cleaver	Quartzite	2054	115	70	34	30	Flake SS	0.49	1.64	Cleaver on flake with platform removal
Handaxe	Quartzite	Sea 1	109	81	57	41	Cobble	0.7	1.35	Bifacial
Handaxe	Quartzite	9690	100	70	55	51	Cobble	0.79	1.43	Protobiface-like, bifacial shaping
Handaxe	Chert	2053	93	51	27	25	Cobble/slab	0.53	1.82	Bifacial
Handaxe	Quartzite	10,120	117	83	47	41	Flake (ES?)	0.57	1.41	Proto-biface-like tool on large flake with distal shaping
Handaxe	Quartzite	10,520	120	74	43	43	Flake CS	0.58	1.62	Pick-like trihedral shape, mostly unifacial flaking
Handaxe	Quartzite	2066	141	74	48	43	Flake ES	0.65	1.91	Pick-like trihedral shape, mostly unifacial flaking
Handaxe	Quartzite	6612	127	79	44	41	Flake SS	0.56	1.61	Mostly unifacial with minor bifacial shaping
Handaxe	Quartzite	2373	169	87	59	50	Unknown	0.68	1.94	Pick-like shape, trihedral flaking
Handaxe	Quartzite	10,521	128	62	51	51	Unknown	0.82	2.06	Pick-like shape, trihedral flaking
Pick	Quartzite	139	Damaged	86	64	n/a	Cobble	0.74		Roughly pointed tool/crude pick

Figure 3.6: A list of the LCTs from Sterkfontein Caves (from Kuman and Gibbon 2018).

Rietputs 15

One of the earliest Acheulean sites in South Africa outside of the Cradle of Humankind is Rietputs 15 in the Northern Cape (S28° 19' 37.26", E24° 44' 47.57") (Gibbon *et al*. 2009). It is an alluvial gravel site complex which lies within the Rietputs Formation and is approximately 1500m from the modern Vaal River (Figure 3.7). At Rietputs 15 there are multiple deposits found in miners pits containing ESA artefacts in a basal gravel, assigned to the earlier phase of the Acheulean. Five pits from the site have been dated with the cosmogenic nuclide burial method to between 1.73 ± 0.16 to 1.26 ± 0.21 Ma (Gibbon *et al*. 2009; updated in Leader *et al.* 2018), and two assemblages have been described in detail. Pit 5 on the eastern side of Rietputs 15, with 1174 artefacts, has been dated to ca 1.3 Ma and has evidence of organised core working technology (Leader 2009; Leader *et al.* 2018). The organised cores are asymmetrical with flatter upper faces, and some of these cores also show preferential removals, which Leader *et al.* (2018) argue represents the upper limits of cognitive ability of the hominids at the time.

The second assemblage of interest is on the western side of Rietputs 15 and is named the Artefact Collection Pit (ACP), which has yielded 453 pieces. Although it is undated, it is argued to be older than 1.3-1.5 Ma because it lacks organised core technology as found in Pit 5 at Rietputs 15 and a layer at Canteen Kopje provisionally dated to ca 1.51 Ma (Leader 2009, 2014; Leader *et al.* 2018; Kuman and Gibbon 2018). The ACP core reduction strategies are 'simple' in nature with bipolar, chopper and multifacial cores dominating, with little focus on shaping the overall core. There is also limited removal of cortex and no indications of core preparation. These technological features of the assemblage lead to Kuman and Gibbon (2018) hypothesising that the deposit predates Pit 5. This hypothesis would need to be tested

across multiple sites and assemblages and is a factor to consider in the discussion of the results presented in this thesis (see section 2.3.3).

Pit 5 and the ACP collections have cores and LCTs that typologically belong to the early phase of the Acheulean technocomplex. The ACP cores and LCTs were housed at the University of the Witwatersrand in Johannesburg, as well as the LCT assemblage from Pit 5. This meant I was able to study the material in June 2020 during the Covid 19 lockdown of South Africa. I was unable to visit museums or cross provincial borders during this time, which heavily delayed my access to the McGregor Museum in the Northern Cape Province where the Canteen Kopje and Rietputs 15 Pit 5 core assemblages are housed.

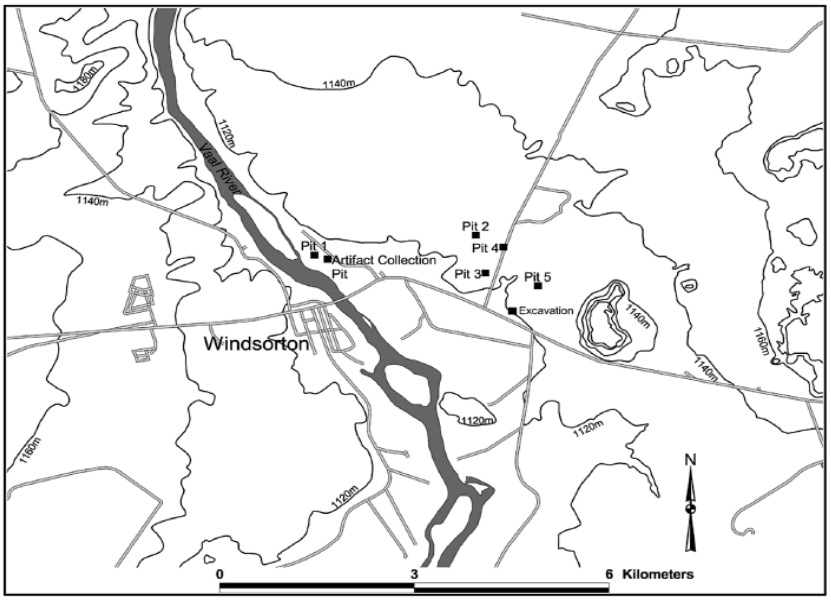
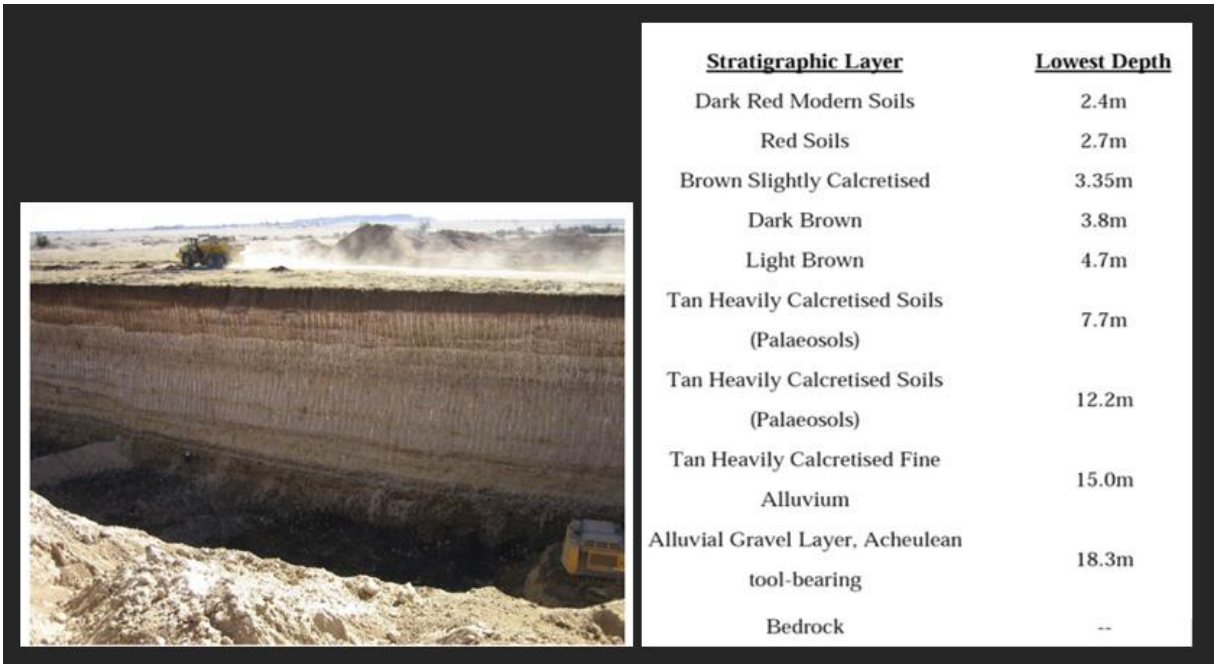


Figure 3.7: Map of Rietputs 15 (Image from Leader et al. 2018).

The core assemblage from Pit 5 at Rietputs 15 has been housed at the museum since 2019., however, the museum has been unable to locate the Pit 5 core assemblage yet for analysis the material. Due to this I have excluded the cores from the thesis. However, there is much information that can be gleaned from the LCTs, as well as the ACP assemblage.

The early Acheulean material from Pit 5 was found deeply buried in mining pits in a river gravel horizon above bedrock, at a depth of 18.3m (Figures 3.8 A and B). It was also the first Acheulean site in the country to be dated radiometrically using cosmogenic nuclide burial dating (Gibbon et al. 2009; Leader *et al.* 2018). As is shown in Figure 3.8 B, the archaeological layers lie beneath multiple layers of calcretised sediments, devoid of archaeological material, as well as below a sterile alluvial layer right above the gravels. This means that the early Acheulean layer does not contain artefacts from upper layers (Leader *et al.* 2018).

Artefacts were recovered from diamond mining conveyor belts and the stratigraphic context had to be assessed quickly before pits were backfilled. Thus, the artefacts were a sample and not from an archaeological excavation, but the stratigraphic layer was identified clearly.



Stratigraphic Layer	Lowest Depth
Dark Red Modern Soils	2.4m
Red Soils	2.7m
Brown Slightly Calcretised	3.35m
Dark Brown	3.8m
Light Brown	4.7m
Tan Heavily Calcretised Soils (Palaeosols)	7.7m
Tan Heavily Calcretised Soils (Palaeosols)	12.2m
Tan Heavily Calcretised Fine Alluvium	15.0m
Alluvial Gravel Layer, Acheulean tool-bearing	18.3m
Bedrock	--

Figure 3.8: A profile view of the stratigraphy of Rietputs 15 Pit 5 (A) and the stratigraphic layers of Pit 5 and the relevant depths (B) (images from Leader 2009).

Canteen Kopje

Canteen Kopje, located in the Northern Cape of South Africa, lies roughly 40km north of Kimberley, close to the Vaal River. The site was discovered in the 1800s through diamond mining activity and was first excavated in 1997 under the direction of Peter Beaumont (van Riet Lowe 1948; Beaumont and Morris 1990; Beaumont and McNabb 2000; McNabb and Beaumont 2011). Earlier study of the area focused on material from the gravels all along the river, including at Canteen Kopje, which helped identify the Acheulean-bearing deposits, including a Victoria West prepared core industry component (van Riet Lowe 1945).

The 1997 excavations updated the stratigraphy as defined by Helgren (1978), from simply Stratum 1 and 2, to Stratum 1, Stratum 2a, 2b Upper and 2b Lower. Stratum 1 is more commonly referred to as the Hutton Sands is about 5m thick and contains material from the LSA, MSA, and the Fauresmith (Beaumont and McNabb 2000; 2011). They opened the Pit 6 excavation on the western edge of the site (Figure 3.9), from which the analysed material presented here originates.

For his PhD, Mike Leader (2014) analysed newly excavated ESA assemblages from Pit 6. He classified three techno-typological stratigraphic layers within the Acheulean deposits. These

layers had may similar typological features, with increased complexity among the core reduction strategies. The layers are named; the Basal Early Acheulean at >1.51 Ma, the Organised Core Technology Assemblage at 1.51 ± 0.8 Ma, and the Prepared Core Victoria West Technology, which is older than 1 Ma (Leader 2014). The Basal Early Acheulean layer had a dominance of casual and irregular core strategies (definitions used by Leader 2014). The overlying Organised Core layer yielded 26 asymmetrical bifacially worked, making up 31.3% of the assemblage. He argued that the asymmetry demonstrated an organised (hence the term) control of core reduction, a possible precursor to the Victorian West prepared core technology (Leader 2014). The analysis presented here used a method that interrogates the patterns of core edge management and volume control, which would test the conclusions presented by Leader.

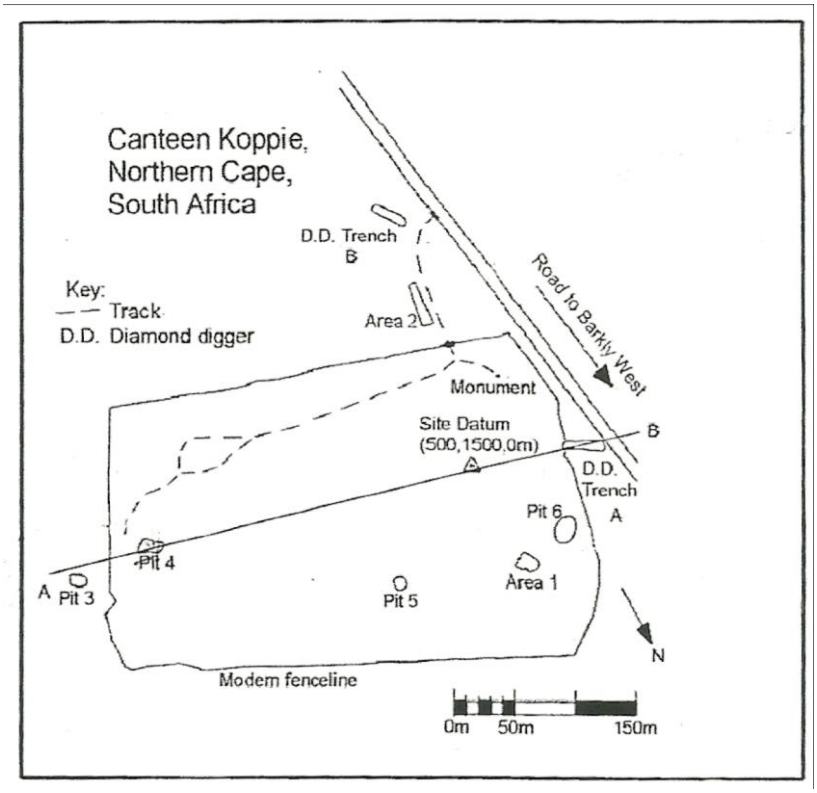


Figure 3.9: Map of Canteen Kopje site (image from Leader 2014)

For this thesis, the material from the Basal Early Acheulean and Organised Core Technology layers will be analysed. Unfortunately, due to the time constraints imposed by the lockdown in South Africa, a total of 164 artefacts were studied, 39 and 40 cores, respectively, and 33 and 52 LCTs, respectively from each layer. The full study by Leader (2014) is being prepared for publication and will be discussed in relation to the results presented here. Again, this work does not aim to reclassify the layers as defined by Leader (2014), but instead, to interrogate

the specific reduction strategies to fully understand the shift from ‘simple’ to ‘organised’ core technology, and if a similar trend can be identified at the other sites.

East Africa

Earlier Stone Age (ESA) archaeological techno-complexes were defined using East African assemblages, including the Oldowan and Early Acheulean from Olduvai Gorge (Leakey 1971; de la Torre 2016). Overall, the region hosts a large body of work reflecting the lithic technology trends, but there had been limited comparisons of the earlier assemblages (Gallotti 2016). More recently, the technological features of sites have been compared to understand the complexity of the overall ESA (de la Torre and Mora 2018 a, b; Duke *et al.* 2021).

Olduvai Gorge has long been the subject of archaeological and palaeoanthropological enquiry. Mary Leakey began extended fieldwork seasons with the first dedicated archaeological excavations in 1960 to 1963 of Beds I and II (Leakey 1971; de la Torre 2016). She excavated over 10 sites and produced unprecedented results with artefacts dating to 1.8 Ma, the oldest known artefacts at the time, found associated with fossil bone (Leakey, 1971). The Olduvai handaxe assemblages were used by Leakey to define the Acheulean stratigraphically and typologically. Recent research into the nature of the earliest Acheulean has shown the need for new analyses to define the overall techno-complex and its various phases technologically (de la Torre and Mora 2018b). This work would allow archaeologists to investigate the nature of cultural evolution in the area and the inter- and intra-site variability of hominid technological behaviour (de la Torre and Mora 2014).

EF-HR, Olduvai Gorge, Tanzania

EF-HR site (named after Evelyn Fuchs and Hans Reck; Figures 3.10 and 3.11) was discovered in 1931 and excavated by Mary Leakey in 1963 (Leakey 1971; de la Torre *et al.* 2017). From 2009 to 2013 the Olduvai Geochronology Archaeology Project (OGAP, headed by Profs Ignacio de la Torre and Rafael Mora) once again excavated the site, with special focus on the stratigraphy and site formation processes at the site. These excavations have revealed 2300 new lithic pieces, including a hundred LCTs found in stratigraphic context, and 128 cores (de la Torre and Mora 2018b). These enlarged assemblages come both from multiple new trenches and from enlarging older excavations (de la Torre *et al.* 2018).

De la Torre and Mora (2018b) conducted a technological analysis of the early Acheulean assemblages dating to >1.33 Ma from EF-HR and described them as having two distinct reduction patterns: a more expedient and Oldowan-like reduction strategy seen in the smaller cores, and a production of large, thick flake blanks for LCTs. They argue that in the smaller core reduction pattern, flake removals were unstructured, and the cores quickly abandoned,

with opportunistic and expedient flaking patterns (Figure 3.12). However, Acheulean strategies are recognised in the regularity of large flake blanks used for LCTs.

The LCT blank reduction pattern is distinguished in that knappers sought out high quality raw materials and followed a structured and defined knapping strategy to produce large flakes, which the authors argue represents high cognitive and technical ability (de la Torre and Mora 2018b). LCT shaping followed the same patterns and locations of removals on blanks, leading to standard morphotypes across the site; the technological shaping was consistent, and hominids had a set template from which to produce LCTs (de la Torre and Mora 2018b). Most stages of LCT production are found at the site, including large flakes, and preparation of surfaces, but not LCT cores (de la Torre and Mora 2005). Raw materials differed between the two reduction patterns. Phonolites represent 24.7% of the smaller core reduction and only 7.8% of LCT blank production, while quartzite represents 23.6% of LCT production and 13.8% of the smaller core reduction (de la Torre and Mora 2018b).

Stratigraphically, the site lies above Tuff IIC directly atop a limestone stratum, at the base of Upper Bed II (Leakey 1971; de la Torre and Mora 2005; de la Torre 2016). Ten new trenches were excavated across the landscape, with archaeological material found in all, but T2-Main Trench (Figure 3.11), which extended Mary Leakey's original 1963 excavation, produced the most material, followed by the T12 trench, both located in the centre of the explored area. The difference in artefact distribution between the trenches reveals variable occupation patterns on the landscape, with a predominance around T2 (see de la Torre *et al.* 2018 for more information of the geochronology of EF-HR). This means that most pieces analysed in this thesis came from the T2 trench, with some other pieces from T9, T12, T13 and T15 (Figure 3.10).

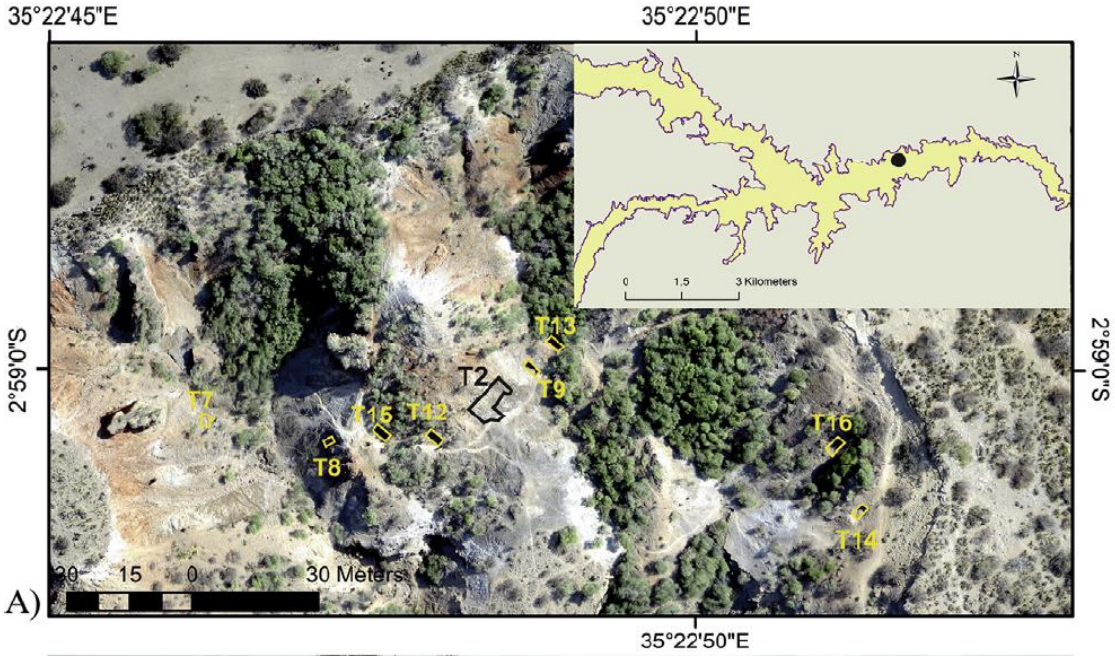


Figure 3.10: A bird's eye view of EF-HR, with the locations of the various trenches (image take from de la Torre and Mora 2018b)

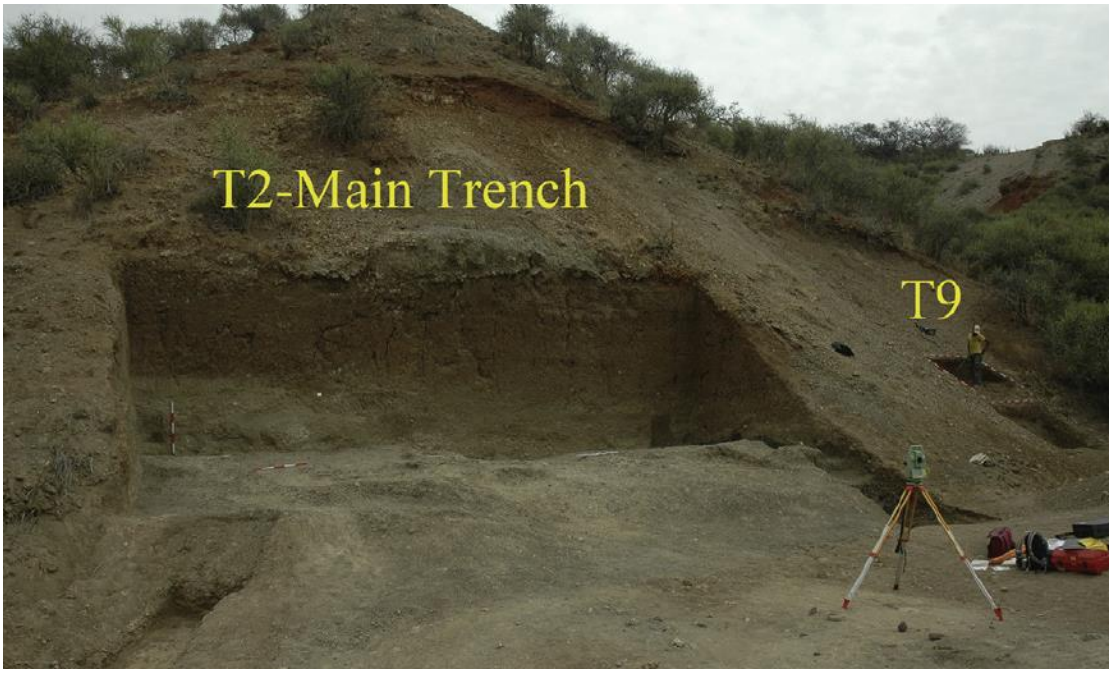


Figure 3.11: The excavated T2-Main Trench and T9 from EF-HR (image taken from de la Torre and Mora 2018b)

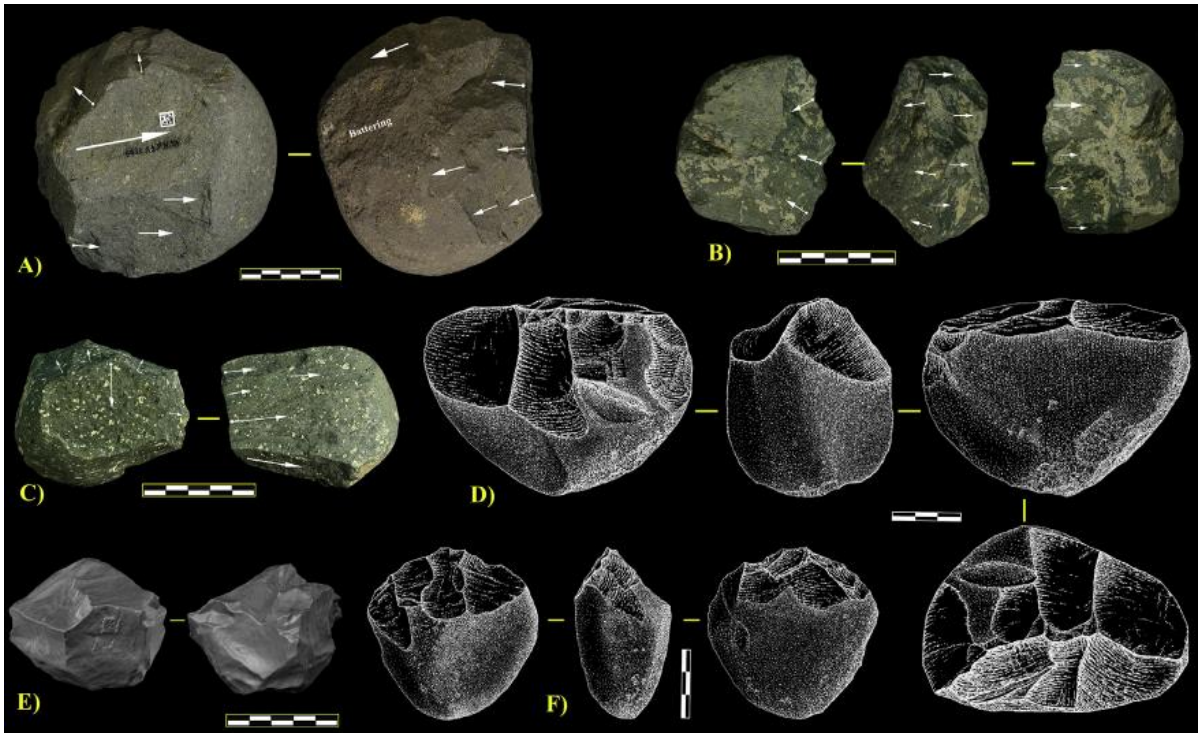


Figure 3.12: An example of cores from the EF-HR assemblage (from de la Torre and Mora 2018b)

3.2 Methods

3.2.1 Core reduction strategies

Cores as a technological category may display all steps within the reduction sequence of an assemblage and can illuminate the specific sequential choices of knappers, as well as the choices around raw material selection and testing. The focus of the data collection and analysis was on the cores, because they are abundant in all sites and quite diverse in knapping strategies even within single assemblages. LCTs are included in the analysis because they represent the diagnostic technological shift at the emergence of the Acheulean technocomplex. Both technological products are included as they are each diagnostically important to define the earliest phase of the Acheulean technocomplex. Cores represent technological strategies outside of LCT production and are often a more dominant component of early Acheulean assemblages.

Schemes of core reduction

There are multiple approaches and methods to studying freehand core reduction strategies, but the approach used here was originally conceived by de la Torre *et al.* (2003) to assess Oldowan material from Peninj, Tanzania and further refined when de la Torre (2011) worked on the early Acheulean at Gadeb, Ethiopia. The updated version of this classification system

which is used here is taken from de la Torre and Mora (2018a) (Figure 3.13). Through refinement of the methodology, a set of diacritical schemes for classifying core reduction strategies was developed that identifies the relationship between unifacial, bifacial, trifacial or multifacial surfaces and the directionality of removals. Exploitation of the mass of the blank is considered, along with the flaking strategy, to infer the skills and technological behaviour of the knapper (de la Torre and Mora 2005). The methodology has been applied to multiple sites in East Africa (de la Torre and Mora 2018 a, b; Stout *et al.* 2005) to compare technological core reduction strategies.

For example, the system allows for a distinction between radially exploited bifacial cores (i.e., the core edge management) that show success in thinning out the central bulk (the term intrusive volume reduction is used in this thesis), versus cores that have a structured and continuous core edge management, but the central bulk remains. Despite the same reduction strategy being applied in both scenarios, there are different outcomes for the final product and the resulting débitage.

Once the same approach has been applied at multiple sites, one can identify inter-site trends in technological behaviours (de la Torre 2011). An example of this approach is the work of de la Torre and Mora (2018a, b) who used a core reduction approach at HWK-EE (Oldowan) and EF-HR (Early Acheulean) in Olduvai Gorge to observe technological behaviour within the transition between techno-complexes.

The approach used here, as laid out in de la Torre and Mora (2018b: 240), is adopted because of the comparative interpretations that have been possible through its application. It visualises a core as an idealised 3D geometric cube, to demonstrate the various core edge management strategies and their relationship to volume reduction. Therefore, the various artefacts are analysed in a standardised manner, and factors such as raw material choice and blank shape can be related back to the technological behaviours. The specific reasons for any similarity or variability between assemblages can then be understood in terms of the core reduction strategies outside of the context, as technological strategies may manifest similarly in different contexts. Obviously, site context is equally as important, and the described core reduction strategies and context must be related to each other (de la Torre *et al.* 2003).

For this thesis, I defined a dominant scheme as those which represent the largest surface exploited on the core, or the scheme with the most removals attributed to it when the surface area is similarly proportioned. These are presented in Figure 3.13. In most cases the dominant scheme is a multifacial reduction with an edge of the core exploited in a more systematic way, such as a BSP or BALP edge. In some cases, the core is quite extensively exploited, usually in a discoidal fashion, and can fit within the grouping of BALT, discoid, or BP for example.

These combinations can cause issues with quantitative analysis as the statistics may not accurately represent the diverse schemes. One could create new categories of cores, but to not over complicate the quantitative interpretations, these anomalies will be classified within the overall technological trends. The combination of qualitative and quantitative analyses is essential to provide a more comprehensive description of the technological trends.

The separation and differentiation of hierarchal bifacial flaking and alternating bifacial flaking is important to note (Figure 3.13). The first refers to the practice of reducing and working one side of the core in order to create platforms for possible preferential removals on the opposing surface. Alternating bifacial knapping refers to the practice of constantly flipping the core between removals to evenly exploit the volumetric surface on both sides of the core. A general definition of discoid technology could be the "centripetal, recurrent and usually bifacial organization of removals. This exploitation proceeds by maintaining a strong stability of the volumetric concept of the core, which requires little specific preparation of its striking platforms and flaking surfaces" (Terradas 2003: 20). In consideration of this terminology, both categories of BALT and discoid in de la Torre and Mora (2018b) could fit. However, in the case of this thesis, they differ depending on the extent of volume reduction. Cores with similar edge management can be classified differently (following de la Torre and Mora 2018b). Total edge exploitation with an alternating sequence can be either BALT or discoid, but the BALT category refers to cores with little success at central volume reduction (de la Torre and Mora 2005; de la Torre [University College London] pers. comm. 2019).

For this thesis, hierarchal scheme often means that one surface is more reduced in volume than the other, and the final piece displays asymmetry between the two surfaces. The idealised schemes that incorporate a hierarchal bifacial knapping surface are BP, BAP, BSP, and BHC. The schemes that denote an alternating approach are BALP, BALT, and discoid. These two general categories of reduction indicate very different ways of core edge management.

A BAP scheme refers to a bifacially worked abrupt edge. There are many examples of pieces that have been worked in a bifacial and sometimes alternating scheme. These alternating cores are not classified as BALP because they have an abrupt edge and do not work into the central volume of the core. Some BALP cores do not have many removals and only work the edge of a core, but they have a less abrupt edge and very clear 'zigzag' edge pattern.

The unifacial models in this schematic categorise an exploitation whereby a single surface has scars from a natural platform. A natural platform could include a split blank surface, but not a surface created by previous removals. The UABI category is still considered unifacial despite having removals from two separate surfaces, because there is no bifacial management of the

edge between the platform and surface. UP cores can also have platforms around the blank, but only one surface is exploited, with no bifacial edge management.

Cores that technically fit within a multifacial scheme but have evidence of a variety of schemes for edge management will be grouped into the secondary category instead. This will be done to discuss the ability of the knappers to reduce volume and successfully remove flakes, and the multifacial nature of the piece will be included in the qualitative assessment. Moll (2017) classified cores from Maropeng, South Africa by the dominant scheme, which was successful in showing the flexibility of knappers to adapt to blank shape, with limited need for core rejuvenation. Despite the success in this instance for using this methodology, it did not allow for nuanced interpretations of the complexity of knapping strategies and technological behaviour of hominids which is necessary for this project to properly analyse the technological variations between regions.

Bipolar reduction

Bipolar core – Even with battering marks from the bipolar reduction it will not be classified as a hammerstone if the battering is not evident of something outside of bipolar. Experimental bipolar knapping was performed by Prof Kuman, Dr Caruana and me. The observations and preliminary results indicated the possible bipolar reduction of cores. The experiments aimed to determine the morphology of bipolar removals on the raw materials available in the Cradle of Humankind in order to differentiate freehand hard hammer versus hammer and anvil percussion. These experiments are ongoing and will need to be explored at a further date so will not be presented here.

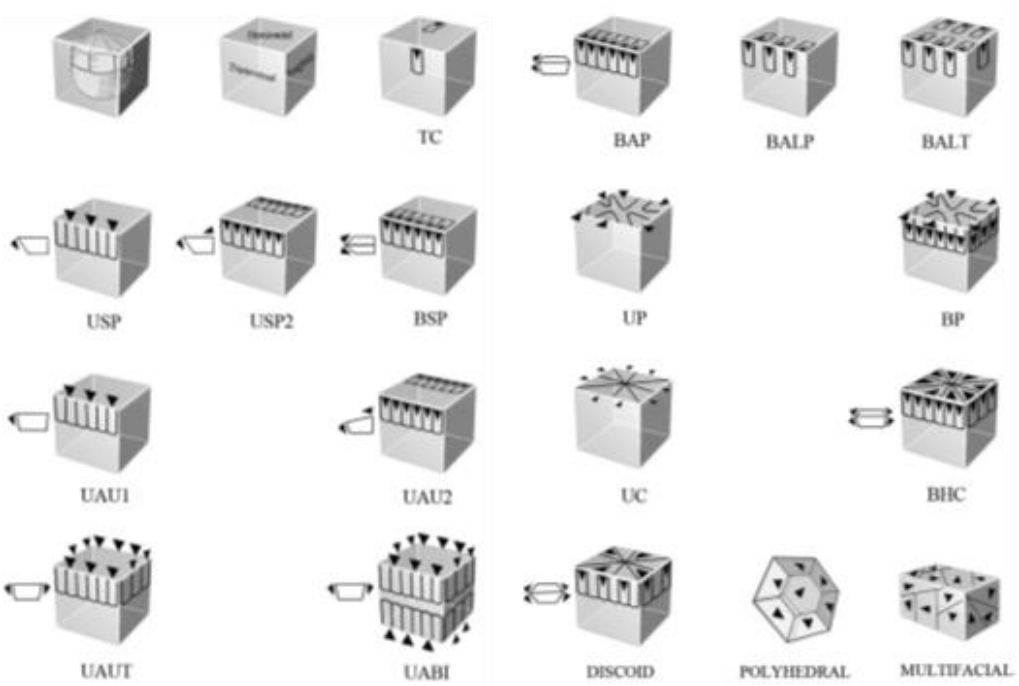


Figure 3.13: Idealised schemes of free-hand core reduction

TC: cores with 1 or 2 randomly distributed removals.

USP2: Flaking is unidirectional and limited to one plane, from a natural striking platform, and the angle between the striking platform and the flaking surface is <45. Although there are two knapping planes, there is no interaction between their respective striking platforms and flaking surfaces. Many of Leakey's (1971) double-sided choppers fall into this group.

Abbreviations:

TC: Test core.

USP: Unifacial simple partial exploitation.

USP2: Unifacial simple partial exploitation on two independent knapping surfaces.

BSP: Bifacial simple partial exploitation.

UAU1: Unidirectional abrupt unifacial exploitation on one knapping surface.

UAU2: Unidirectional abrupt unifacial exploitation on two independent knapping surfaces.

UAUT: Unifacial abrupt unidirectional total exploitation.

UABI: Unifacial abrupt bidirectional exploitation.

BAP: Bifacial abrupt partial exploitation.

BALP: Bifacial alternating partial exploitation.

BALT: Bifacial alternating total exploitation.

UP: Unifacial peripheral exploitation.

BP: Bifacial peripheral.

UC: Unifacial centripetal exploitation.

BHC: Bifacial hierarchical centripetal.

(Image and descriptions taken from de la Torre and Mora 2018a: 241. Expanded from de la Torre et al. 2003; de la Torre and Mora 2005; de la Torre 2011)

3.2.2 Attribute analysis

The various attributes used for analysis in this thesis were recorded in Table 3.3. These attributes do not define the core edge management reduction strategies, which also need to be considered to ascertain whether strategies are applied to different blank types and sizes. In some cases, the ways in which each attribute was measured are explained, along with references for their development and definition. The results of these attributes will be presented in chapters 4-8, and a discussion of their usefulness for comparison will be assessed. As discussed in chapter 2, there are multiple approaches used in the technological analyses of core reduction strategies. A full comparison of these methods is not in the scope of this thesis, which focuses more of the usefulness of applying a single method but is an area of discourse needed in the field.

Table 3.3: Attributes of cores and LCTs to be recorded

Cores	LCTs
Metric features	*Metric features*
Core edge angles	Number of flake scars
Core reduction strategies (Figure 3.13)	Maximum length (mm)
Flake scar numbers	Maximum width (mm)
Maximum length (mm)	Maximum thickness (mm)
Maximum width (mm)	Weight (g)
Maximum thickness (mm)	Refinement Index (Roe 1969)
Number of remaining flakeable platforms	
Percentage of remaining cortex	*Descriptive features*
Weight (g)	Blank type
	Raw material
Descriptive features	Edge shaping strategies
Blank type	
Raw material	

Weight: The weight of each piece was measured using an electric scale (Adam brand) to the nearest 0.1 of a gram. Pieces over 2000g were weighed using a digital scale to the nearest gram. Some pieces from the Canteen Kopje collection were heavier than 16000g (one example was 23000g), and these were weighed using a bathroom scale. This is useful in determining the volume of material at a site, with ideas about raw material transport and selection. The selection of raw material casts is an independent variable, even though the sources of the materials are dependent on the context.

Length, width, and thickness were measured to the nearest millimetre (mm) using a set of digital callipers. In cases where the pieces were too large to use a set of callipers, a standard box measurement was used. This was only necessary for a few artefacts per assemblage and was used mostly with the Canteen Kopje assemblage. Size ranges can be compared between sites. They give ideas about raw material selection, and site-specific behaviours (e.g. Hovers *et al*. 2021). These variables are dependent on the raw material sources at each site but are independent when considering how knappers selected and manipulated the materials available.

Cortex: Amount of cortex was measured using the system developed by Braun *et al.* (2008). Reduction intensity can be recorded based on the proportion of cortical exploitation. Following the system, the cores were ranked in five categories by percentage: 0% = 0, 1-25% = 1, 26-50% = 2, 51-75% = 3, and 76-100% = 4. This is an independent variable that can be compared between sites, with an aim of determining the differences in reduction intensity.

Flake scar count: The number of scars was counted, including identifiable scars that lacked features such as impact points or distal ends. This again links to reduction intensity (see Braun et al. 2008). This is an independent variable that can be compared both between sites and the core flaking strategies.

Largest flake scar: One of the features often measured is the largest flake scar identified on a core. The largest flake scar is often large enough to properly ascertain its size without obstruction, and thus it can be used a proxy for the size of flakes scars on the entire piece. For this thesis, the maximum length and width of the largest flake scar were measured. There are circumstances where these measurements were not taken due to modern damage or weathering on the core. In some instances, the scar was slightly covered by other flake scars but still represented the largest surface area of a scar. This is an independent variable applied by the author to all the cores, and the size of flake scars can be compared.

Scar terminations: when present, the terminations of the scars were described as either feather, step, hinge, overshoot, bipolar, core edge or indeterminate (indet) (Odell 1980; Andrefsky 2005). Feather terminations occur from flake scars that end in a tapered out thin edge, while step scars end in an abrupt snap, meaning the flake broke during reduction, often because of natural flaws within the blank. The hinge termination refers to a flake with a rounded end, that loops back towards the dorsal face, while the overshoot scar extends back on the side of the ventral surface. Core edge flake scars show a surface where a bulky section of the core was removed, sometimes to create a new platform or surface. More force is often required for such removals, as the volume of the flake scars would be relatively greater than other ‘normal’ scars, and the flake termination differs with the other categories.

Flake scar morphology and size have been used to infer the skill of knappers, regarding reduction and shaping, as well as raw material selection (Dibble 1997; Dibble and Rezek 2009; Moll 2017; Sherwood 2019). Feather terminations occur when the force exerted from the hammerstone flows through the core without any obstacles, which can be attributed to either good quality raw material and/ or knapper skill. Thus, if feather terminations dominate on flake scars, one could argue that the respective assemblage was made by skilled knappers or the raw material was of high quality (Sherwood 2021; and see Chapter 2 for discussion on assessing and defining 'skilled' reduction and technological behaviours).

Blank types: The blank types for cores are based on the general shape of blanks found in and around the sites. They will be labelled similarly across the sites have been adapted from the method as used in Field (1999: 38-39; Figure 3.14). For this thesis I have adapted the blank types and described them as block angular cobbles, blocky rounded cobbles, spherical cobbles, block, chunk, tabular cobbles, and split versions of these types. The LCT blanks are labelled as flake, clast, and block, to follow the conventions published on these sites (Leader 2009 and 2014; Kuman and Gibbon 2018; de la Torre and Mora 2018b). Indeterminate blank types are labelled as 'indet' in figures and tables. The blank types applied in this study are meant to be comparable across the assemblages.

The blank types from Field (1999) and Kuman and Field (2009) were developed to describe the shape of cobble blank types in the Oldowan and Acheulean assemblages of Sterkfontein, Swartkrans, and Kromdraai in the Cradle of Humankind. The authors argued that singular words like 'cobble' could refer to any form of rounded river stone, and thus decided to add shape definition to the cobbles. The original blank types from Field (1999: 38-39; Figure 3.14) are as follows:

a. Blocky-angular cobbles are polyhedral in shape with angular edges
b. Blocky-rounded cobbles are polyhedral in shape with rounded edges
c. Rounded-polyhedral cobbles are approaching a spheroid shape but have facetted side
d. Spheroidal cobbles are completely round in shape
e. Disc cobbles are flat in profile and rounded in plan view with rounded edges
f. Tabular-disc cobbles are square in profile and round in plan view
g. Wedge cobbles are thick at one end and taper at the other end; edges are generally rounded

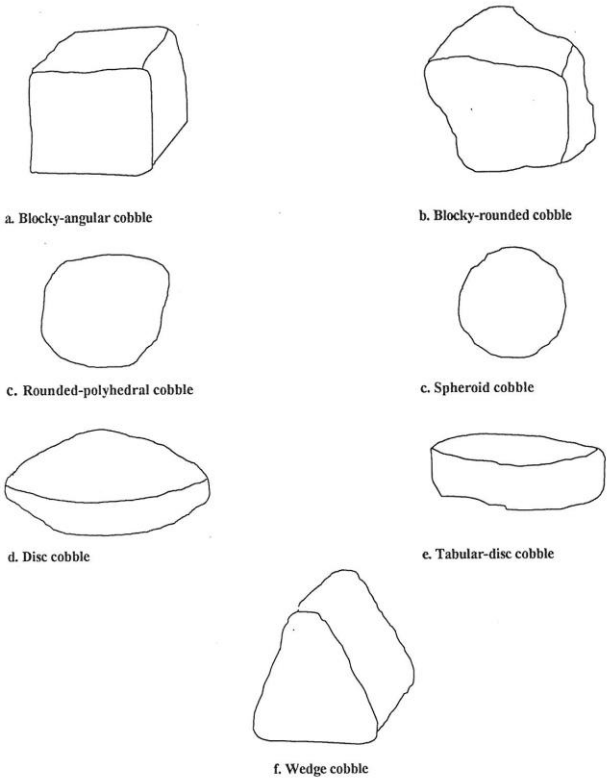


Figure 3.14: The blank types from Field (1999: 39).

3.2.3 Large cutting tools

The definitions of LCTs use the terminology adopted for EF-HR (de la Torre and Mora 2018b). The classifications of handaxe, cleaver, pick, and knife are integrated with the shaping type of the piece. The three shaping strategies used to define the shaping of all LCTs are bifacial alternating (Figure 3.15: A), bifacial (Figure 3.15: B), and unifacial (Figure 3.15: C). The terms are self-explanatory but do not correspond to the number of edges which have been shaped. The diagrams in Figure 3.15 represent an idealised version of the shaping strategies and are meant to show the general classifications. These idealised schemes are meant to be descriptive, similar to the way in which core edge management schemes are descriptive. One of the aims of this thesis is to identify the commonality between core reduction and LCT production at these sites, and to investigate whether there are similarities in these technological strategies.

There is some debate for the early Acheulean over whether LCT technology emerged out of core reduction or was a completely independent development (Dibble *et al.* 2016). The debate centres around the applications of methodologies to study the various components. Dibble *et al.* (2016) argue that if archaeologists adopt the same approach, then the reduction strategies and directionality of removals could be indistinguishable across the technological types. In this

thesis, the terms given to the shaping strategies for LCTs differ with those used for cores but are defined in a way that is comparable to the cores.

The LCT categories are broad, in order to focus more on the shaping strategies. ‘Handaxe’ includes any piece with a shaped tip, either bifacial or unifacial. In order to avoid vague definitions, the categories are further distinguished as either biface, uniface, knives, or pick, along with the specific shaping strategy. A fourth category called rhomboid is used for LCTs that have two unifacial shaping sequences on opposite edges and sides (Figure 3.15) (Kleindienst 1962; Bar-Yosef and Goren-Inbar 1993; de la Torre and Mora 2018b). The term comes from the edge morphology of LCTs that have been shaped in this way, and the final product straddles the line between unifacial and bifacial pieces.

Cleavers are separated from other LCTs by their blank types and location of shaping, as defined by Roe (1994) for ESA assemblages in Africa. This means cleavers are defined as being made on a large flake blank and having a transverse or oblique cutting edge that is unretouched, with possible shaping on the sides (Tixier 1956). Thus, large flakes >10cm are considered to be an integral part of the LCT manufacture process.

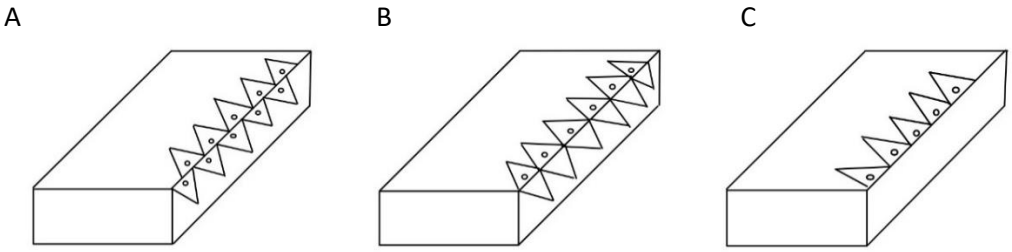


Figure 3.15: Idealised schemes of LCT shaping sequences (image created by R. Moll).

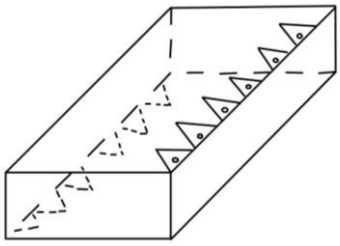


Figure 3.16: Idealised scheme of a ‘rhomboid’ shaping sequence (the dotted lines indicate the opposite side and edge of the piece) (image created by R. Moll).

3.2.4 Refinement Index

The Refinement Index is a commonly used analytical tool created by Derek Roe (1969) which calculates the overall thinning occurs in an LCT assemblage. The maximum thickness of LCTs is divided by their maximum width and the average of these answers is the Refinement Index for a site. It has been used in many studies but researchers to understand LCT refinements (e.g. Kuman *et al.* 2016; de la Torre and Mora 2018b; Shipton 2018).

3.2.5 Diacritical analysis

A diacritical analysis was applied to both the cores and LCTs for the description of reduction sequences. Artefact photos or illustrations (done by R. Moll unless otherwise stated) were labelled using arrows, dots, and a coding system to show directionality and patterns of removals. For the cores, the arrows of the same colour are used to represent the reduction sequence. Arrows were shown on the flake scar, in the direction of the removal. If the direction was uncertain then an arrow with a dotted line was drawn to show the possible direction. If the bulb of percussion and point of impact were present, then a dot was placed at the tail end of the arrow on the point of impact.

Diacritical analysis has been done on all LCTs and more than half of the cores analysed. The pieces shown in the text are examples of these analyses to illustrate the various strategies of edge management and reduction. The analyses presented in the results chapters first covers the quantitative data collected for the entire assemblage while the specific artefacts are presented at the end as examples of the specific reduction strategies and LCT shaping and the nuance that goes into these types of diacritical analyses.

In circumstances where there were multiple sequences of shaping or reduction, such as with LCTs, the sequences were differentiated by various colours. For LCTs, debitage from the production of the flake blank were drawn in red, and the arrows from the shaping sequence were drawn in yellow. If there were multiple sequences in the shaping process then they were labelled as Sequence A, B, C (SA, SB, SC) and so on. In some cases, it was possible to tell the order of removals, such as with the very fresh material from EF-HR. These specific flake scars were thus labelled chronologically. An example of two labelled sequences on a single piece is SA-1, SA-2, SA-3, etc, and SB-1, SB-2, SB-3, etc.

The orientation of cores followed rotations of either 90 or 180 degrees to the right. All LCTs were orientated by their ventral and dorsal surfaces, based on the flake blank. In circumstances where the LCT was not made on a flake blank, or the blank was indeterminate, surfaces were assigned a front and back surface (which could be correlated to the ventral and dorsal surfaces, respectively) to compare them with other pieces. If the two sides of the LCT

were asymmetrical, then the convex side was labelled as the ‘back’ surface, and the flatter side as the ‘front’.

3.2.6 Statistical analysis

The statistical tests chosen for this thesis were as follows: t-test, and Kruskal-Wallis tests. These were performed in Microsoft Excel and with PAST. The t-test was used to compare the means of two sets of data and following de la Torre and Mora (2018b), while the Kruskal-Wallis test compared the variance of means between multiple data, specifically for the non-parametric data. These analyses were added to understand the distribution of variation within each site and were presented throughout chapters 4-7.

Chi-squared tests are applied to test the correlation of variables between two groups at a time. It was especially used to test the null hypothesis that scar count averages and reduction strategies were correlated similarly at each site, which are used as proxies for technological behaviours in the earliest phase of the Acheulean technocomplex in East and South Africa, which is presented in chapter 8.

The equation for the t-test is:

$$t = x1 - x2 / \sqrt{(S21N1 + S22N2)}$$

The equation for chi-squared analysis is:

$$\chi c2 = \sum (Oi - Ei)2 / Ei$$

c=Degrees of freedom; O=Observed value(s); E=Expected value(s)

Bi-variate linear regression analysis is used often throughout this thesis in order to correlate two data sets. Data are point-plotted along two axes, and a trendline is generated from that follows the minimum distance between the points. An R-value is calculated from the trendline based on the proximity of data points to other. If the R-value is close to 1 or -1 then there is a strong positive or negative correlation, respectively (Drennan 2009).

Principal Component Analysis (PCA) and correspondence analysis was done in PAST and analysed the core and LCT assemblages from all the sites together in chapter 8. This type of analysis is done to summarise large databases by specific components that can be identified. The standardisation of the data allows researchers to understand the variation of the components from the mean, giving a distribution of all variables in relation to each other. For this thesis, it was used to identify if the different sites were differences or similarities in their representation of core reduction strategies and LCT shaping, and if so, what features of the sites caused the variation.

The data accumulated during the analysis were both qualitative and quantitative. This can lead to issues in statistical analyses as many qualitative categories, such as the core reduction strategies, can be ordered as non-parametric data, while metric data for volume, dimensions, and scar counts is parametric.

3.2.7 Early Acheulean in Africa

The results of the thesis will be discussed in chapter 9 section 9.2, and how these results compare to other early Acheulean sites and assemblages. The sites presented in chapter 2 will be considered, but five particular early Acheulean assemblages will be considered. These assemblages come from regions either within proximity to the sites studied in this thesis, or from a similar time period but a different context. The sites are Maropeng, an open-air site dating >1 Ma in the Cradle of Humankind, South Africa which has been argued to have comparable technological behaviours as Sterkfontein M5W assemblage (Pollarolo *et al.* 2010; Moll 2017), and has 693 pieces, including 101 cores, and 12 LCTs.

The other sites are all in east Africa. BK in Olduvai Gorge, Tanzania, will also be discussed and was originally meant to be a site to be studied in this thesis and has material from around 1.3 Ma. The Leakey (1971) assemblage I intended to study comprises 729 pieces, with 124 LCTs and 652 cores (Leakey 1971; de la Torre and Mora 2005; Diez-Martín *et al.* 2019). The last assemblage to be discussed is MW2-L3 from Melka Kunture in Ethiopia which is a highland site with material dating to ~1.6 Ma->0.7 Ma and has complex core reduction strategies and few LCTs (Gossa 2020; Hovers *et al.* 2021). The assemblage has 6402 artefacts, with 6 LCTs and 1588 cores. Two layers from TK in Olduvai Gorge will also be discussed, with 1161 lithic artefacts with 53 bifaces and 91 cores, and 5805 pieces with 85 LCTs and 268 cores. The oldest Acheulean site of Kokiselei 4 in Kenya will also be discussed, and has 28 LCTs (called heavy tools by Texier 2018) and a total of 202 pieces. These assemblages will be introduced and discussed in relation to the results of this thesis in chapter 9.

Chapter 4: Results: Sterkfontein Caves

4.1 General observations

The material presented in this chapter comes from the two excavations into the Member 5 West infill at Sterkfontein caves, the first by John Robinson in 1956/7 and the second over a much longer period by Alun Hughes and then R.J. Clarke (see Kuman [1994, 1998] for historical review). Both samples are from the same deposit and constitute a single early Acheulean assemblage. Artefacts with the label 'SEA' followed by a number come from the Robinson excavation, while artefacts with only a number or with the prefix 'Stk13' and a number are from the Clarke and Hughes excavations.

4.2 Raw material

There are relatively few raw materials found in the Sterkfontein archaeological record, with a majority of quartzite in the Acheulean deposit (Figure 4.1). In the core assemblage, quartzite makes up 61% (Figure 4.2). The quartzite from the Bloublank river source is hard and durable, and reduction patterns tend to be visible and well preserved. Vein quartz is the second most common material throughout the early Acheulean core assemblage, representing 35% overall, which is a shift from the Oldowan where the quartz dominates (Field 1999; Caruana and Mtshali 2018). The quartz is more brittle than the quartzite, and the final products tend to be smaller and sometimes difficult to assess. Due to the nature of the vein quartz prone to shattering during knapping, there are many scars or fractures on cores and chunks that could either be purposeful flake removals or shatter. Field (1999) demonstrated the shattering of quartz through her experimental work and the difficulty in accurately ascertaining all flake scars. Chert is rarely used in the early Acheulean (4%), and there is only one core made on an igneous rock type.

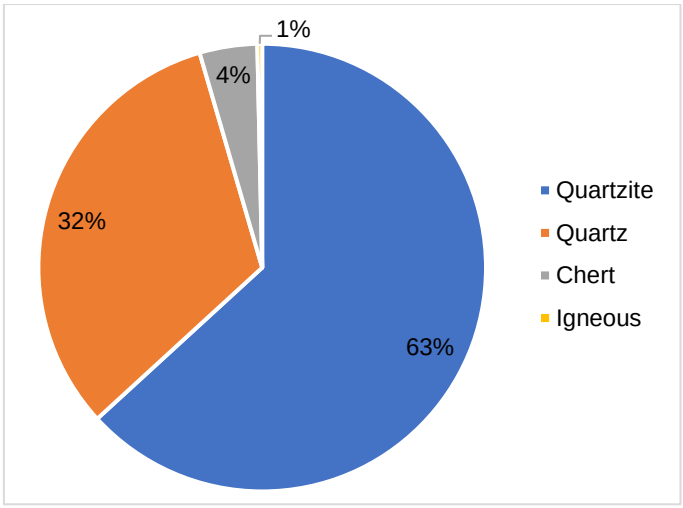


Figure 4.1: Raw material distributions from the early Acheulean core and LCT assemblages

4.3 Cores

4.3.1 Raw material

The raw material distribution in the cores (Figure 4.2) is very similar to the overall raw material proportions for the full assemblage shown in Figure 4.1. The two pie charts show a similar representation in rock types with the only igneous piece included in the core assemblage.

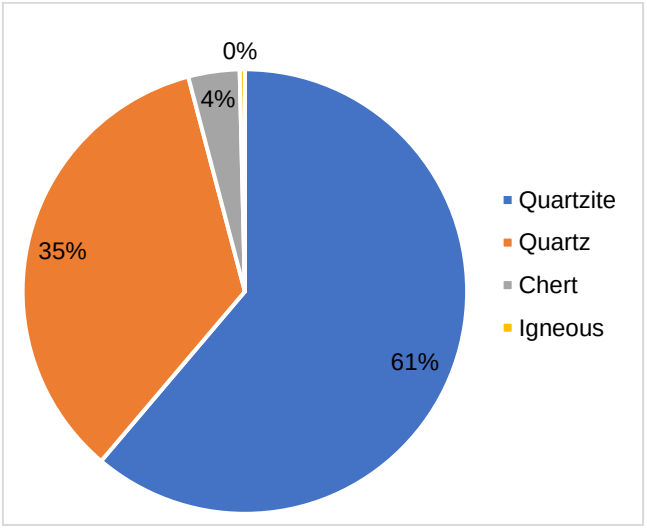


Figure 4.2: Raw material distribution in cores

4.3.2 Core reduction strategies

In total there are 264 cores (Figure 4.3), with a dominant multifacial category (n=111; 42%) where cores were exploited along at least three separate platforms and surfaces, in a way that shows no continuous strategy. The second most common schematic is Test Core (TC; definition from de la Torre and Mora 2018a) (n=58; 22%), with have one or two removals before the core was abandoned. These core types could show that hominids were testing raw material or practiced a more opportunistic exploitation on natural surfaces of core blanks. The indeterminate category (n=10; 3,8%) includes cores that have weathered in such a way that the full reduction strategy, especially the core edge management, is not identifiable. Along with the single polyhedral core (0.4%), these four categories make up 68.2% of the total assemblage.

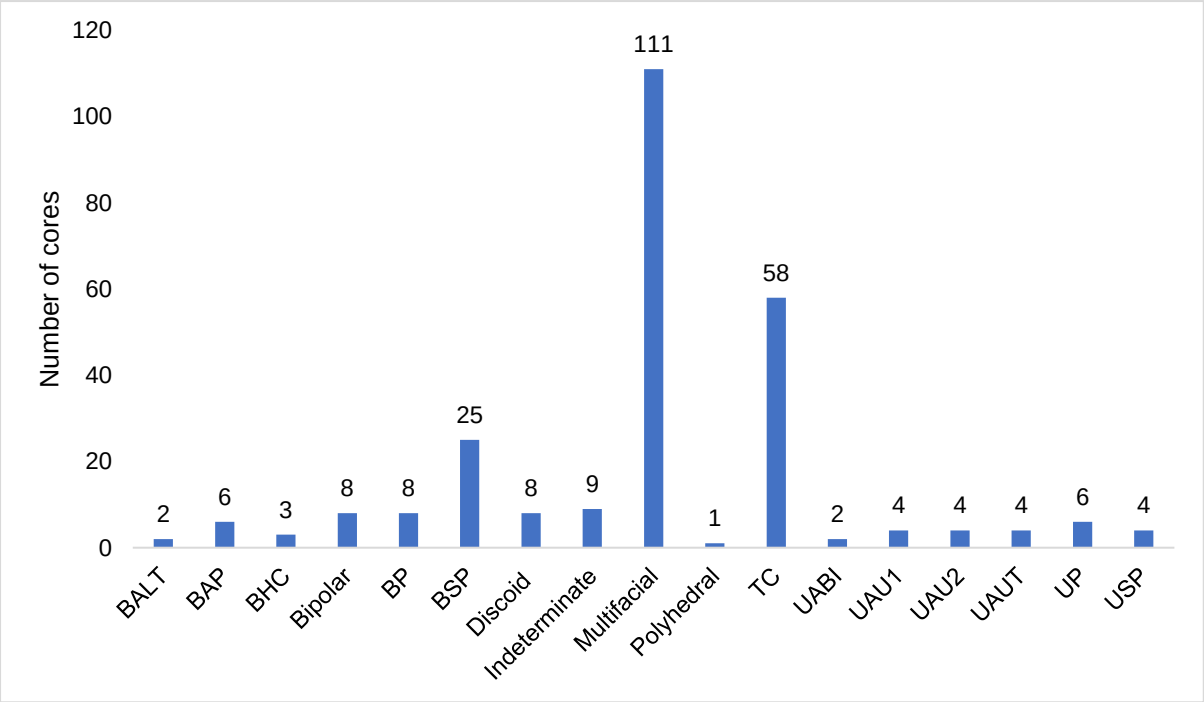


Figure 4.3: Core reduction strategies

The BSP (n=25) strategy makes up 9.5% of the core assemblage but 48.1% of all the bifacially worked cores, more than the other groups that have between 1-8 pieces in each. BP and discoid cores have eight examples each, and both represent strategies where either the entire or most of the edge between two surfaces is exploited. The discoid cores were exploited alternatingly, and along with the BALT cores (n=2), suggest a less common use of bifacial alternation in core edge management. However, in combination with the BHC cores (n=3) that favour an asymmetrical exploitation of the two surfaces, there is evidence of continuous and

structured reduction whereby the removals of early flakes on a core provide platforms for further knapping. Knappers thus had a good sense of raw material fracture mechanics and were able to control the central volume of the core while maintaining a workable core edge. Therefore it could be argued that the knappers were skilled and demonstrated forethought and planning.

In total there are 52 (19.7%) cores that display a bifacial core edge management, spread over six categories of core reduction: BALT, BAP, BHC, BP, BSP, and discoid schemes. This is more than double the number of unifacially exploited cores, with a total of 21 (8%) pieces, also spread over six categories: UABI, UAU1, UAU2, UAUT, UP, USP. The mean of the bifacial cores per category is 8.67 and 4 for the unifacial cores, however, the distribution between the unifacial categories is more equal than in the bifacial groups. The knappers were likely more adept at unifacial edge management so could be more flexible in its application, and while the bifacial strategies were common they were applied in a similar (less flexible) way. Only in a very few cases were the bifacial strategies used to exhaust the core.

Raw materials are distributed across the core categories in no particular rank order (Figure 4.4), apart for the dominance of quartzite. The only exceptions are bipolar cores, where there are more quartz cores and an equal number of quartzite and chert pieces. There are almost the same number of quartzite and quartz cores in the TC category, which could indicate that knappers tested all raw material clasts.

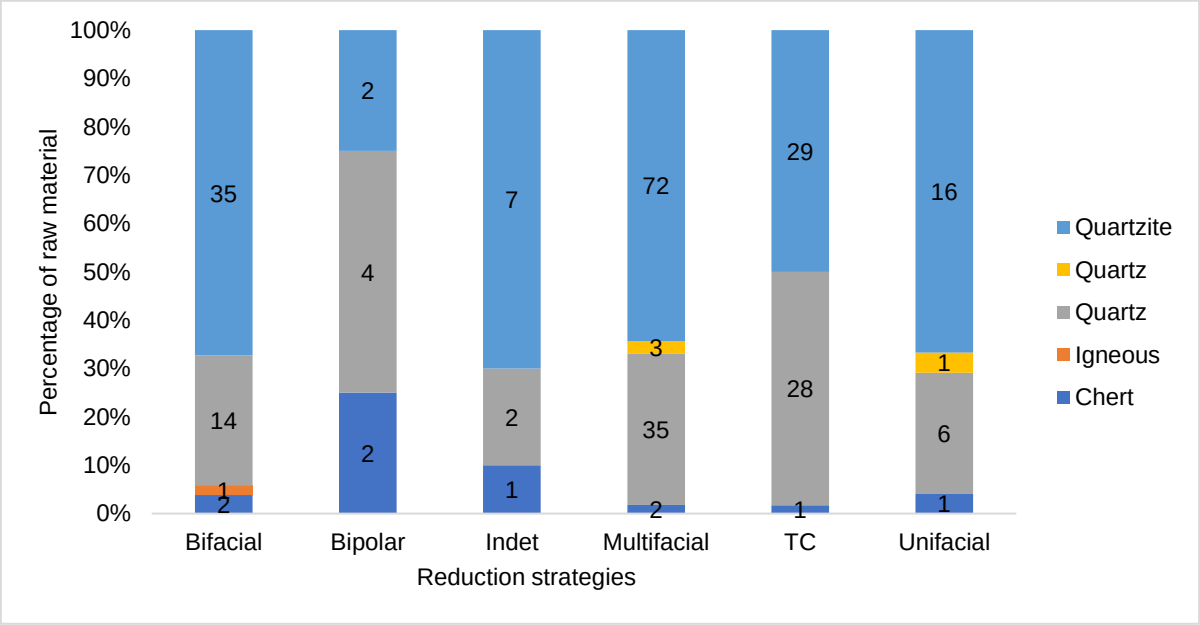


Figure 4.4: Percentage of raw material in the reduction strategies

4.3.3 Cores with multiple core edge management strategies

In chapter 3, there was a discussion of how to analyse cores that combined more than one strategy of reduction and core edge management. The data presented thus far has used information regarding the dominant strategies, but there are multiple examples of cores that have more than one strategy. In total there are 28 cores (10.6% of the core assemblage) with a combination of schematics, and many of them can be classified under multifacial as either the dominant or secondary scheme.

As discussed, there are no cores with a dominant BALP strategy, and relatively few alternating bifacial cores at all. However, when you consider the secondary schemes, more examples of bifacial alternating edge management emerge, albeit on partial sections of a core. Figure 4.5 shows two examples of cores that could have a combination of schemes with a bifacial alternating component (both pieces are fully described at the end of the core section). This often happens on pieces that are more heavily exploited, and thus these are often smaller cores. The core on the left has a combination of bifacial alternating core edge management, with partial central volume reduction. It would thus fit into the BALP scheme, corresponding to a bifacial alternating partial exploitation. The central volume reduction is characteristic of a discoid, per the methodology. In terms of the quantitative analysis, this piece was classified as a BALP because it dominates the reduction sequence, while the discoid characteristics are minimal. It is important to note this combination, as the reduction of central volume in the cores is not common throughout the assemblage, which shows how the diacritical analysis can detect such nuances.

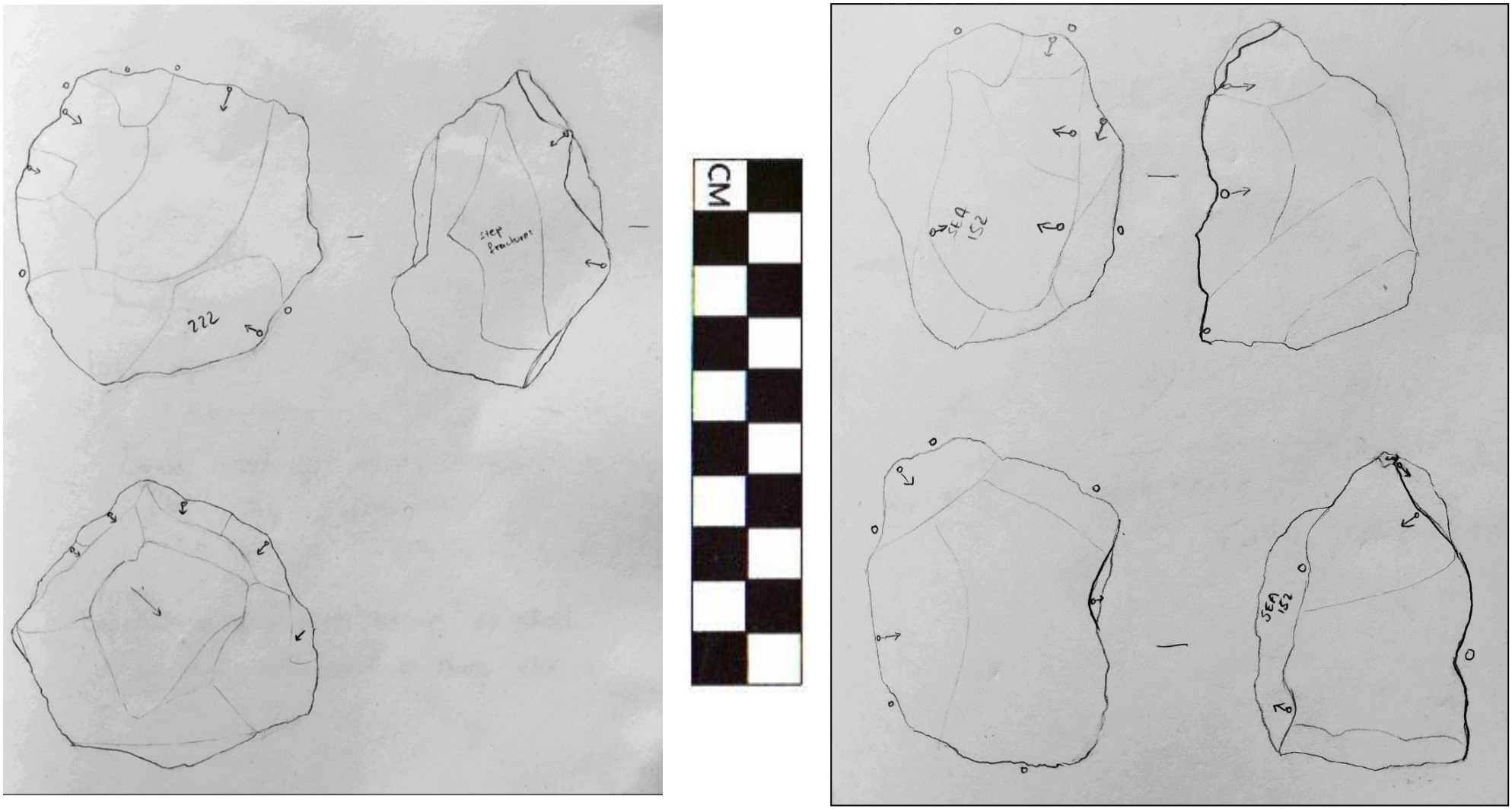
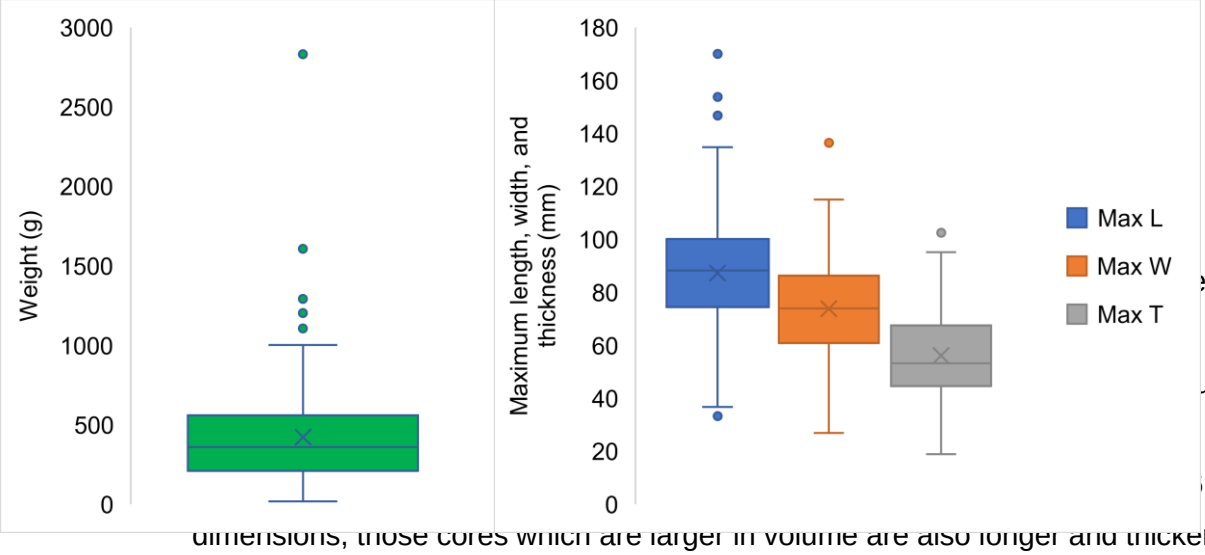


Figure 4.5: Cores with multiple idealised schemes



er to remain as broken during urate weight, or than 500g, but A). Regarding dimensions, those cores which are larger in volume are also longer and thicker but not wider, resulting in the larger pieces being somewhat elongated (Figure 4.6 B).

Figure 4.7 is a bar graph showing the distribution of core mass in intervals of 100g. Of the cores >500g, 45 weigh between 201-300g, 40 between 301-400g, 39 between 101-200g, and 32 in the 401-500g range (12.6% of the assemblage). Only five examples weigh more than 1000g (2% of the assemblage), with three of those weighing 1001-1100g and 74 cores weighing between 500-1000g (29.2% of the assemblage). Thus overall, the cores are small, certainly relative to the Canteen Kopje assemblages, which will be discussed in chapters 6 and 8.

A B

Figure 4.6: Box and whisker plots of the weight (g) (A) and the dimensions (mm) of the core assemblage (B)

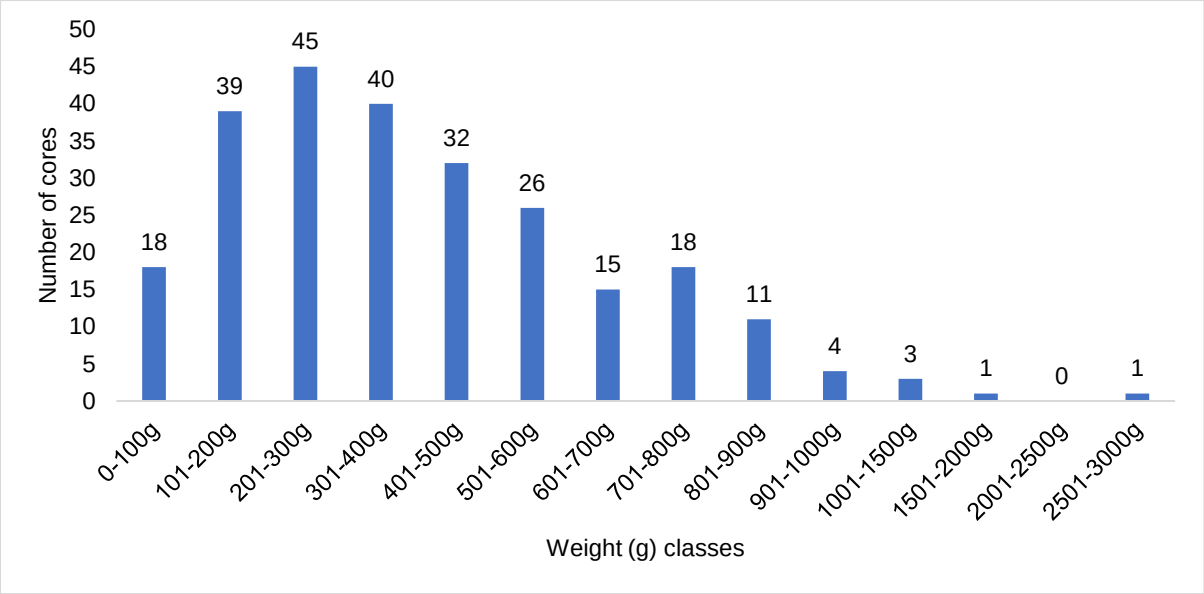


Figure 4.7: Weight classes of cores (g)

4.3.5 Flake scars

Generally, the cores preserve an average of 6.26 flake scars but overall scar counts increase to an average of 12 scars for discoid cores (n=8), and 14.3 scars for BHC (n=3), the highest averages for any reduction scheme. The most common category, multifacial, averages 8.25 scars per core. A chi-squared test of the core reduction strategies and flake scars gave a p-value=0.24, indicating that there is a correlation between these factors.

Within the bifacial cores, there are 20 cores that demonstrate total exploitation, while 32 show a partial exploitation. Partial exploitation again dominates the unifacially worked cores, with 18 examples from UAU1, UAU2, UP and USP. On average, the bifacial cores have 7.84 flake scars, and the unifacial cores have 5.13 which makes sense as there are more scars when more surfaces are exploited. There are only 10 examples of extensively exploited unifacial cores within the categories UABI and UAUT. In general, many of the partially exploited cores were abandoned once the natural platforms became too abrupt.

Figure 4.8 is a scatterplot graph of the correlation between the number of flake scars on cores and their weights. There is little significance between these features (R-value = 0.0161), and thus core size is not a direct indicator of how exploited a core could be. However, in agreement with the data presented above on core types, those categories with high scar averages (BHC and discoid) have some of the smallest volumes.

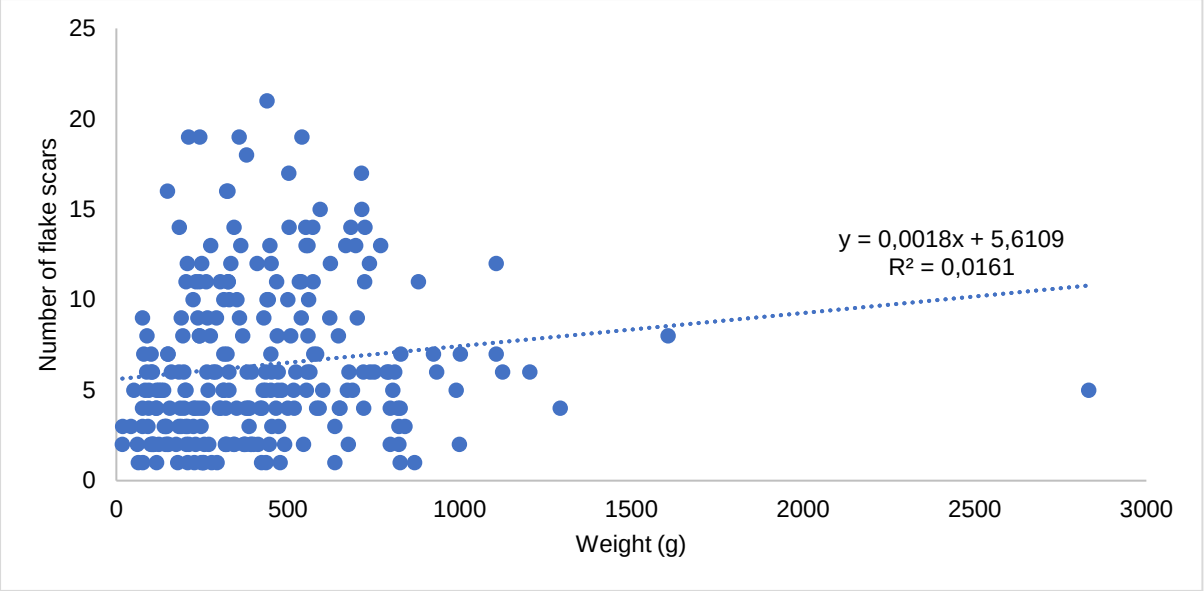


Figure 4.8: Correlation between weight (g) and number of flake scars

4.3.6 Core reduction schemes and weight

Figure 4.9 presents the weight ranges of the various core reduction strategies. The widest range is in bifacial cores, because the BAP category contains the largest core in general. This core skews the data because the mean of the BAP category is quite low <500g. The category with the highest mean is UAU1 (720.8g), but this is a single artefact, so the next highest average is UAP (560.4g), followed by UABI (541.45g). This suggests that cores with abrupt working edges tended to be larger in size. A Kruskal-Wallis test of the category medians shows no significant difference between the weights of core reduction strategies (p-value 0.4146), suggesting that despite the wide range of volume, generally the cores were of a similar size and weight.

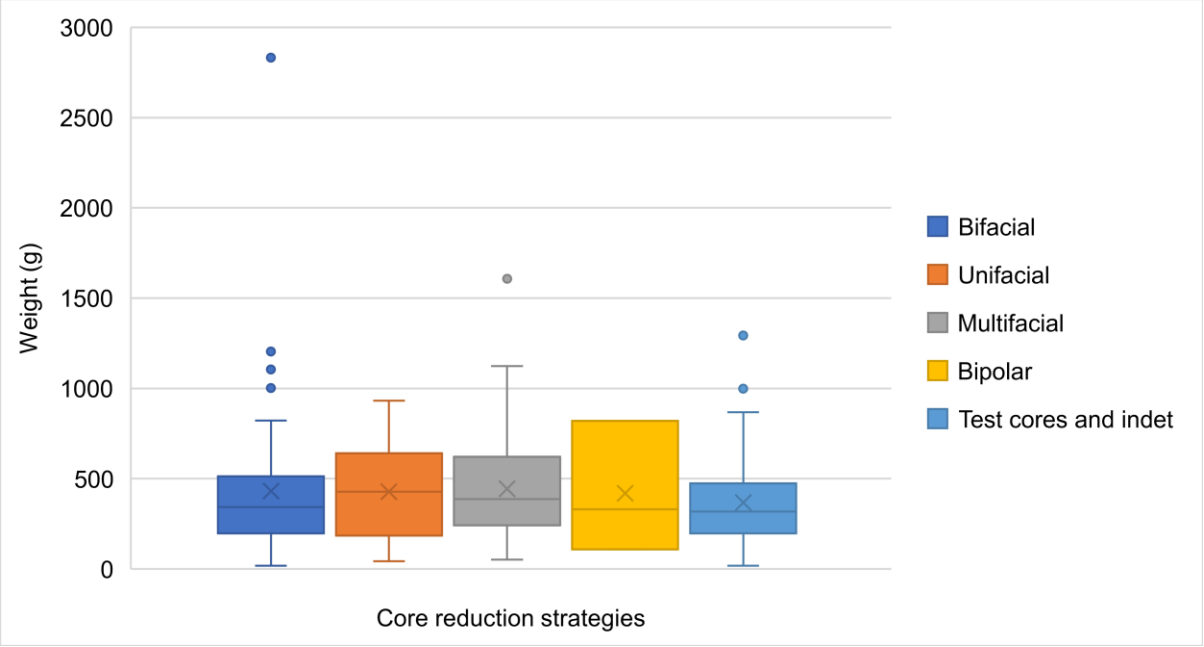


Figure 4.9: Weight ranges for core reduction strategies

The BHC category has the smallest mean weight (215.1g), which correlates with the fact that these core types are heavily reduced. Discoid cores which are also heavily exploited have a slightly larger weight range and a mean of 293.9g, but they do not get much heavier than 500g. The most populous categories, multifacial and TC, have wide ranges relative to the other categories, but their quartile ranges are focused around or just under 500g, respectively. They also have means of <500g: these are 445.26g for multifacial and 352.72g for TC. Generally, the core weight averages and medians are <500g, indicating a more common selection for slightly smaller blanks.

Specific clast sizes were not necessarily chosen for specific reduction strategies, but their shape and edge angles were important features. There is a huge range of core sizes in categories, such as with bifacial cores (BAP and BSP have the widest ranges), and multifacial cores, which have a range of roughly <100g to >1000g. These cores have both acute and abrupt edges, meaning the overall size of blanks was not as important as the shape.

There is a similarity between the median blank weights of certain idealised scheme blank categories (Appendix 5): BP, BSP, discoid, indeterminate, multifacial, polyhedral and TC. Overall, a Kruskal-Wallis test for equal medians shows no significant difference between the sample medians (p [same]: 0.4406). A t-test of the mean and median of each category gives a p-value of 2.0369, indicating there is no correlation between the two. Thus, even though the size range is large, there is little significance to selection of clast size for reduction strategy,

despite the similarity in medians which suggests a possible consistency in clasts sizes from the river gravels.

Figure 4.10 presents the data of cortex remaining on the cores. Roughly a quarter (26.9%, n=71) of the cores have between 1-25% remaining cortex, indicating they could have been heavily reduced. In total, 140 (53%) cores have <50% cortex, while 124 (46.9%) have >50%. Even though there is a varied range of cortex remaining, just over half the assemblage is more exploited, with most of those having <25% cortex and thus heavily exploited. A t-test comparing the data of the amount of remaining cortex, and the idealised core strategies gave a result of p=1.9645. This indicates a strong correlation between the categories, and the remaining cortex could be inferred by the edge management scheme on the core.

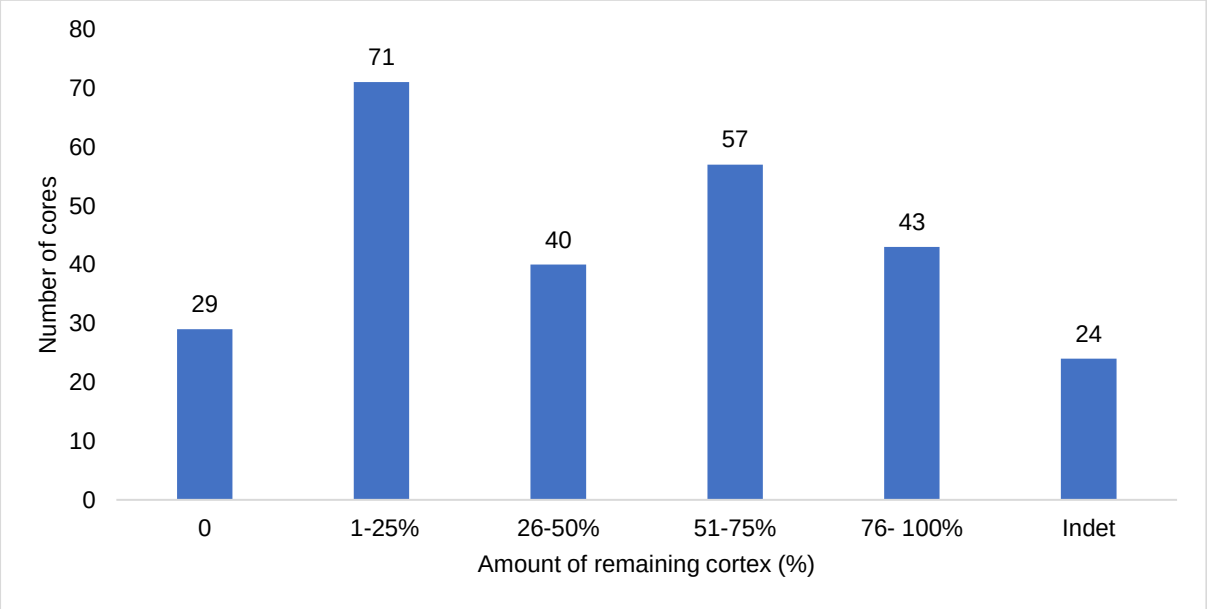


Figure 4.10: Remaining cortex

4.3.7 Core blanks

As mentioned, all quartzite raw material was sourced from the Bloubank River, while other rocks could derive from either the river gravels or from surface outcrops. Figure 4.11 shows that 25.4% of identifiable core blanks are blocky clasts that have rounded edges (n=68), while 39.6% are indeterminate (n=106), because multiple artefacts are either damaged or too heavily exploited to determine the blank. The block category (8.6% of the blanks) refers to pieces that are angular in shape but have no cortical surface remaining.

There are multiple examples of angular clasts, which are river cobbles (n=52). These blank types, along with the blocks, chunks, and split clasts usually have abrupt edges, and they are exploited by all the reduction strategies. These edge shapes are highly influential or the reduction strategies.

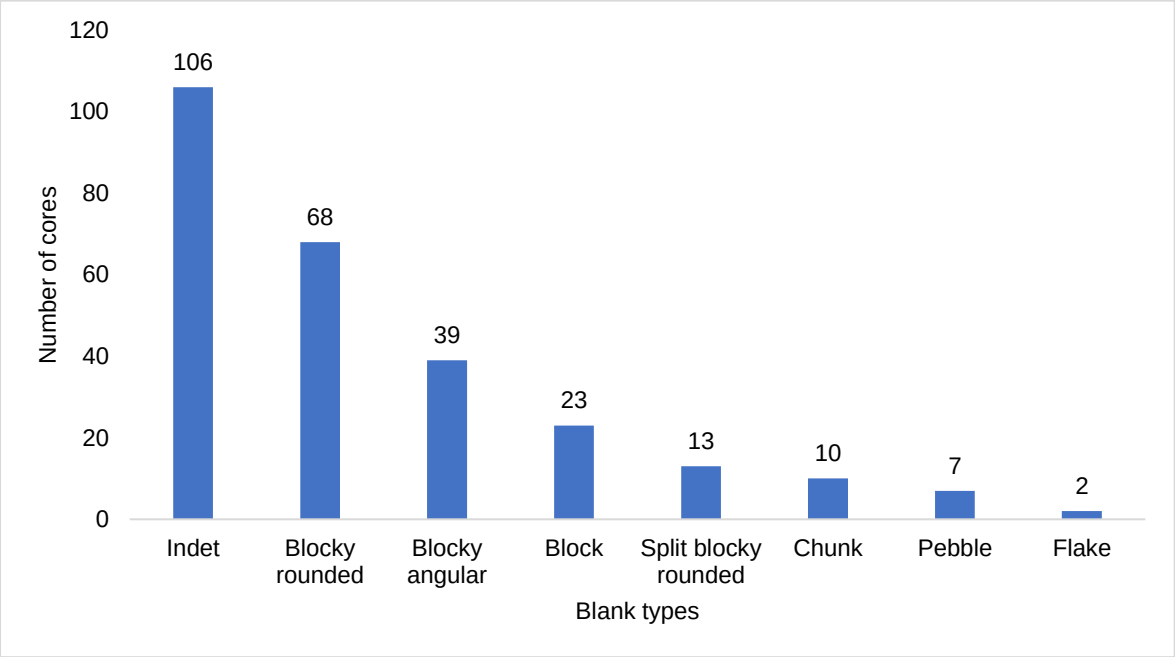


Figure 4.11: Core blank types. The term 'pebble' here follows the size category from the Wentworth scale (1929, Appendix 1)

Figure 4.12 presents the core reduction strategies by blank type. Blocky clasts with rounded edges are most used for multifacial and test cores, followed by bifacial cores. Bifacial cores have multiple indet blanks, followed by blocky rounded blanks. Unifacial cores have a range of different blank types with no more than six examples from any single type, suggesting that unifacial strategies are applied to a range of blank shapes. Multifacial cores also have multiple blank types, also suggesting that the edges of blanks are important to their reduction strategy.

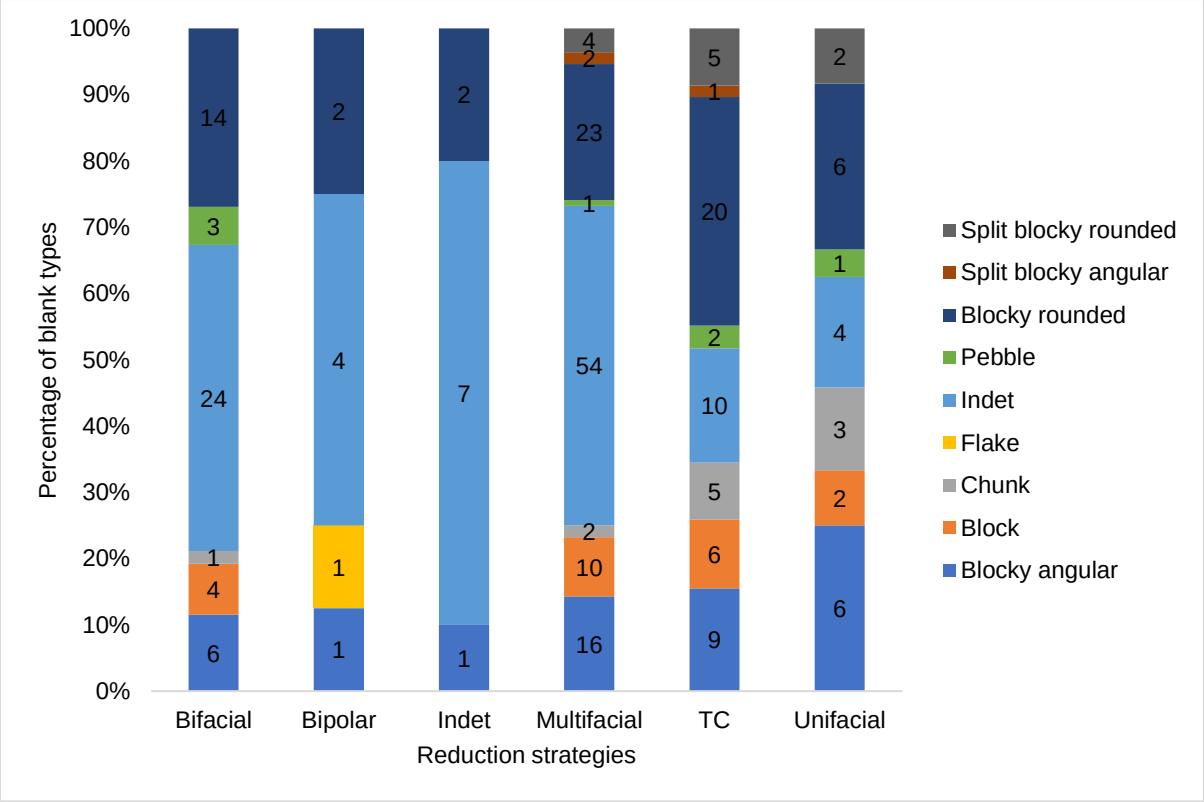


Figure 4.12: Percentage of blank types in core reduction strategies

4.3.8 Largest flake scars

As discussed in chapter three, the dimensions and morphology of flake scars can be useful in inferring knapping trends and skill levels. The pie chart in Figure 4.13 only includes the freehand cores, 46% of the LFS in the early Acheulean core assemblage has feather terminations, while 17% end in a step, hinge or overshoot fracture. A large portion of the assemblage has indeterminate flake scars, either because of the weathering on cores, or because the edges of the LFS are not identifiable. Overall, there is a high proportion of flakes produced with thin cutting edges.

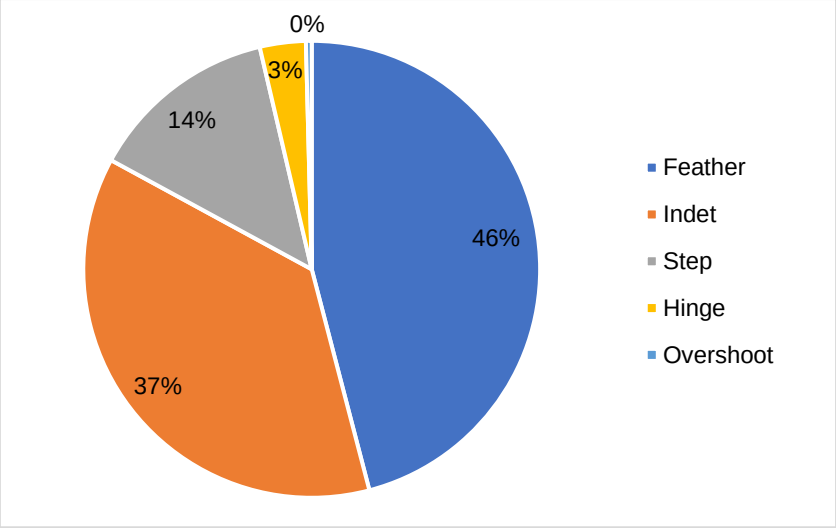


Figure 4.13: Largest flake scar terminations of freehand cores.

Feather terminations are found on cores from all reduction categories (Figure 4.14), except for the polyhedral and USP, which all have indeterminate LFS. The bifacial cores with higher scar averages have feather terminations, like BALT, BHC and discoid. Thus, even though knappers did not often follow these extensive reduction sequences, they were successful at extracting sharp flakes. Step fractures occur on cores with abrupt edges (BAP, UABI and UAU2), as well as some multifacial cores, which can have abrupt edges. It could be logical to assume that any test cores with step fractures were abandoned early because of the raw material quality.

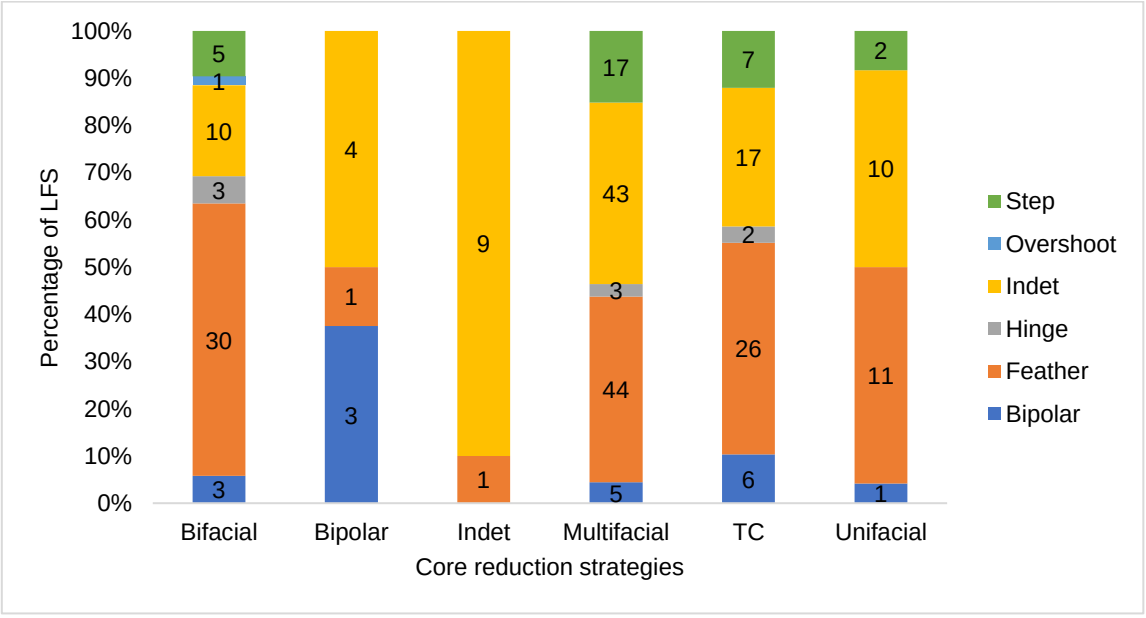


Figure 4.14: Percentage of largest flake scar terminations by core reduction strategies

To summarise, freehand flake scars are well made and the knappers demonstrate good understanding of how to detach pieces with workable edges. As discussed, the raw material quality at the site is good, but the quartz blanks have multiple flaws within them that tend to produce stepped terminations.

Figure 4.15 shows the divisions of LFS terminations by raw material types. Overall, quartzite represents the highest number in each group, except for bipolar cores, and there are equal proportions of quartzite and quartz in the indeterminate category. The quartzite is tough material to work with (Kuman *pers. comm.*), but knappers demonstrate technical skill as they were successfully producing flakes with tapered cutting edges. The quartz is more brittle, and thus it can shatter easily and lead to more step fractures, which is more frequent in bipolar reduction due to the force exerted on both ends of the core.

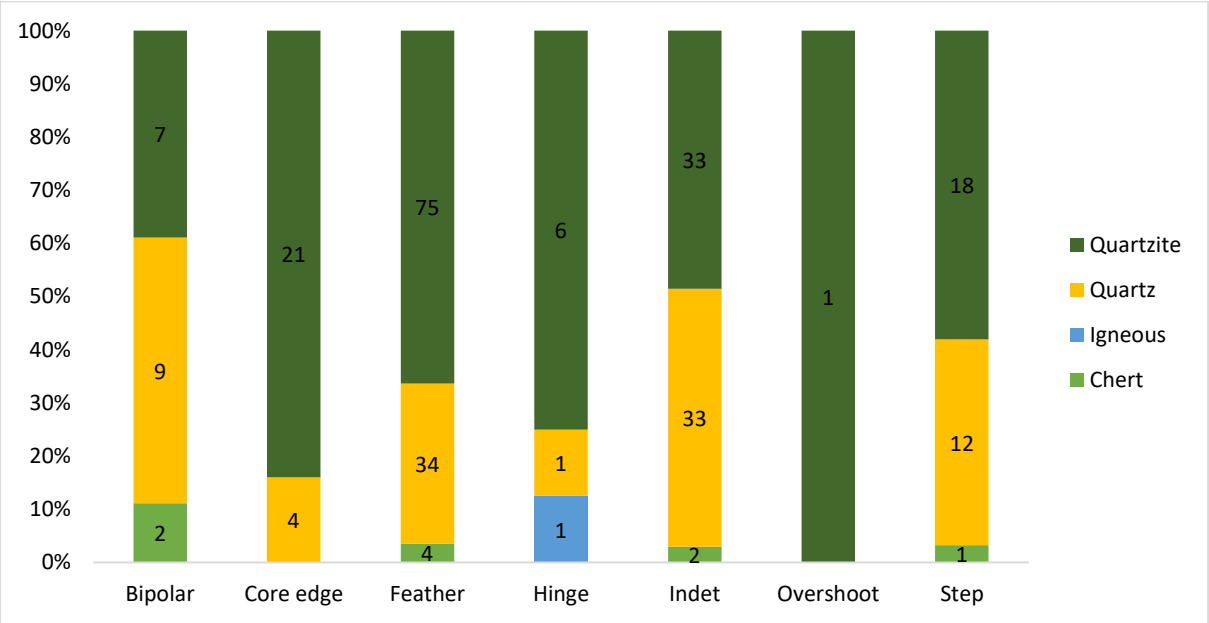


Figure 4.15: LFS terminations distributed by raw material

4.3.9 Diacritical analyses of cores

The following diacritical descriptions are intended to give an overall idea of the Sterkfontein M5W cores by providing examples of individual cores from the assemblage. They represent both a portion of the core reduction strategies described in the above data and the variety of core shapes within each idealised scheme of core reduction. Thus not every scheme is presented.

UAU1 cores



Figure 4.16: Artefact 1409

Figure 4.16 is a quartzite core with evidence of possibly being used first as a hammerstone. On this core, the battering is on one side, with the opposite side having been exploited. This pattern is seen on quite a few of these examples. The core blank was a flat cobble exploited in an abrupt manner along one surface. It fits into the UAU1 category of the schematic, which means a unidirectional abrupt unifacial exploitation on one knapping surface. It differs with a traditionally defined chopper core as the edge is abrupt.

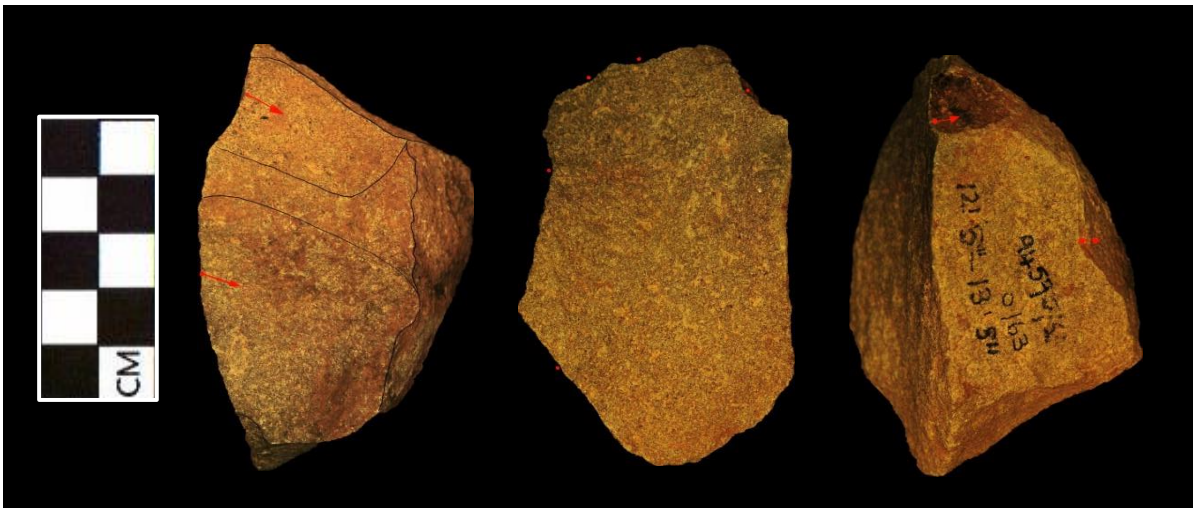


Figure 4.17: Artefact 9459

Figure 4.17 is a UAU1 core made on a quartzite spilt cobble blank with six scars. The split surface was most likely made by the knapper as it is smooth in texture and fresh like the flake scars. However, there are no clear impact points to verify this. The flakes were removed at an

abrupt angle around one side of the piece. The unknapped surface has some remaining cortex, as does the tip opposite the flaking platform.

USP cores

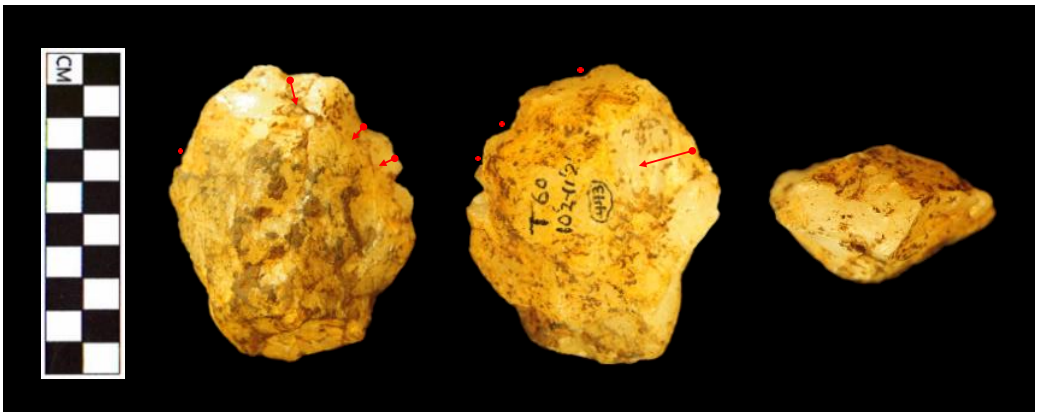


Figure 4.18: Artefact 443

Figure 4.18 is a small USP quartz core, with only four distinct flake scars. Three of the scars form a single USP sequence, with a fourth scar (which is the LFS) located on the other edge and surface. Despite the fourth scar, the USP sequence reflects a rotation of the piece along one axis and is therefore the dominant sequence.

BAP cores

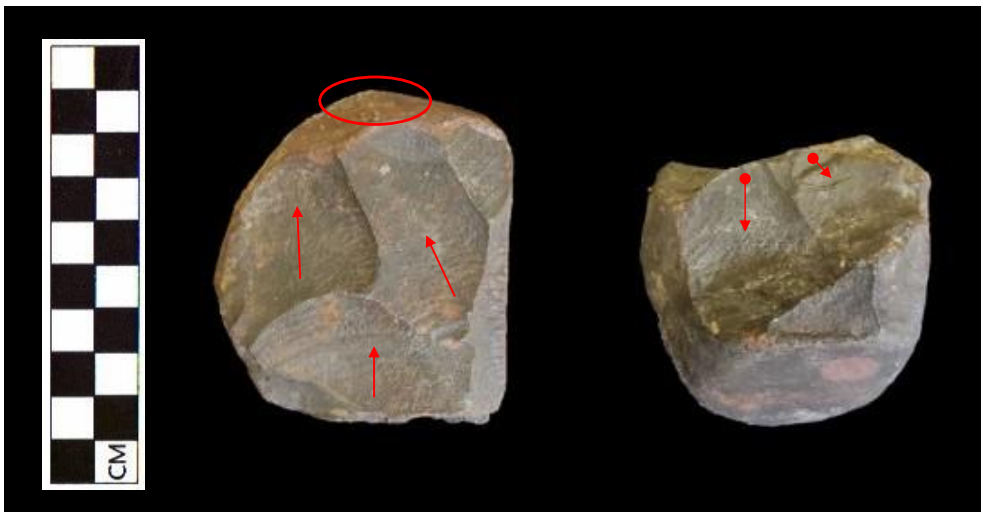


Figure 4.19: Artefact SEA 40

Figure 4.19 is of a core exploited along an abrupt edge bifacially, with one surface being exploited before the core was turned and exploited on the perpendicular surface. It is classified

as a BAP, meaning a bifacial abrupt partial exploitation. This example reflects the adherence to the shape and size of the platforms on the blank which is the common trend throughout the assemblage, especially with bifacially exploited cores. The red circle on the BAP core indicates an area of battering, suggesting that this piece was possibly a recycled hammerstone, or used as a hammerstone after the flake were removed.

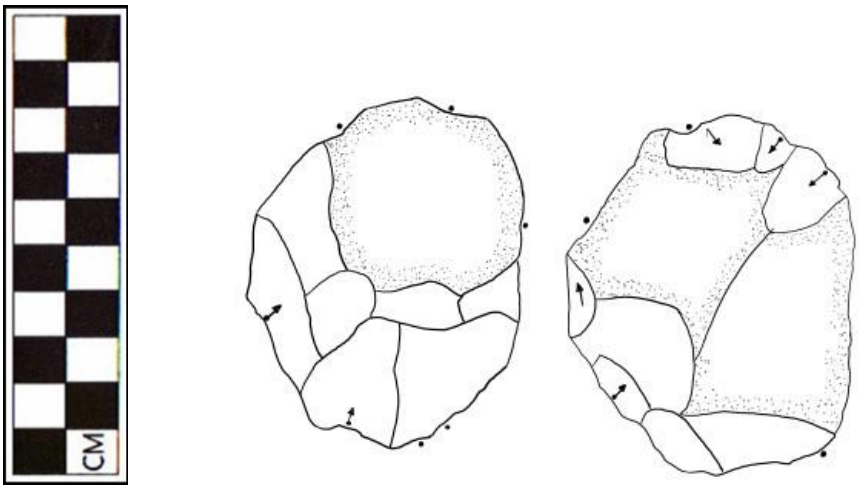


Figure 4.20: Artefact 1420

Figure 4.20 shows a core made on a quartzite cobble blank with eight scars in a BAP scheme. The largest and highest proportion of flake scars is focused on one edge opposite a rounded cortical surface. There are some removals going around the piece, but it was abandoned.

BSP cores

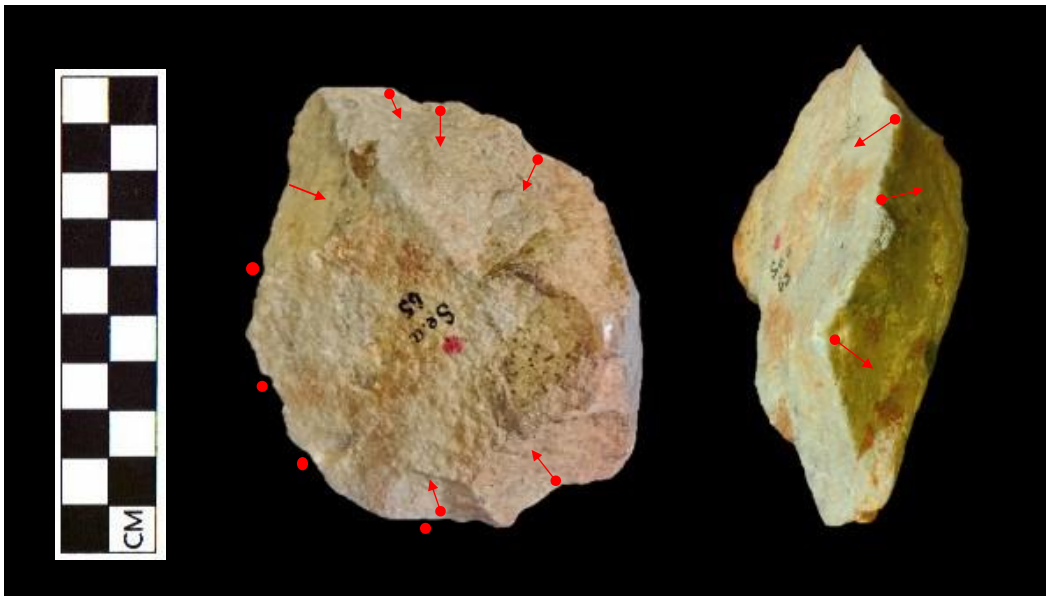


Figure 4.21: Artefact SEA 65

Figure 4.21 is a bifacially exploited quartzite core with a BSP reduction strategy and is made on a large flake. This piece, as with the LCT assemblage, demonstrates an ability to produce large flake blanks. The edge is worked bifacially but does not show any evidence of an alternating edge management. It would fit into the BSP classification, or a bifacial simple partial exploitation. It is unclear whether this piece was an LCT which was reused as a core, or whether it was directly knapped as a core.

BP cores

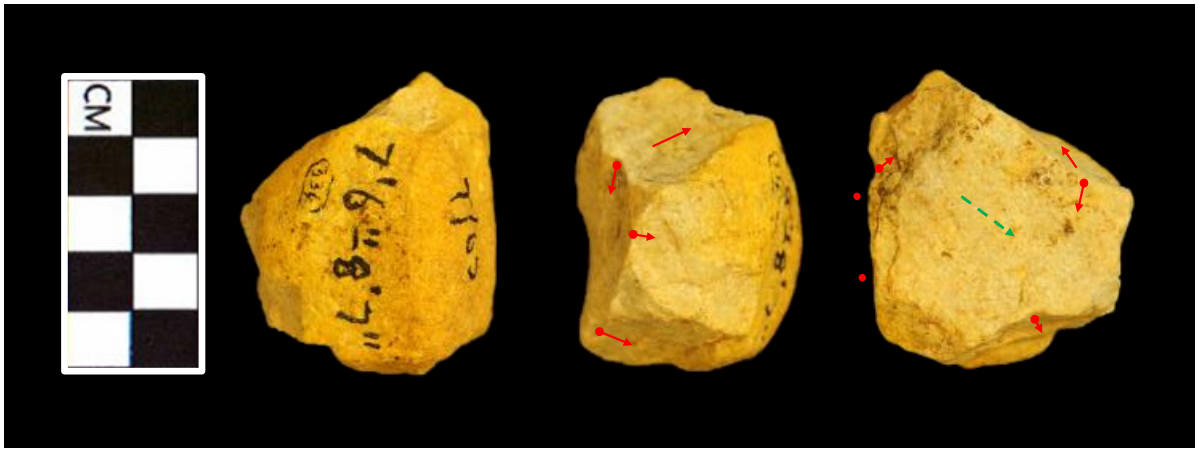


Figure 4.22: Artefact 334

Figure 4.22 is a small quartzite core made on a pebble blank. It fits into a BP scheme with seven scars in two bifacial sequences. The blank was split to create a platform from which

flakes were removed. Around 25% of the cortical surface remains opposite the platform surface. This and core 443 show how knappers were exploiting a wide range of core blank sizes.

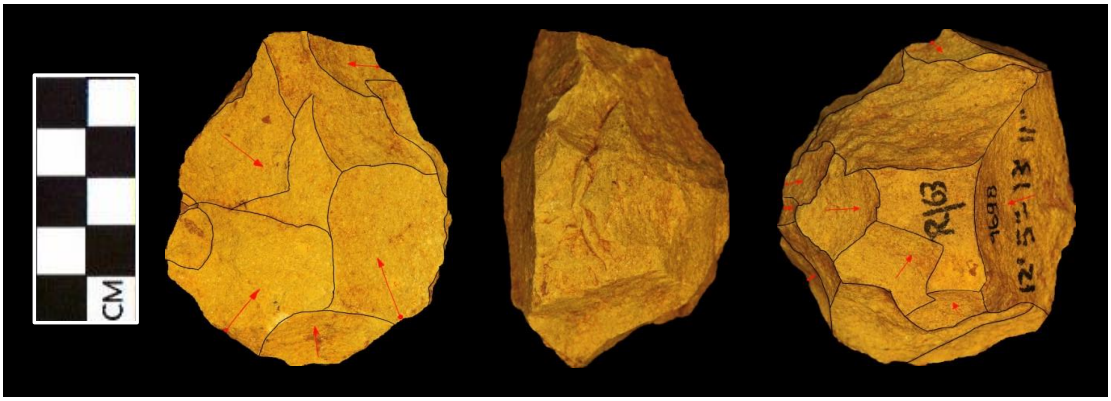


Figure 4.23: Artefact 9698

Figure 4.23 is a small BP core made on fine-grained quartzite. The two sides of the core are exploited asymmetrically, with cortex remaining on the bulkier side. The flatter surface has evidence of multiple flake scars. The edge between the surfaces is bifacially worked but there is not clear evidence of alternation. One could argue for the core being classified as BHC, but it is hard to distinguish if the flat side was exploited preferentially, or whether the blank shape was naturally flatter on that surface.

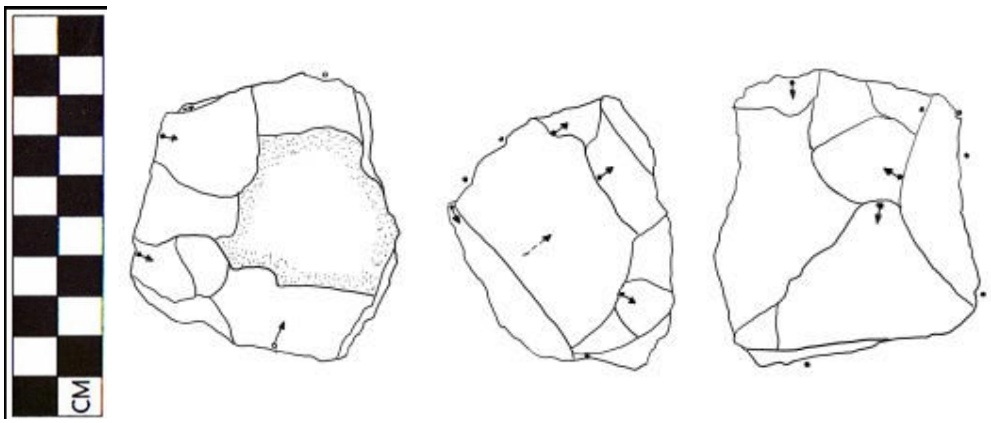


Figure 4.24: Artefact 9619

Figure 4.24 is made on a quartzite cobble and has eleven flake scars, and about 10-25% remaining cortex. This piece is one of the cores with a combination of schemes, namely a dominant bifacial peripheral (BP) with a small multifacial component. The final product is roughly triangular, with the flatter surface being used as the platform for the BP removals. The multifacial schematic is represented by perpendicular removals to the BP sequence, which

are smaller in size and less numerous. Like with many other cores, the removals follow the natural shape of the blank and show how knappers were able to work with the shape of the raw material.

BALP cores

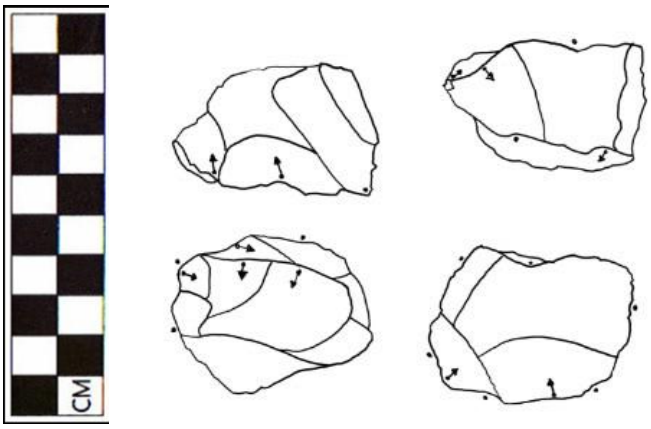


Figure 4.25: Artefact SEA 152

Figure 4.25 is a core made on a quartz chunk and again has a BALP, or bifacial alternating core edge management. However, the final product is asymmetrical due to the shape of the blank, and therefore the central volume is not reduced. The flatter side of the core has been used a platform for multiple abrupt removals on the convex side. The dominant abrupt core edge management fits into the BP sequence, or a bifacial peripheral exploitation. This example demonstrates that a bifacial alternating reduction can be combined with non-alternating exploitation, indicating the flexibility of knappers, and the ability to adapt strategies to specific artefact shapes. Overall, this is an example showing that the knappers were capable of more controlled and extensive reduction strategies, but it is not the common trend throughout the assemblage.

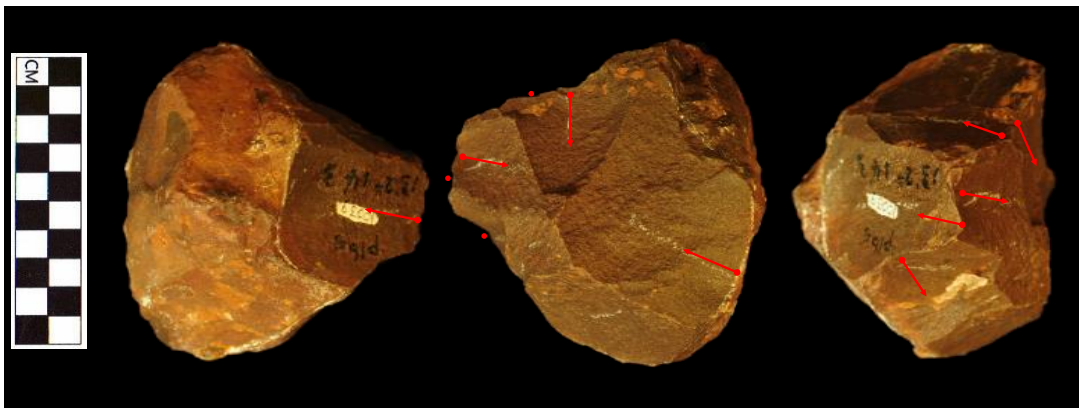


Figure 4.26: Artefact 10039

Figure 4.26 is a quartzite BALP core made on a cobble. The final morphology of the piece is triangular, and the alternating sequence is focused on the tip of the piece. One flake scar does not fit into the sequence and is on the opposite side of the cobble, struck from a platform opposite the BALP edge. This scar was cut off at the distal end by other scars but covered a large surface area and might have created the platform necessary for the bifacial alternating core edge management. Consequently, the core is somewhat asymmetrical. The cortical surface is bulky and round and would have been difficult to knap, indicating when the sequence was discarded.

BALT cores

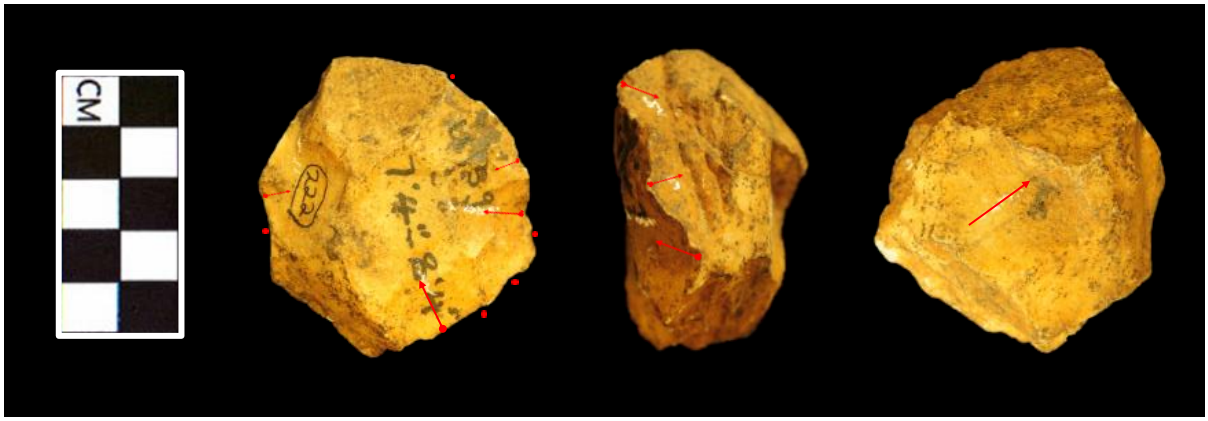


Figure 4.27: Artefact 222

Figure 4.27 is a heavily reduced chert discoid core that fits in the BALT/ Discoid category. It is one of the only cores that could be in the discoid category according to the definitions used in this thesis (see chapter 3 for category definitions), as the knapper had success in removing part of the central volume bulk using a bifacial alternating pattern (Figure 4.27). Reduction is seen through the bifacial alternating sequence which appears on over half the edge between surfaces. There is a small section of cortex remaining on one side, which ends the flaking sequence, as well as the volume reduction with a step fracture, as seen on the right image of Figure 4.27.

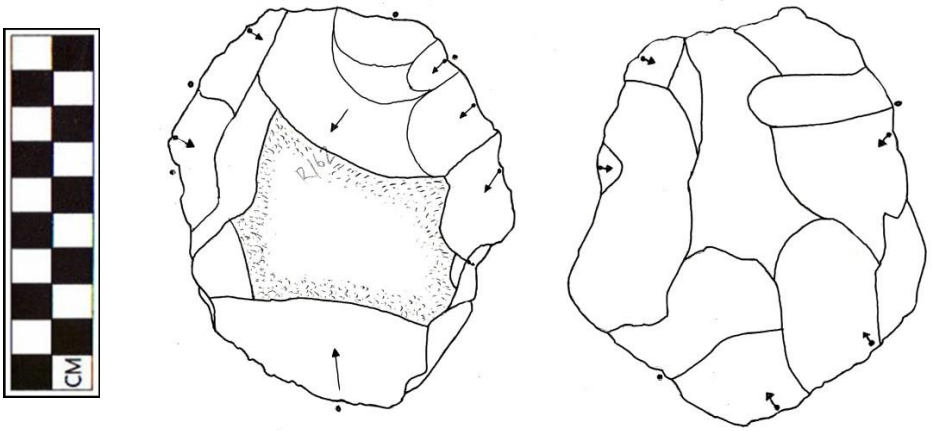


Figure 4.28: Artefact 9662

Figure 4.28 is a quartz core made on a cobble. As with all the quartz pieces, some removals may not be identifiable, and so only clear flake scars are described. Overall, there are nine distinct flake scars within a bifacially alternating total scheme (BALT). The central volume of the core is not reduced and there is cortex remaining on one surface. The piece is symmetrical in profile, though it does not separate equally between the two surfaces, all around the edge.

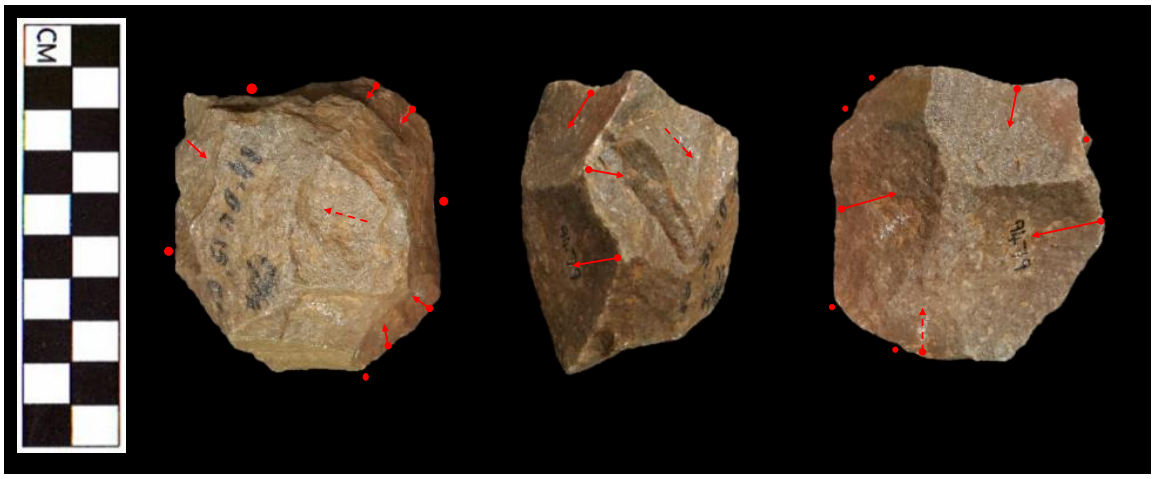


Figure 4.29: Artefact 9479

As discussed, most of the cores are exploited in a multifacial strategy or are test cores. However, the more extensively knapped cores tend to demonstrate a more controlled core edge management. Figure 4.29 has been characterised as a quartzite BALT core, which refers to a bifacial alternating total exploitation, meaning it has been exploited around the whole piece. As you can see, the flatter surface has been used as a platform for removals on the convex side, so despite the asymmetrical shape of the piece, there is no evidence of this being a prepared core. The interpretation I have made is that the knapper demonstrates a good ability to control the knapping sequence and rotation of the piece, especially on the flatter

surface. However, they encountered many stepped scars, which hampered any possible attempts at reducing the volume on both sides.

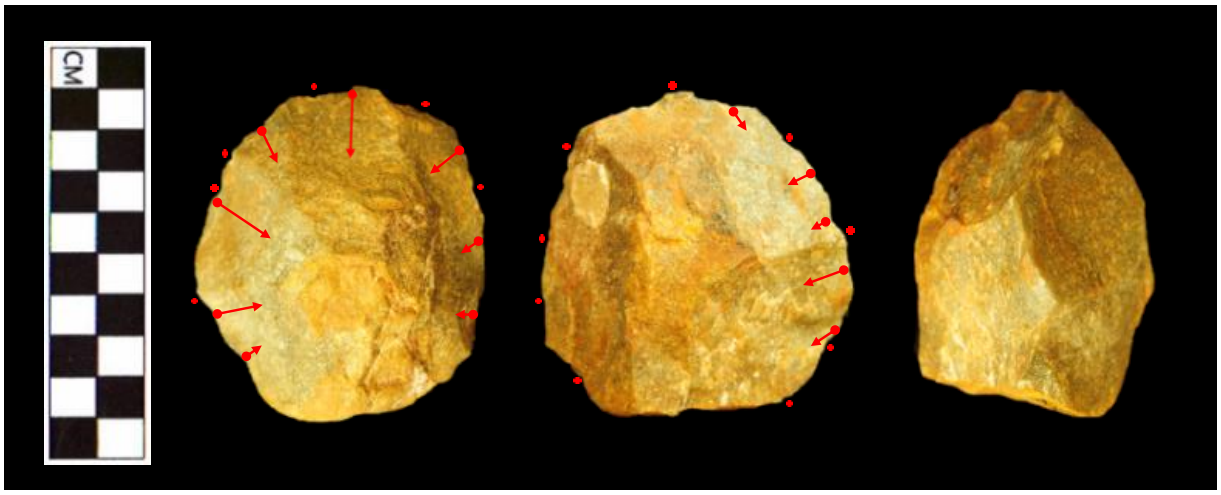


Figure 4.30: Artefact Stk13-7

Figure 4.30 is a heavily exploited quartzite core, made on a cobble blank with 14 bifacial and alternating scars along most of the core edge, and fits into the BALT sequence. The flakes have feather terminations but did not remove much volume. This is evident through the central volume not being thinned, the bulky symmetry of the two surfaces, and the cortex in the centre of both surfaces. The proximal end of the core, as seen in Figure 4.30, is blocky and cortical and could not be easily knapped leading to the core being discarded. This is an example of the controlled and continuous core edge management of which the knappers were capable, despite the obstacles imposed by the natural shape of the blank.

Multifacial cores

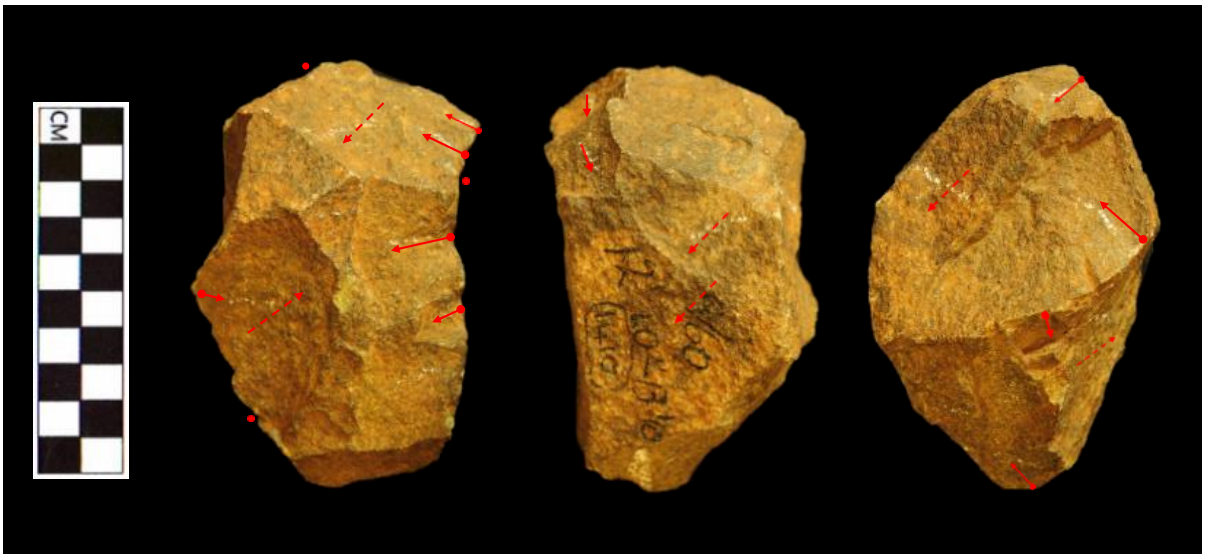


Figure 4.31: Artefact 1410

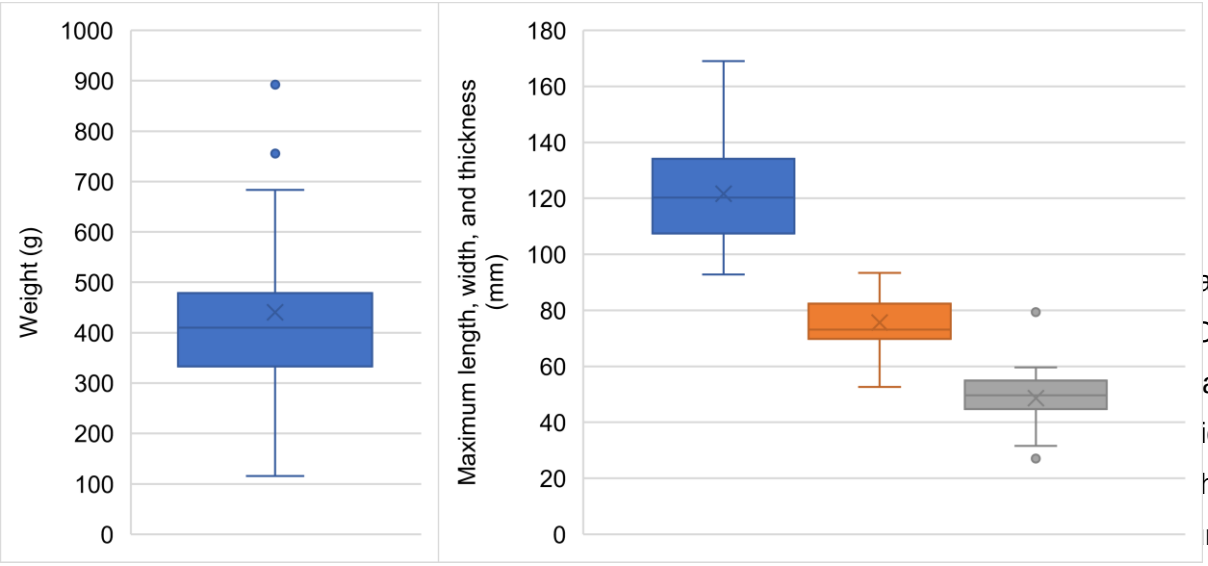
Figure 4.31 is a quartzite multifacial core, with 10 scars. Most flake scars are focused on one platform, and the piece was not excessively rotated or flipped. The final shape of the core is blocky, with angular edges, a similar trait of other pieces in the assemblage. Some of the scars are quite flat and could have been produced through bipolar activity.

4.4 Large cutting tools

In the M5W assemblage, there are 16 LCTs from the in situ excavations and includes four examples that have been reclassified and added to the collection. Two further pieces were collected from the Dump 21 (Stratford 2008; Kuman and Gibbon 2018). The statistical analyses presented below will use these 18 pieces. Overall, the LCTs were made on both cobble and flake blanks and were crudely shaped. They also showed little success in reducing the central volume. The size range of the LCTs is varied but there are similarities in general shaping and minimal retouch. Flake blanks are most common, and all are made on quartzite, bar one piece made on a chert clast. Technologically, the LCTs demonstrate a consistent technological production of flake blanks and LCT shaping.

4.4.1 Raw materials

There is no figure presenting the raw material in the LCT assemblage from M5W because they are almost all made on quartzite, which was easily accessible in nearby river terrace gravels. Therefore, it can be argued that quartzite selection was imperative in the LCT manufacture.



aximum length, CT assemblage an weights are ickness ranges he length, they red dimension, and there is a trend towards longer pieces. Clearly, knappers were successful and making heavy-duty tools.

A B

Figure 4.32: A: Weight ranges (g) and B: maximum length, width, and thickness (mm) of LCTs

A scatterplot graph of the correlation between the weight and maximum length, width, and thickness (mm) (Figure 4.33) confirms the trend, as the width and thickness trendlines sit parallel to each other at different intervals, but there is more significance to the correlation between width (R-value=0.7465) and weight than the other two dimensions (maximum length R-value=0.5253 and maximum thickness R-value=0.4878). Overall, LCT length increased with greater weight, but the weight was more closely correlated with the width of individual pieces.

When comparing the maximum length to the width and thickness of LCTs, there is little correlation (Figure 4.32), indicating that even though there is steady increase in the length of pieces with greater weight, and a connection between width and weight, LCT size increase does not link to the 2D dimensions, and these factors can be independent of each other.

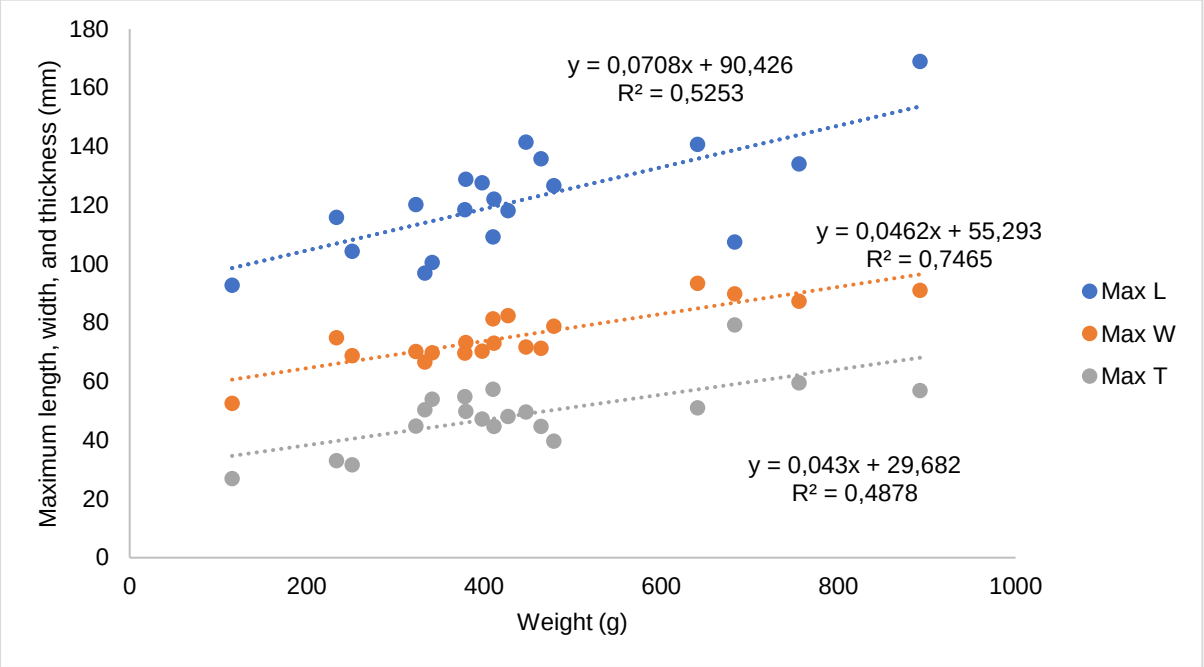


Figure 4.33: Correlation between weight (g) and maximum length, width, and thickness (mm)

4.4.3 Refinement Index

The result of a Refinement Index test on the thickness and width of LCTs is a mean of 0.64. This is above 0.5, which indicates that overall, the LCTs were thicker than half the maximum width. These pieces were therefore not thinned intensely, which corresponds with the data presented that the LCTs tend to be bulky. This will be compared with the indices of the other sites in the discussion to compare LCT reduction and shaping.

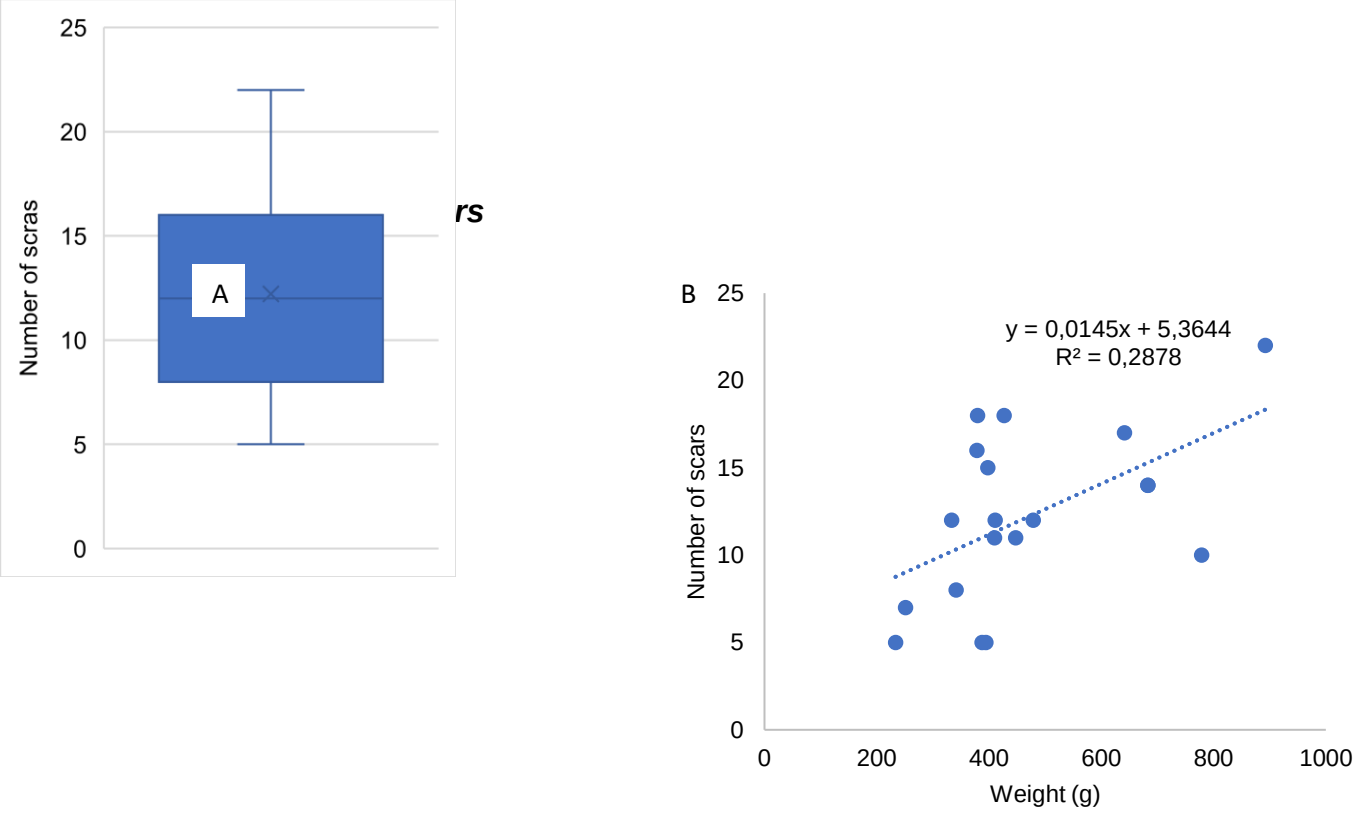


Figure 4.34: Number of scars on LCTs (A), and correlation between number of scars and weight (g) (B)

There is a range between 5 and 22 flake scars on the LCTs (Figure 4.34 A). The average number of flake scars is 13.8, and the median is 14 scars. Overall, the LCTs tend to have higher numbers of flake scars than cores, but this is not relative to the weight of the piece. Figure 4.34 B is a scatterplot of the two features, which shows an insignificant correlation between them (R^2=0.1061).

4.4.5 Large cutting tool blanks

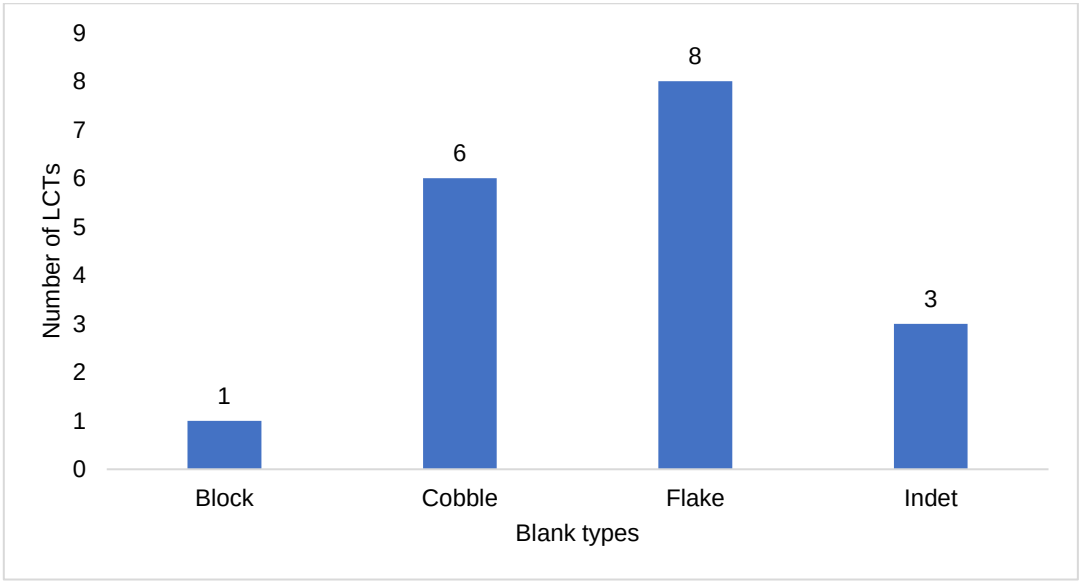


Figure 4.35: LCT blank types

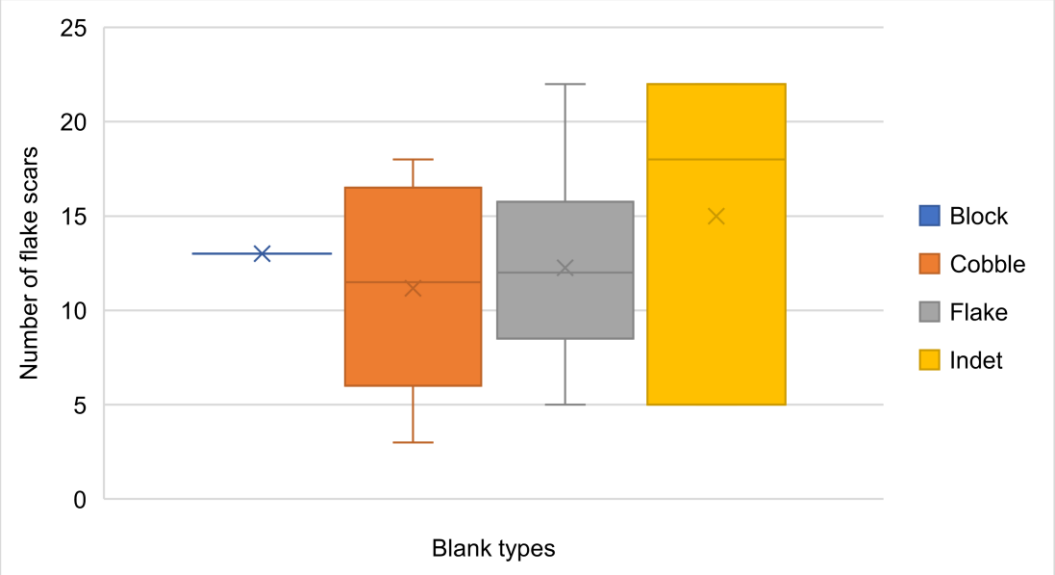


Figure 4.36: Range of scar numbers by blank types

All the analyses can be understood in relation to the blank types used in LCT production, as this could influence the number of scars on a piece, as well as the size. These types are flakes, cobbles, and indeterminate. Flake blanks slightly outnumber rounded blanks 7:5, but they are close (Figure 4.35).

The average and median number of flake scars is similar for LCTs made on cobble (12.4) and flake blanks (11.4), as shown in Figure 4.36, but these are much higher for the indeterminate blanks (17.1). This could be because heavily reduced LCTs obscure the blank types, but also because some of those pieces have been weathered. The range of flake scars for flake blanks (5-18) is wider than for cobbles (8-16), which indicates that knappers utilised longer shaping sequences on cobble blanks and the shortest sequences on LCTs.

4.4.6 Shaping strategies

Despite the smaller size of this LCT assemblage compared to the other sites studied in this thesis, all the categories of LCT shaping strategies are represented (Figure 4.37). Bifacial alternating strategies dominate and make up 50% of the LCT assemblage. This is important as the other strategies only have one or two examples each. There is a preference for this strategy over the others, indicating a cohesiveness in LCT production.

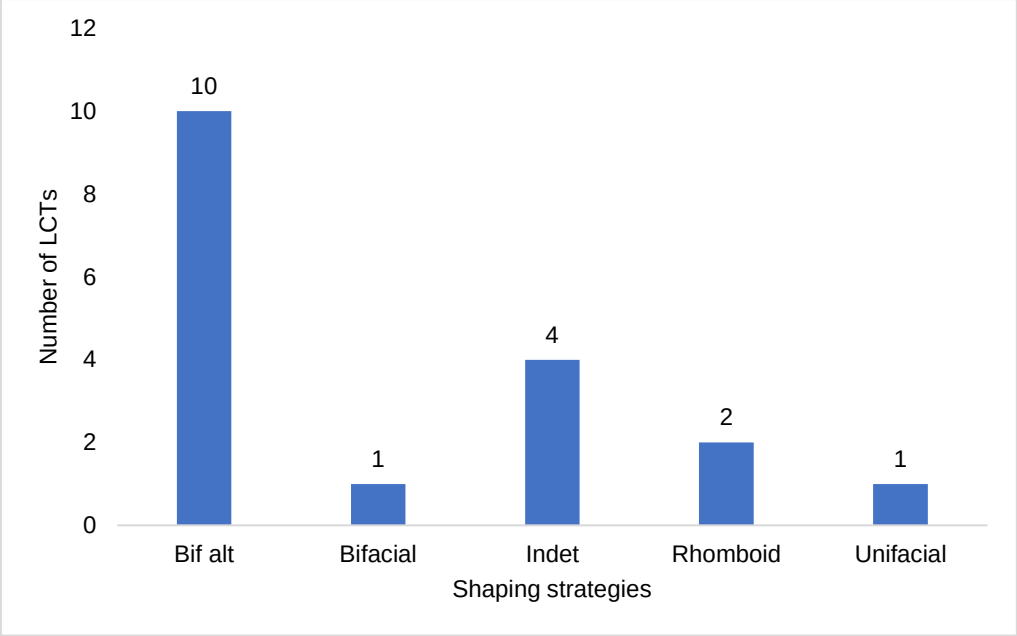


Figure 4.37: Shaping strategies

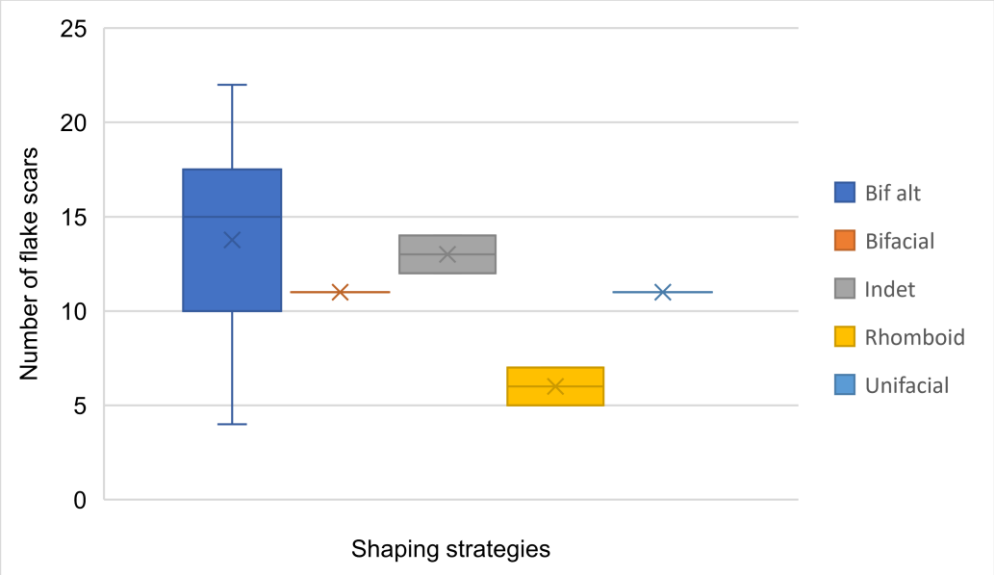


Figure 4.38: Number of flake scars by shaping strategy

The biggest range in number of flake scars is also found in the bifacial alternating pieces, while the rhomboid pieces have the fewest scars (Figure 4.38). There is only one example each of bifacial and unifacial, which have the same number of flake scars (n=11 scars). Overall, there is a preferential shaping strategy used in LCT production at the site, across two types of raw material and different types and sizes of blanks.

The LCT shaping strategies denote how the pieces were handled during reduction, and a critical t-test comparing the means of the number of flake scars and the number of times a

piece was flipped gives a p-value = 2.0369. This indicates that the more shaping flake scars an LCT has, the more times it was flipped during production. Like with the Refinement Index, these values will be compared between sites in the discussion chapter.

4.4.7 Diacritical analyses of LCTs

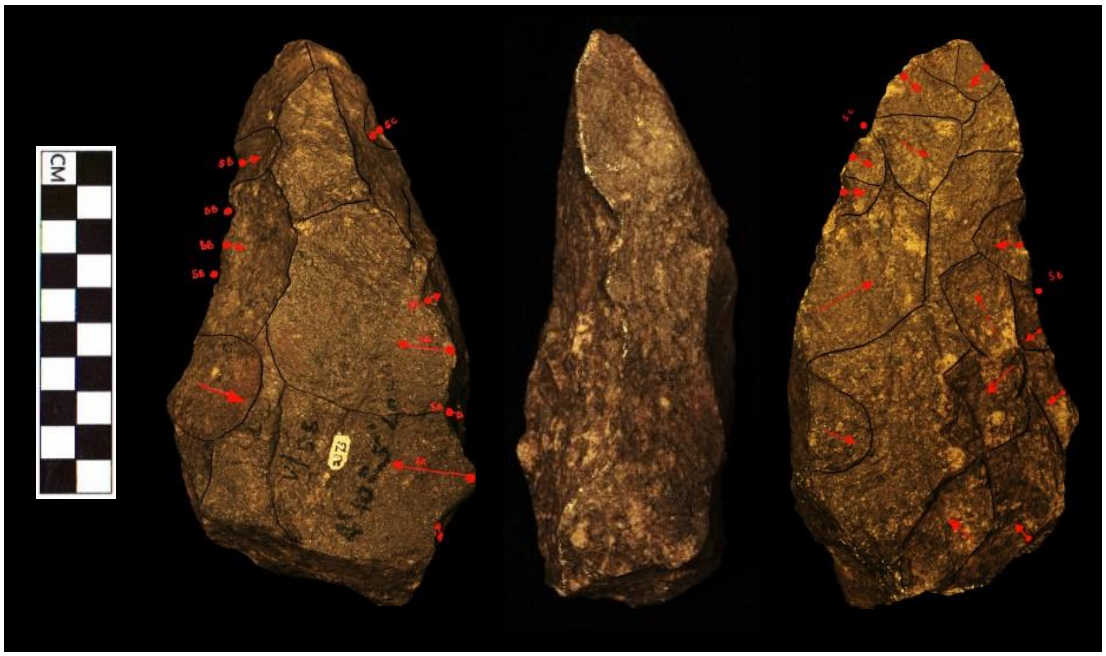


Figure 4.39: Artefact 2373

Figure 4.39 is a quartzite pick and the largest LCT from the assemblage, weighing 892.18g. It has been extensively shaped over the entire surface, with no clear indication of the blank type. The central bulk could mean it was made on a recycled core, but this is not definite. However, due to the thickness of the final product, and the flat planes on one face, I hypothesise that the blank could have been a large chunk, rather than a cobble or complete block. It is difficult though to distinguish whether certain scars form part of the débitage or shaping sequences. With this assessment in mind, there are three distinct shaping sequences labelled SA, SB and SC, while the various unlabelled scars are part of the debitage. To compare it to the other LCTs made on flake blanks, the more convex side of the piece is referred to as the 'dorsal' surface, and the flatter side as the 'ventral' surface, following the conventions detailed in chapter 3.

Sequence A is made up of four bifacial alternating removals located on the edge between the lower right side of the 'dorsal' surface and onto the thick profile. This means that sequence A does not appear on the ventral surface and the worked edge is abrupt. The B and C sequences are also bifacially alternating, with four and five removals, respectively. SB extends along the right edge of the 'ventral' surface between the proximal and medial sections. SC is on the same edge as SA but occurs only within the proximal section and shapes the tip. Overall, the

piece has been rotated and reduced using the same core edge management strategies, both to reduce the volume for handling (SA), and to create functioning edges (SB and SC).

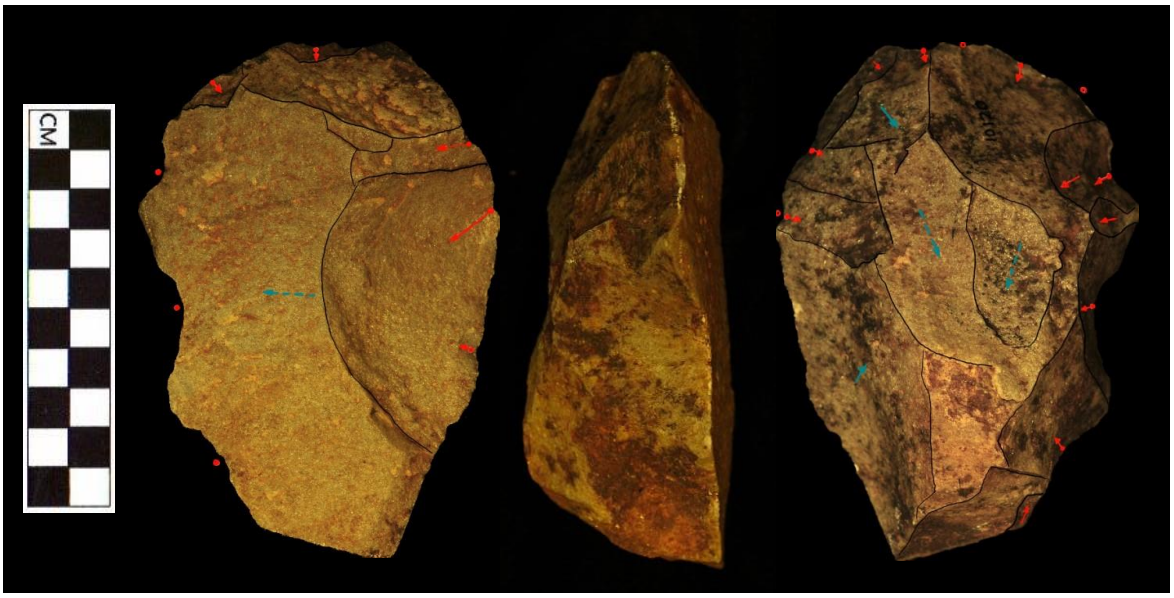


Figure 4.40: Artefact 10120

Figure 4.40 is an LCT which is made on a large quartzite flake blank and is very fresh. It is wider towards the distal end of the piece and is heavily shaped around this tip. Technologically, it falls within the handaxe family and could be classified as a knife despite the distal end shaping. This is because there are two large, notched shaping removals on the right side of the dorsal surface, with fewer shaping removals on the opposite edge. Following the cleaver classifications laid out in the methods chapter, despite the wider business end of the piece, it does not fit into a cleaver definition because that end is shaped. Due to uniqueness of this LCT in the Sterkfontein assemblage, I suggest calling this a bifacial LCT, with a knife working edge.



Figure 4.41: Artefact 10363

Figure 4.41 is a handaxe with a transversal edge made on a very fine-grained quartzite cobble. There are multiple débitage scars on the dorsal surface, with two large shaping scars on the ventral surface. There are only two other distinct shaping scars with impact points, both found on the right side of the dorsal surface. The organisation of the scars results in a bulky and somewhat asymmetrical final product. Morphologically, it could be argued to be a cleaver (Kuman and Gibbon 2018), but following Tixier (1956), the shaping on the transversal edge means it falls in the handaxe category. Definitions of cleavers and handaxes have not been strictly uniform in the literature so this classification follows the standard used in this thesis.

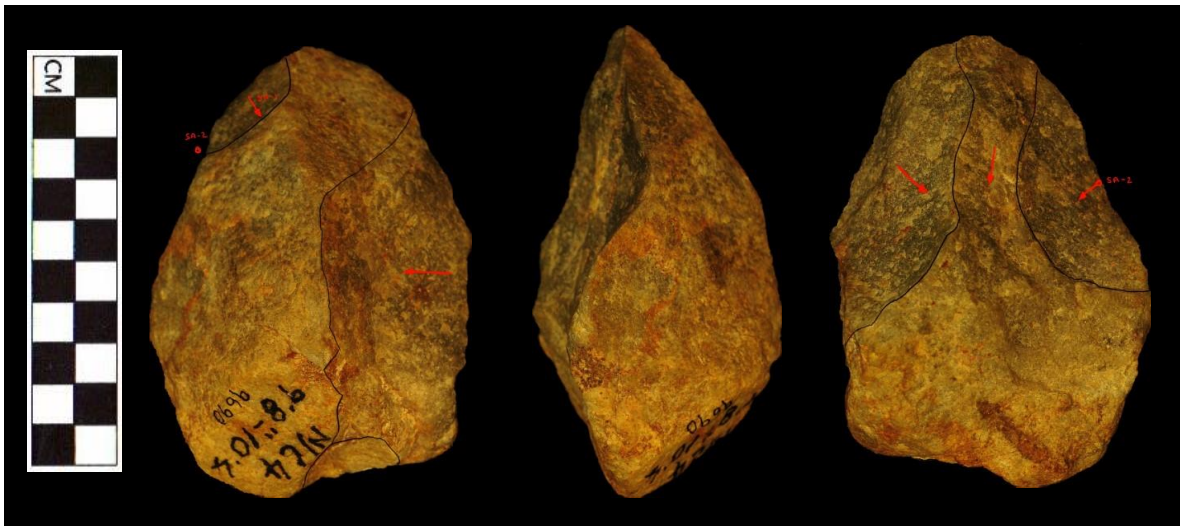


Figure 4.42: Artefact 9690

Figure 4.42 is an LCT made on a quartzite cobble blank and has remnants of cortex on both sides of the distal end. There are five shaping scars on both sides of the piece, with cortex remaining present on mainly the distal end. There is damage along the edge running from the medial to distal sections, as seen on the right side of the third image in Figure 4.45. This damage obscures the impact points of some scars, but their directionality and location suggest a bifacial edge management. Two scars opposite the damaged edge show an alternating bifacial shaping pattern towards the tip (SA-1 and SA-2), and in combination with other scar patterns, I put this piece in the handaxe technological category.



Figure 4.43: Artefact 6612

Figure 4.43 is a LCT which is made on a large side struck flake. The core was likely heavily exploited as there is no cortical surface, along with multiple debitage flake scars. The two largest shaping scars removed the butt and platform of the flake blank, as well as thinned the ventral surface, which in turn created a platform for retouch. The retouch is found in various positions of the edge between the ventral and dorsal surfaces, including the left dorsal side between the proximal and medial portions, as well as the distal edge on the opposite side.

The platform edge of the piece was shaped bifacially, though not in a single continuous sequence. The largest shaping scar stands alone and removed the bulb and platform of the flake blank, which was likely quite bulky, which could have been done to handle the tool more easily.

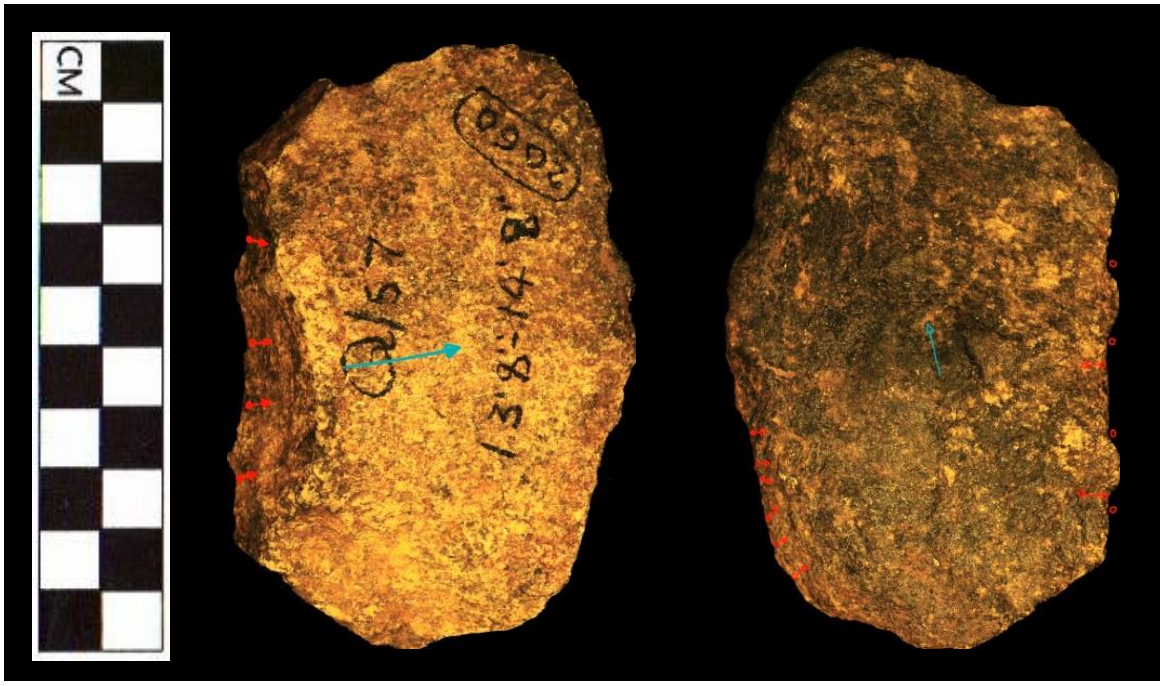


Figure 4.44: Artefact 2060

Figure 4.44 is a cleaver which is made on a large side struck quartzite flake, with 'rhomboid' retouch. The platform on the medial ventral side was removed with a series of unidirectional and unifacial flake scars, with a unidirectional series of scars along the distal dorsal side, as seen on the right image in Figure 4.47.

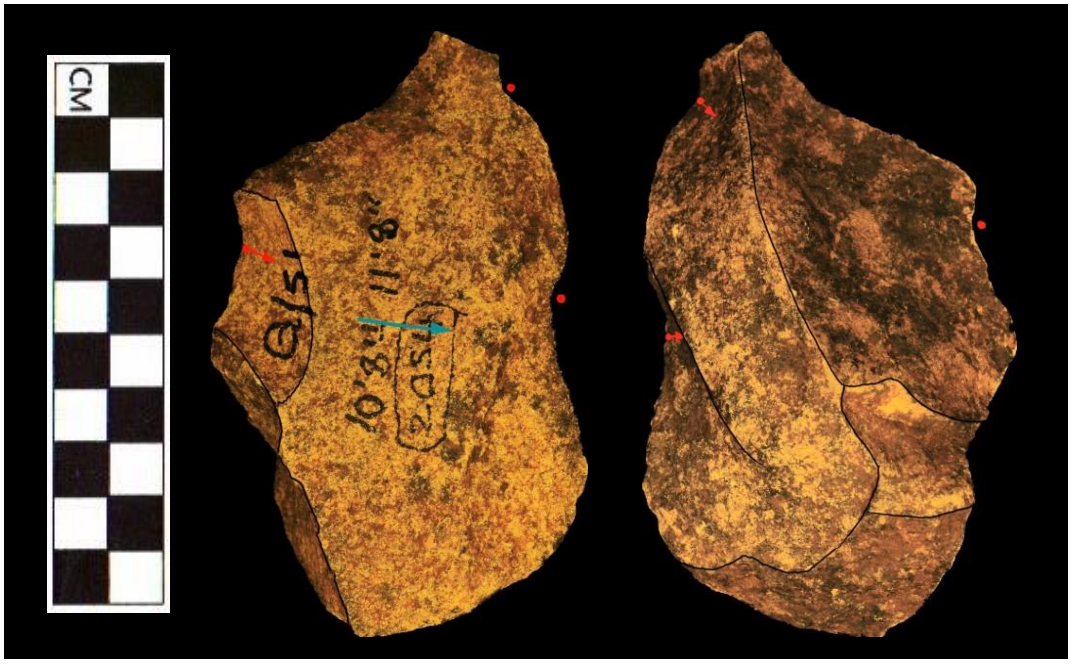


Figure 4.45: Artefact 2054

Figure 4.45 is another cleaver made on a side struck quartzite flake and shaped in the ‘rhomboid’ manner, but only with three scars. The flake blank was relatively thin, and about half of the dorsal surface is still covered in cortex.

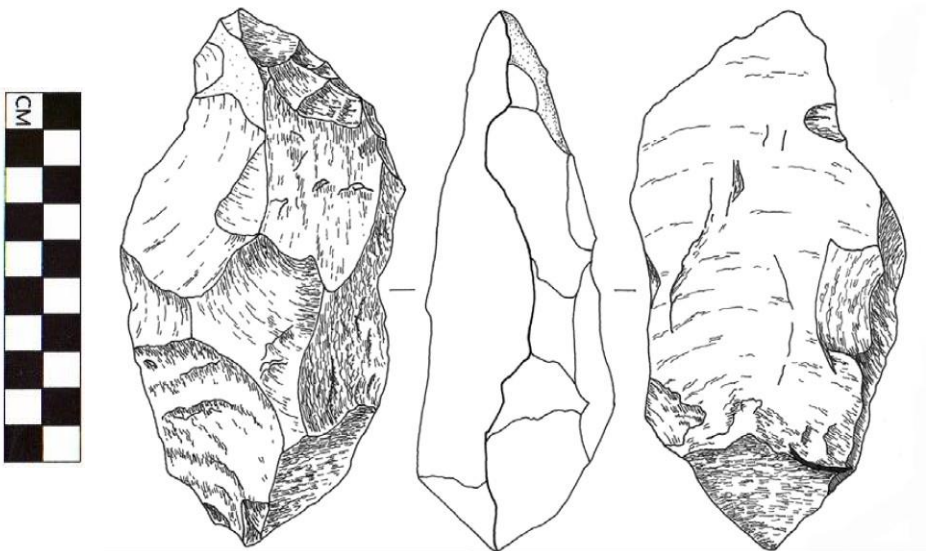


Figure 4.46: Artefact 2066 (Image from Kuman and Gibbon 2018)

Figure 4.46 is a handaxe which is made on a large quartzite end struck flake with multiple debitage scars on the dorsal face. There is also no cortex remaining on this surface. Retouch is focused along the right proximal side of the dorsal surface, and a larger shaping scar spans the proximal and medial portion on the left-hand side of the dorsal side.

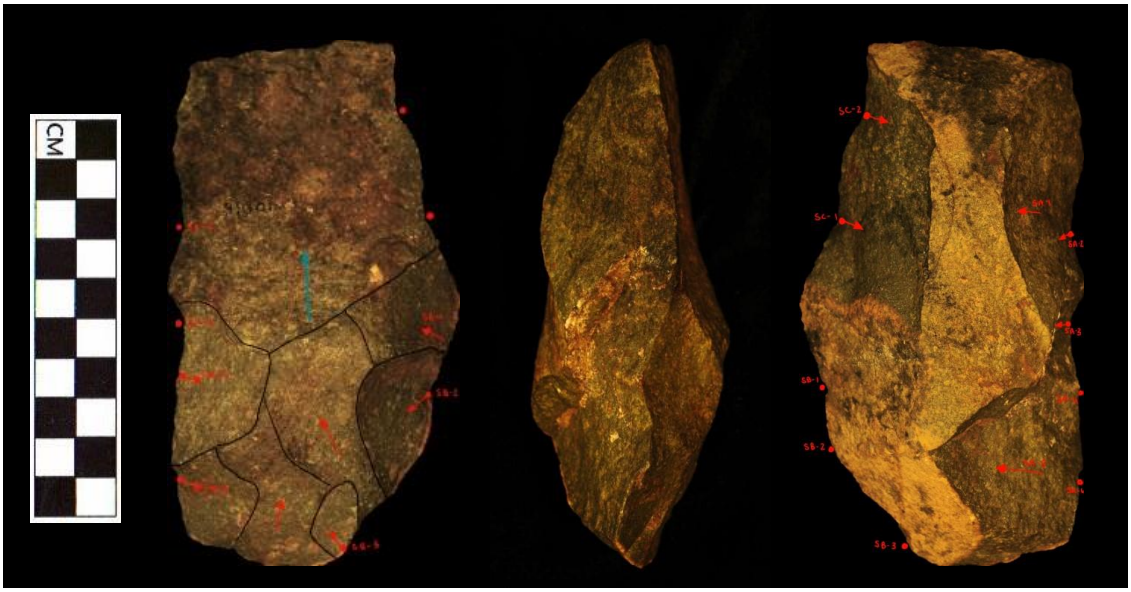


Figure 4.47: Artefact 10016

Figure 4.47 is a quartzite cleaver made on a large end struck quartzite flake. The butt of the piece is heavily shaped bifacially, while the sides are shaped on the dorsal surface only. There is damage along the tip and proximal edges which could be use wear.



Figure 4.48: Artefact 9481

As mentioned previously in the chapter, there are some pieces previously classified as cores that have been reclassified within the LCT C*haîne Opératoire.* Figure 4.48 is an example of one of those pieces, which I have classified as a broken quartzite LCT. It was previously labelled as a sub-radial core with a broken edge by Field (1999) because of the bifacial shaping around the one edge. In consultation with Prof de la Torre, the blank was identified as a large flake. The green arrow on the left view indicates a ventral surface, and although damage has obscured and removed the flake platform and point of impact, the bulb of percussion is still visible. As per the classification system described in chapter 3, the manufacture and shaping of large flake blanks is connected to the production of LCTs, which dominates in the Sterkfontein assemblage. The shaping around the edge of the piece is similar to the other LCTs, as the scars are small and continuous around the unbroken edge. As shown, the flake scars on cores tend to intrude more into the central volume, while the scars on artefact 9481 correspond closely to retouch scars. A trait that differs from the other LCTs is that this piece is heavily weathered, which may be related to the piece breaking. However, there is enough evidence to identify the blank and retouch scars. It is because of these traits that it has been reclassified as a broken LCT.

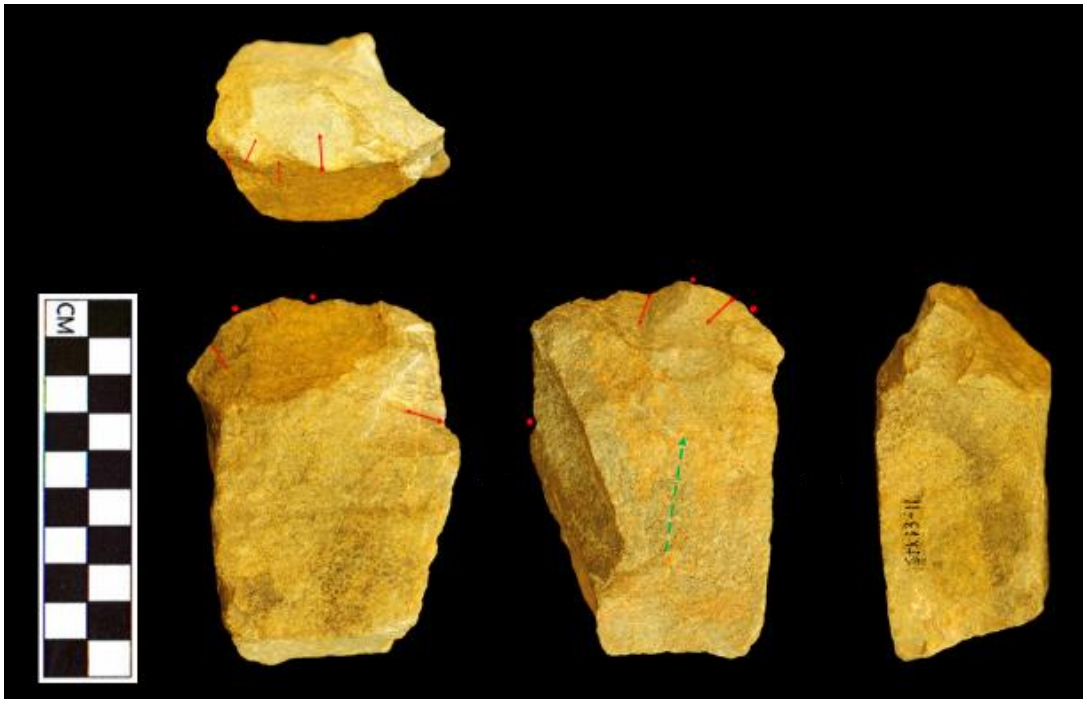


Figure 4.49: Artefact Stk13-11

Figure 4.49 is a unique piece in the assemblage as it is a chopper tool made on a split piece from a large quartzite block. It may have been a flake blank, as there is a bulge towards the distal end which could be the remnants of a bulb of percussion. There are five small retouch scars, concentrated along the proximal end, with an extra shaping scar on the side. These scars do not reduce the central volume of the blank and are small in relation to the overall size. The working edge has some damage, indicating possible use wear, but due to the post-depositional processes affecting the assemblage, this cannot be confirmed. Due to all these reasons, it is being included in the LCT category as it is a tool.

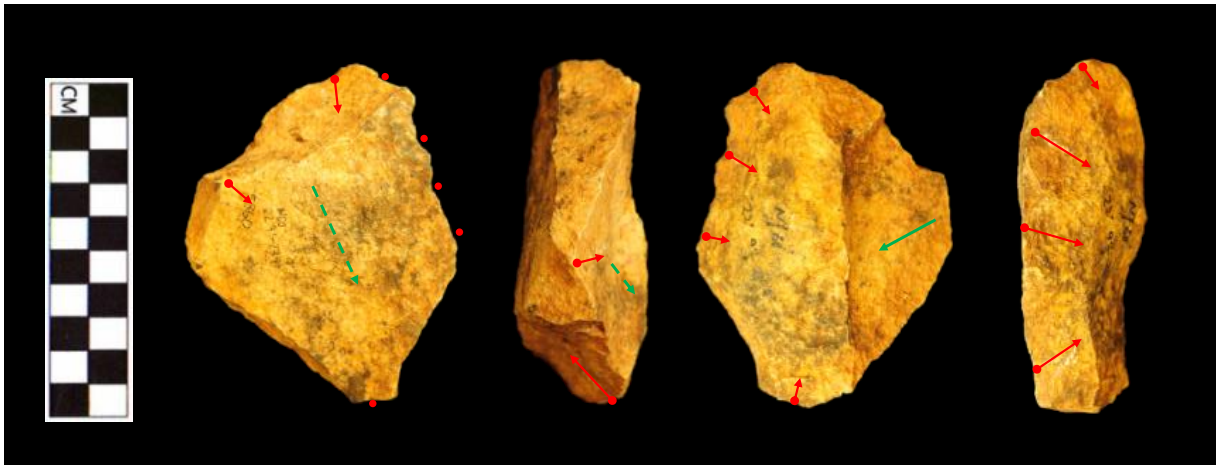


Figure 4.50: Artefact 5860

Figure 4.50 is the fourth piece reclassified as a broken LCT in this study. It was originally labelled as a sub-radial core on flake. However, the fact that it is made on a large flake blank and has adjacent flake scars on one side that do not reduce the central volume but rather shape the edge, suggests to me that it is part of the LCT category. It appears to have been broken, but it is unclear whether this was natural or from the knappers' actions. There is a bulb of percussion, and what appears to be an impact point obscured by slight edge damage. It has been marked with an arrow to both show the location and because it could be a flake scar.

4.5 Technological trends at Sterkfontein

The assemblage demonstrates an adaptability in edge management and understanding of raw material properties for both core reduction and LCT production. The differences between the core and LCT assemblages are the trends around artefact size, the strategies of edge management, blank types, and the number of flake scars.

In the core assemblage, multifacial reduction was most common, but the knappers could produce structured and continuous sequences in some cases, and there was a large proportion of other strategies encompassing both unifacial and bifacial knapping but little alternating strategies. However, most cores were only partially exploited before being abandoned due to the abrupt nature of many angles on core blanks. Overall, the knappers at the site were adaptable and displayed a range of technological behaviours. There are multiple examples of cores with combined reduction strategies, such as multifacial cores which demonstrate variable edge management on different surfaces. This suggests an adaptability to the specific landscape on the part of the knappers. It was noted by Prof de la Torre that this is a reduction strategy he has seen at other sites in Eastern Africa (*pers. comm.*).

The LCTs were predominantly shaped using bifacial alternating sequences, which differs to the general edge management seen in core reduction. The LCTs were generally consistent in size and largely made on flake blanks, while the cores had a more varied range in size and blank types. Flake blank production on fine-grained quartzite was successfully used for LCTs as some pieces are quite large, while core reduction was often restricted by the shape and size of natural clasts.

A demonstrable difference between the assemblages exists in the number of flake scars, with LCTs having a higher average than cores. However, the LCT flake scars were used to shape the tool, while cores were knapped for sharp flakes. Despite the different purposes of flake scars, LCT shaping indicates that knappers were skilled in maintaining long shaping sequences on almost all the pieces, while core reduction was more varied, and reduction was commonly focused on single edges and faces of pieces.

There is a consistency in the technological patterns within the assemblage. The quartzite is of a high quality and is fine grained and almost all the LCTs and pieces related to LCT production are made on quartzite. It suggests a specific selection pattern for the purpose. The quartz in the assemblage can be of good quality despite a general poor consistency found in the assemblages from various sites in the Cradle of Humankind, such as Swartkrans (Sherwood 2021).

A common trait of Acheulean assemblages is the presence of two manufacture processes, one to produce LCTs, and one for core and flake strategies (de la Torre and Mora 2018b). Sometimes this distinction is not very clear but at Sterkfontein there is a clear separation of the size profiles of LCT flake blank production and the larger sample of cores and flakes. Overall, these components make up a single, homogenous assemblage, but with two different processes for core reduction and LCT shaping.

Chapter 5: Results: Rietputs 15

5.1 General observations

The site of Rietputs 15 was discovered when archaeologists inspected a series of deep diamond mining pits near the town of Windsorton in the Northern Cape Province, South Africa (Gibbon *et al*. 2009; Figures 3.7, 3.8, and 3.9). Artefacts from two of the dated mining pits were collected by R.J. Gibbon and G.M. Leader from conveyor belts used for the sorting of mining material, and while they lack exact provenances, dates on these gravels range from ca 1.3 to 1.7 Ma (see section in chapter 3 for details). Material from two pits at the site is analysed as two separate assemblages.

The two deposits are part of the same site complex but lie roughly 2km apart from each other. The material from the Artefact Collection Pit (ACP) has not been directly dated and contained no organised core technology, as defined by Leader (2009 and 2014), but it has been compared to the Sterkfontein early Acheulean in M5W by Kuman and Gibbon (2018) and argued to be older than 1.3 Ma. The Pit 5 deposit has been dated directly to ~1.3 Ma and does contain examples of organised core technology.

The data presented in this chapter aims to understand the specific core reduction strategies applied to these assemblages from one site, and the connection between core management and LCT production. Material from both pits is presented here, but as was discussed in chapter 3, the location of the core assemblage from Pit 5 at the McGregor Museum is currently unknown. Therefore, only the core material from the ACP will be analysed, along with the LCTs from both pits.

5.2 Cores

The material presented under the core section is that of the ACP only.

5.2.1 Raw material

The site is located close to the Vaal River and so there were many river clasts available to the knappers, many of which are of a fine-grained quality. Of the 88 cores analysed, quartzite, which is generally fine-grained, is the most common raw material used for cores in the ACP (34% of assemblage), followed closely by CCS (including chalcedony and chert) (27%). Quartz is the least common (5%) raw material, and Ventersdorp lava and hornfels make up 10% and 17% of the assemblage, respectively. There is thus a dominance of fine-grained quality rock types for use (Figure 5.1). This core assemblage probably approximates the original raw material proportions that would have been present in an unselected assemblage,

because the material was collected from a conveyor belt during mining operations and so the smaller pieces were more likely to be missed.

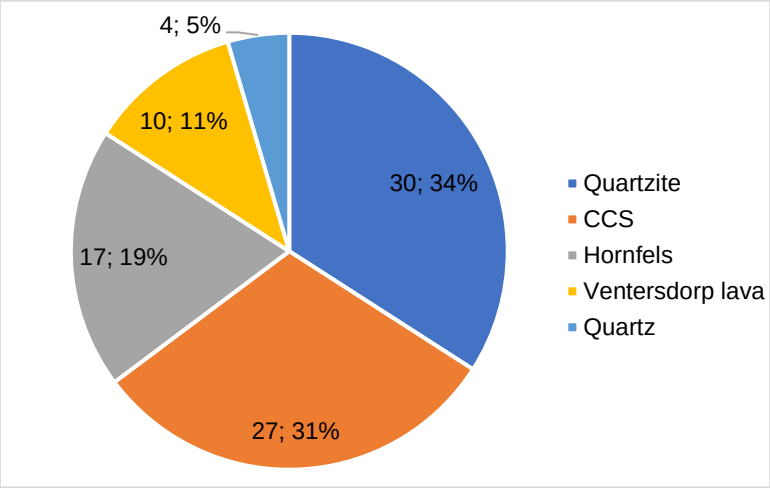


Figure 5.1: Raw material in the ACP core assemblage, by both number and percentage.

In total, the assemblage weighs 15893.2 g (<160kg). Quartzite accounts for the greatest weight (6131.8g), while CCS only makes up 2855.6g. Hornfels also outweighs CCS at 3714.8g, and Ventersdorp lava weighs slightly less than CCS at 2645.8g. Quartz represents the fewest artefacts and weighs the least at 545.2g.

5.2.2 Idealised core reduction schemes

Figure 5.2 presents the number of cores per idealised scheme of core reduction. Bipolar cores are most prominent in the core assemblage (23.9%). The bipolar category is not included in the schemes defined by de la Torre and Mora (2018b), because they are based on freehand percussion techniques. Two of the bipolar cores were made on rounded clasts and also have evidence of also being hammerstones. For the freehand percussion categories, BALP, BAP, and BSP cores are the most common groups with 12 examples each (13.6% each). There are eight TC (9.1%) examples, seven multifacial (8%), and five UAU2 (5.7%), with other categories only containing 2 (2.3%) or 3 (3.4%) pieces, and BP has 1 (1.1%).

Bifacial cores outnumber unifacial and multifacial cores with a total of 40 (45.5% of assemblage) in five categories (BALP, BALT, BAP, BP, and BSP). There is an average of eight cores per category. There are 12 unifacial cores (13.6%) over four categories, and an average of three cores each. Multifacial, TC and bipolar cores combined make up 40.9% of the assemblage. Hence the bifacial core group is the most numerous.

Within the bifacial categories, BALT and BP cores are the smallest groups (n=3 and 1, respectively), which are core reduction sequences that indicate long and continuous edge

management of the surface between the two main sides of a core. UAU2 cores also indicate there is exploitation of at least two surfaces in a unifacial sequence, but the overall surface and central volume of the core is not intensely reduced. The multifacial category includes cores with multiple surfaces exploited, but not a full reduction of the central volume. All these categories combined (BALT, BP, UAU2, and multifacial) make up 18.2% (n=16) of the assemblage, while the schemes that focus on partial reduction (BALP, BAP, BP, UAU1, UP, and USP) make up 48.9% (n=43) of the total assemblage. TC and bipolar cores are not included in these categories, and they make up 33% of the total assemblage.

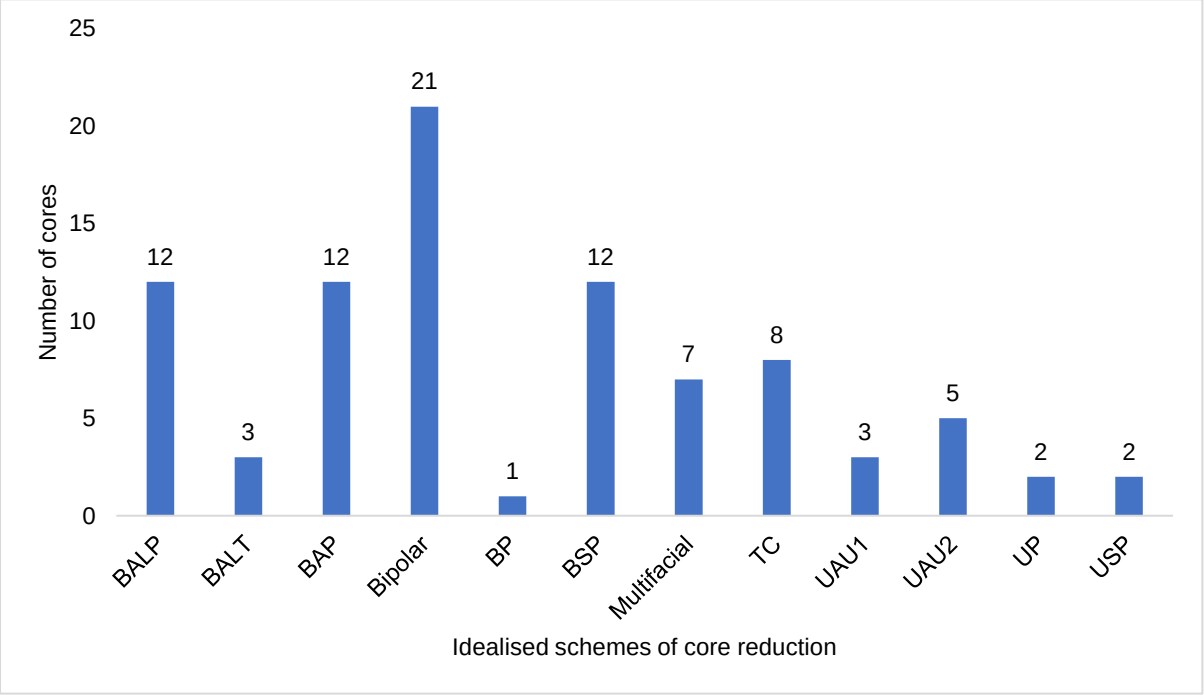


Figure 5.2: Idealised core reduction schemes

In general, cores were not heavily reduced, and edge management and flaking sequences were most applied to partial sections of a core. Bipolar cores dominate when you consider the individual idealised core schemes, but bifacial reduction, including all bifacial cores, makes up almost half the assemblage. Leader (2009) and Kuman and Gibbon (2018) argue that the ACP collection has no clear pattern of organised core reduction. Leader *et al.* (2018) argue that bifacial exploitation is the generalised core edge management seen in the organised cores from Pit 5.

The bipolar category has examples of four of the raw material types, excluding Ventersdorp lava. Nine examples are made of CCS (42.9% of bipolar cores). Ventersdorp lava and CCS were used for freehand reduction of mainly bifacial cores. Quartzite is represented in all categories with the highest proportions in the BAP and bipolar cores (38.2% of all quartzite

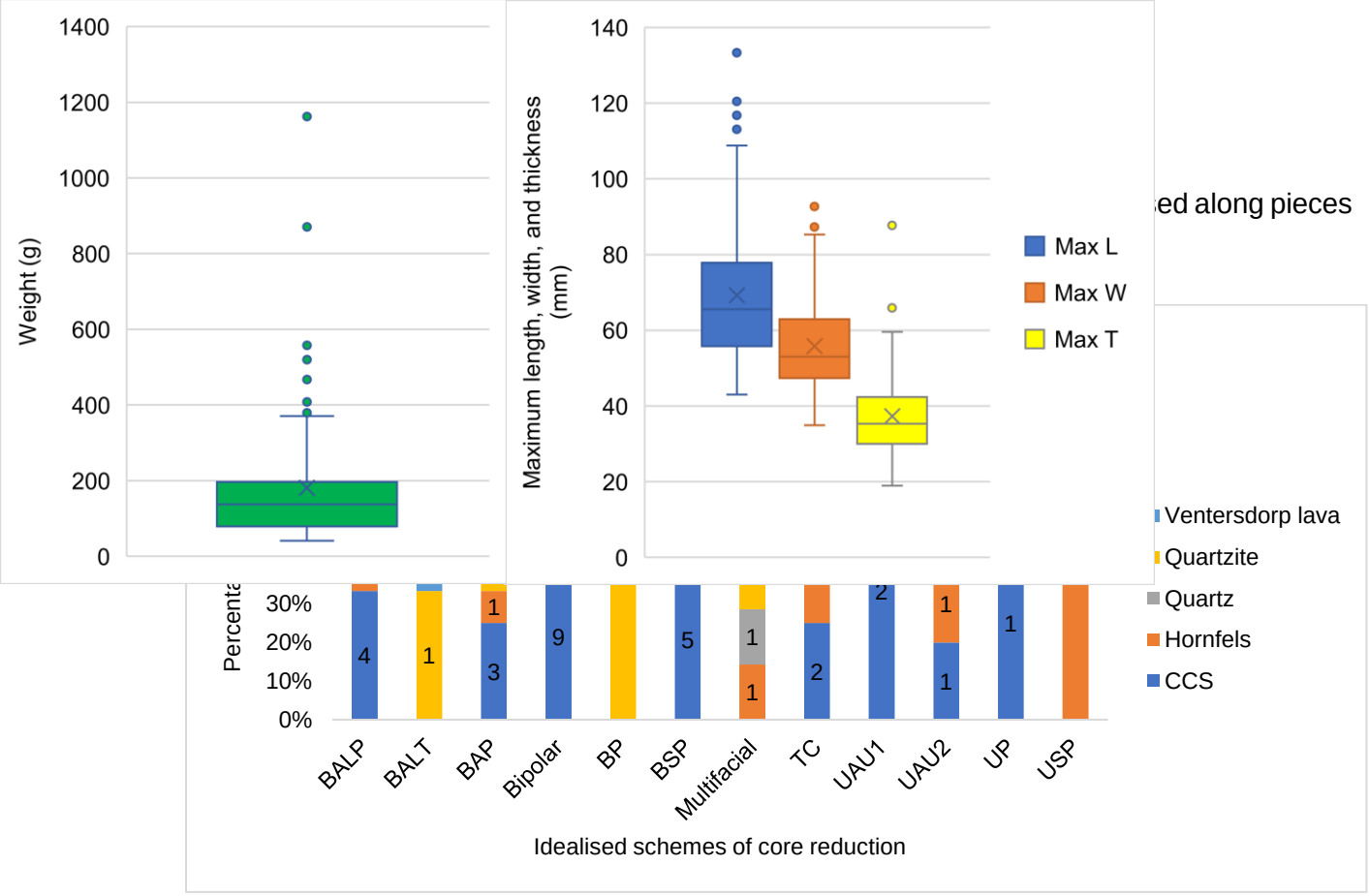


Figure 5.3: Percentages of raw material by idealised core scheme

5.2.3 Weight and dimensions of cores

A B

Figure 5.4: A: Weight (g) and B: maximum length, width, and thickness (mm) of cores

Only 20 cores weigh >200g (22.7%), with the heaviest piece weighing 1162.3g and the lightest weighing 41.2g (Figure 5.4 A), and the mean and median weights are 180.6g and 137.2g,

respectively. The maximum length of cores ranges between 43mm and 133.3mm, and the mean is 69.2mm. The maximum width ranges between 92.7mm and 34.9mm with a mean of 55.8mm, and the maximum thickness ranges between 87.7mm and 18.9mm with a mean of 37.3mm (Figure 5.4 B). Overall, the assemblage is smaller in size. Sixty-eight cores weigh <200g, and nine weigh between 201-300g (Figure 5.5). There is a clear pattern of small cores in the assemblage, which could be due to the raw material availability, but the selective choice of the hominids cannot be excluded.

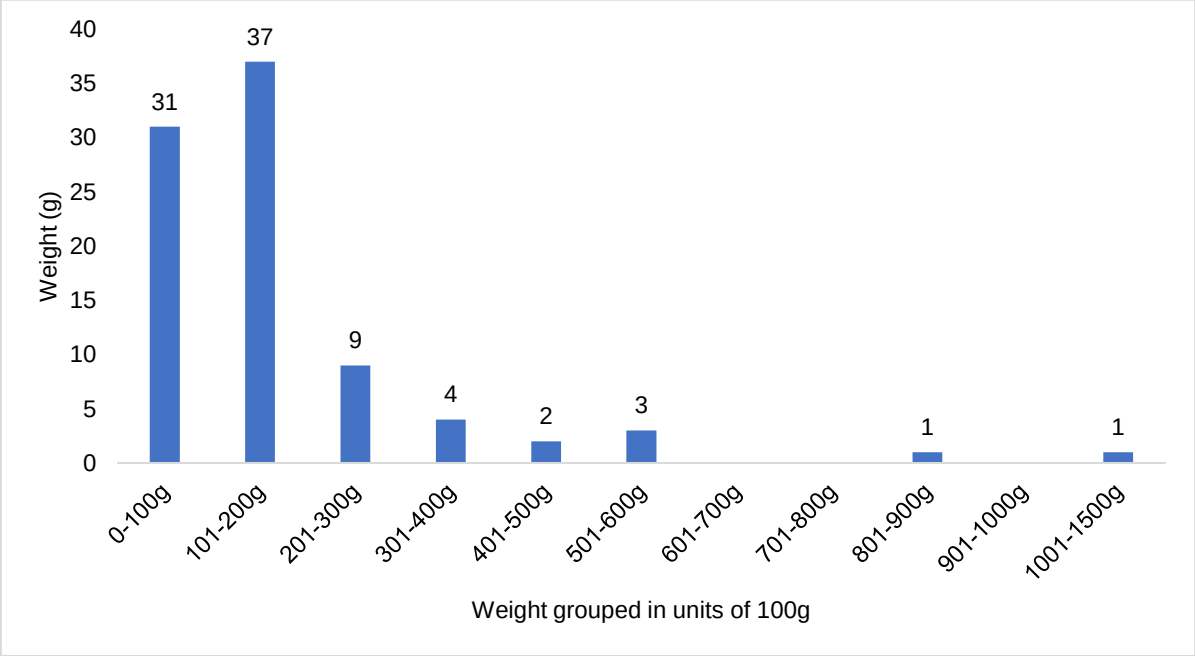


Figure 5.5: Weight (g) ranges of cores

5.2.4 Flake scars

The flake scars range between 1-15, with an average of 5.2 scars for all cores. Within the bifacial cores, there is an average of 5.9 scars per core, compared to the 3.3 scars per unifacial category, which is almost double the number of scars, while multifacial cores which have the highest average of 9.7 scars per core. As more surfaces are exploited on a core, the more scars it has on average. A chi-squared test of independence gave a result of p=0.05, neither accepting nor rejecting the null hypothesis that there is an association between the reduction strategies and scar counts on cores. Even though average scar counts ascend from unifacial to bifacial to multifacial, there is evidence of only marginal significance between the categories.

The flake scars on bipolar cores are hard to ascertain as a single break can cause multiple surface fractures (Caruana 2017; Pargeter and Eren 2017). As stated in chapter 3, the bipolar

reduction in these sites needs to be assessed further experimentally with regards to how the various raw materials break and splinter.

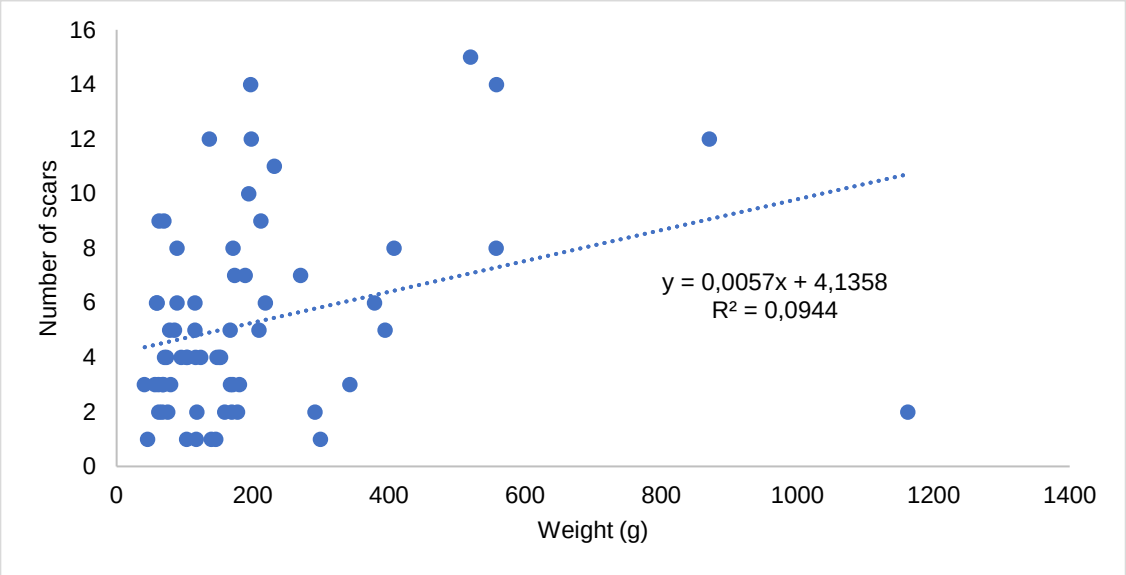


Figure 5.6: Correlation between the weight (g) and the number of scars on cores

Figure 5.6 is a scatterplot of the core weights and their corresponding number of flake scars. The resulting R^2=0.0944 indicates little significance between the two factors, meaning that core size does not infer reduction intensity. When considered with the data presented in the figure, the core reduction strategies and edge management also do not correlate with certain weight classes.

5.2.5 Core reduction schemes and weight

The weight ranges of cores have been broken down in generalised groups of idealised core reduction schemes, namely bifacial, unifacial, multifacial, bipolar, and test cores (Figure 5.7). The heaviest single core is unifacial but the mean and median of the category is 193.6g and 102g, respectively. These are both below the same calculations for the larger bifacial group with a mean and median weight of 198.9g and 159.1g, respectively, indicating bifacial cores were overall bigger. The highest mean weight is for multifacial cores at 211.3g, and the lowest is for test cores at 120g. Bipolar cores average weight is 151.2g.

When the weight ranges are broken down by category, the BALT category has the highest average weight of 380.4g, while UP cores have an average weight of 58.4g, the lowest of all. Despite the wide variation between the specific idealised core reduction schemes, there is no serious difference between the group means and medians, and various core reduction strategies are applied to all core sizes. A Kruskal-Wallis test for equal medians gives a result of p[same]=0.2228, which confirms the mean similarities between the groups, and that there is no substantive difference between core sizes based on reduction strategy.

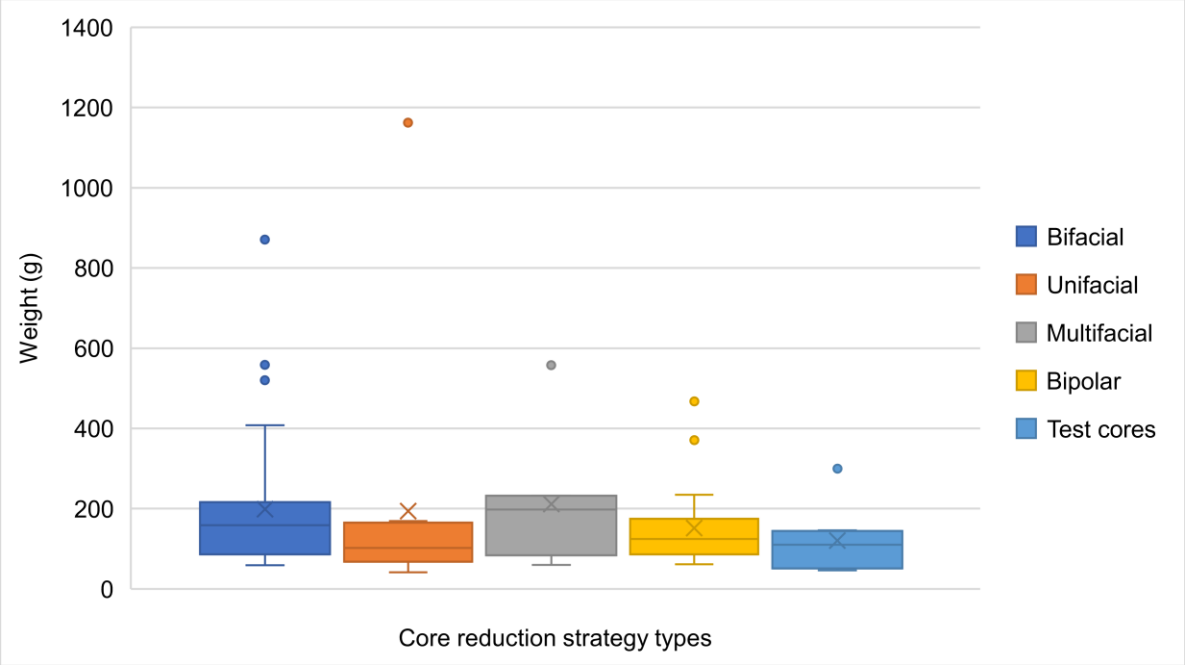


Figure 5.7: Weight ranges of core reduction strategy groups

The blocky and angular blanks are the heaviest types on average (mean = 347.6g), but this is skewed because of the heaviest core weighing 1162.3g, while the other examples are <200g. Split blocky and rounded have the next highest mean weight of 199.9g, indeterminate blanks at 141g, and flake blanks with the smallest average weight of 74g. All the heaviest blanks were clasts with rounded edges, while the flake blanks for core reduction were generally quite light in weight.

5.2.6 Remaining cortex

Figure 5.8 presents the data of cortical surfaces on cores following the methodology from Braun *et al.* (2008). 32 cores (36.4% of assemblage) have between 51-75% remaining cortex, meaning that less than half the surface area was reduced. 20 cores (22.7%), the next highest category, were more heavily reduced and had 1-25% cortical surface remaining. Only two pieces had no cortex, indicating that the full exhaustion of a core was rare. In total, 48 cores (55.7% of the assemblage) had >50% cortex, and 39 cores (44.3%) had <50%. There is thus not a huge difference between cores with more or less than 50%, but in general, cores were not heavily reduced. A t-test comparing the data of the amount of remaining cortex, and the idealised core strategies gave a result of p=1.9737. This indicates a strong correlation between the categories, and the remaining cortex could be inferred by the edge management scheme on the core.

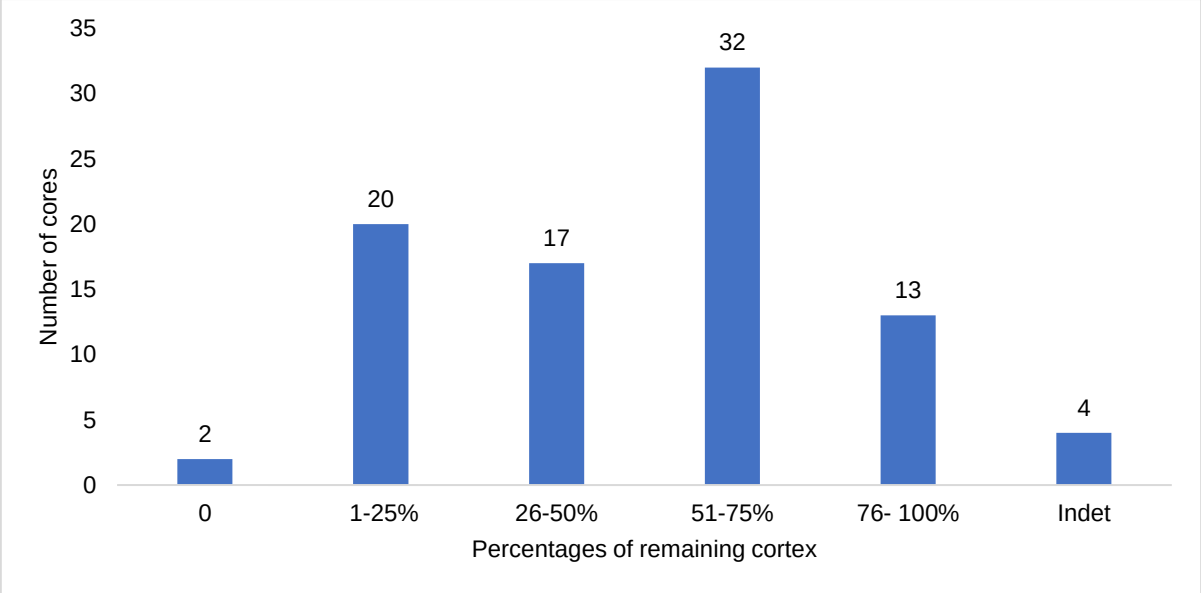


Figure 5.8: Number of cores with amount of remaining cortex (%)

5.2.7 Blanks

As the definition of cobble used in this thesis relates to clast size (see the Wentworth scale in Appendix 1), the blank types are classified according to their general shape (see chapter 3, section 3.2.2). All the identifiable blank types from ACP are either rounded, have rounded edges, or are small flake blanks. There are 55 blocky rounded blanks, making up 62.5% of the assemblage, followed by 14 split blocky rounded blanks (15.9%). Flake and blocky angular blanks each have five examples (5.7%), indicating a trend of more rounded blanks being used in reduction (Figure 5.9).

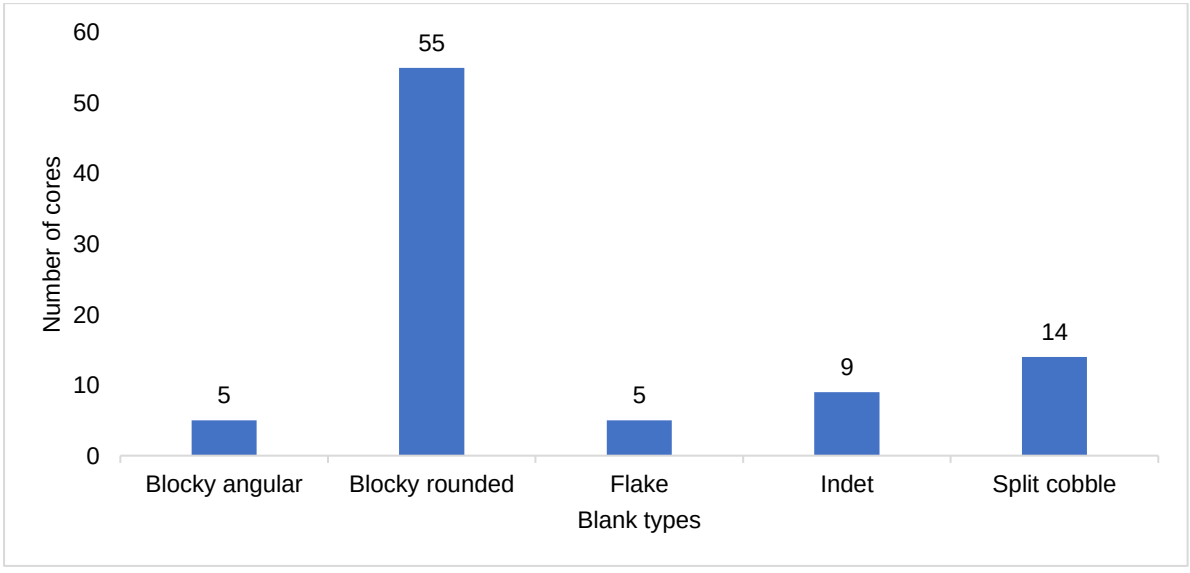


Figure 5.9: Blank types of cores

Figure 5.10 presents the contributions of blank types to the reduction strategies. Blocky rounded blanks are more prominent in the bifacial and bipolar categories, while unifacial cores tend to be made on split blocky and rounded clasts. The few flake blanks are also unifacially flaked, excluding two TC examples. Two multifacial cores are made on blocky angular pieces, and most indeterminate cores are bifacial. There appears to be a clear pattern of blocky rounded blank shape affecting reduction strategies.

Hornfels and quartz only appear in the blocky and rounded and split blocky and rounded clast blank types, except for one indeterminate hornfels blank. All four quartz blanks are blocky and rounded, and 11 hornfels pieces are split blocky rounded pieces. Ventersdorp lava is represented in all groups except split clasts, while CCS and quartzite are the only raw materials in every blank type. The majority of CCS pieces are blocky rounded blanks, followed by five split blocky blanks, and one to two examples in each other blank type. 56.7% of the quartzite clasts are blocky rounded blanks with between two to four examples of other quartzite blanks. The overall trend is to use more blocky rounded clasts in core reduction, which were sometimes split before use, which, as mentioned, could be because of the local gravels.

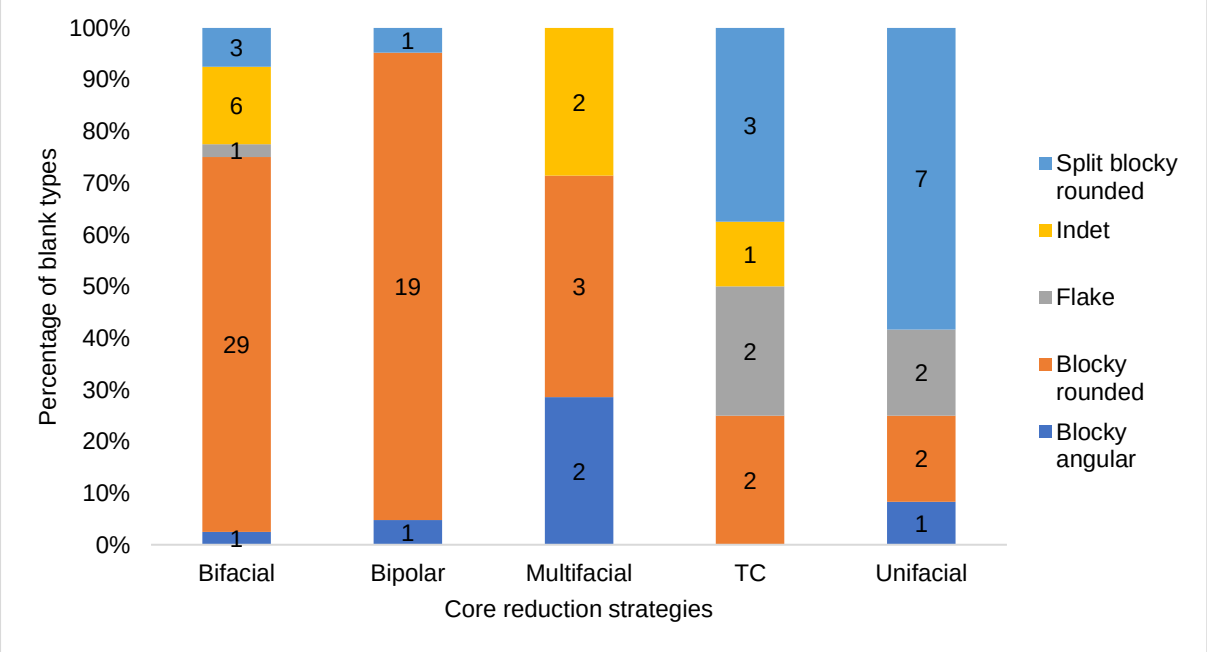


Figure 5.10: Percentage of core blank types in the core reduction strategies

5.2.8 Largest flake scars

Feather and indeterminate flake scars have a similar representation in the core assemblage, making up 31% and 30%, respectively. Many indeterminate scars in this assemblage occur

due to various reasons. Some pieces experienced modern damage during the mining activity or were obscured by other removals on the core. Core edge scars and step fractures also have the same number of examples, 14% of the assemblage each. Excluding the indeterminate LFS types, the knappers were achieving sharp edge flakes more regularly than step and hinge terminated flakes (Figure 5.11).

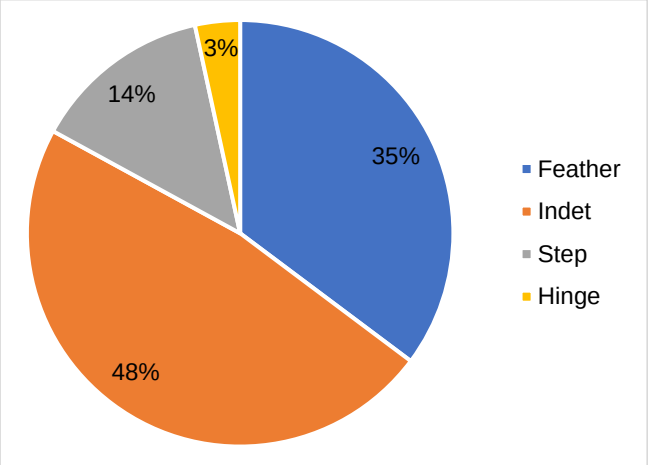


Figure 5.11: Largest flake scar types on cores

The bipolar cores, which are the most common type, all have indeterminate LFS types following the categories used in this thesis (see chapter 3). Feather terminations are represented in all freehand percussion idealised core reduction schemes, except for BALT and USP cores, with the most examples in BAP (n=7), BALP (n=6), and BSP (n=5) cores. They have between 1-4 examples in the other categories. Step fractures have between 1-3 examples in all groups except BALT, BP, UAU1, and UP, while core edge flakes have 1-3 examples in all except BP, UP, and USP. Only the BSP cores have examples of every LFS type. Overall, there was variable production of sharp flakes across all categories, with no clear idealised schemes having exclusively feather terminations (Figure 5.12).

Figure 5.13 presents the data of LFS types within each blank types. Eighteen feather termination examples, and 23 indeterminate examples are made on blocky rounded blanks, followed by 4 feather terminations on indeterminate blanks. All LFS types are found on blocky rounded and indeterminate blanks. Feather and step terminations have a split 7 to 6 examples on split blocky rounded blanks. Overall, the blocky rounded clasts have a range of LFS types but have good evidence for sharp edge feather terminated flakes.

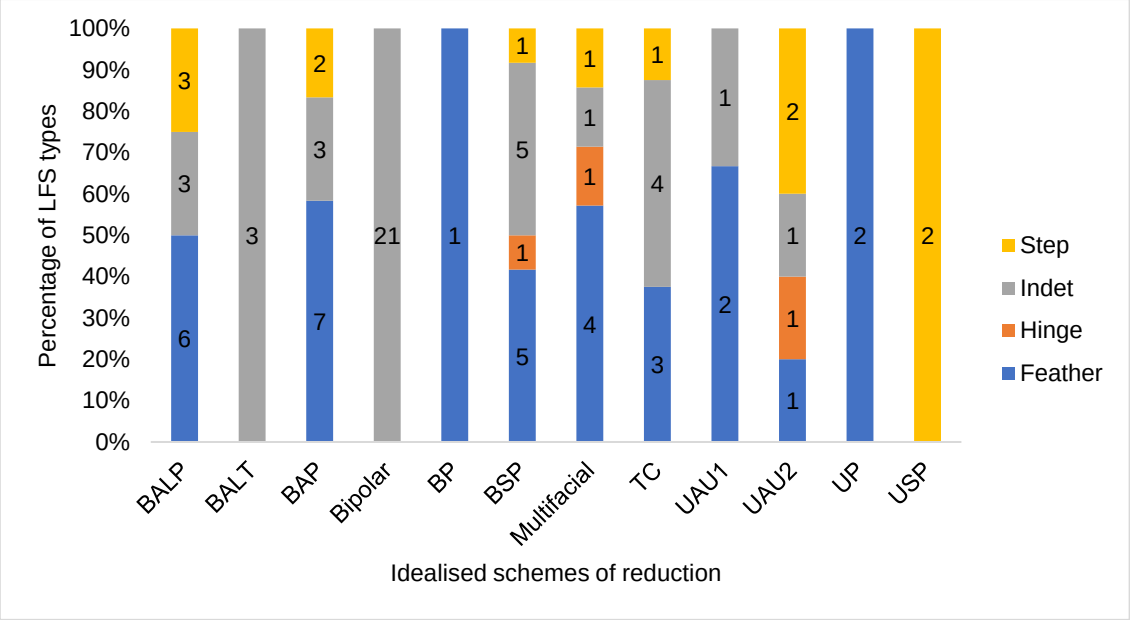


Figure 5.12: Percentages of largest flake scar types in idealised core reduction schemes

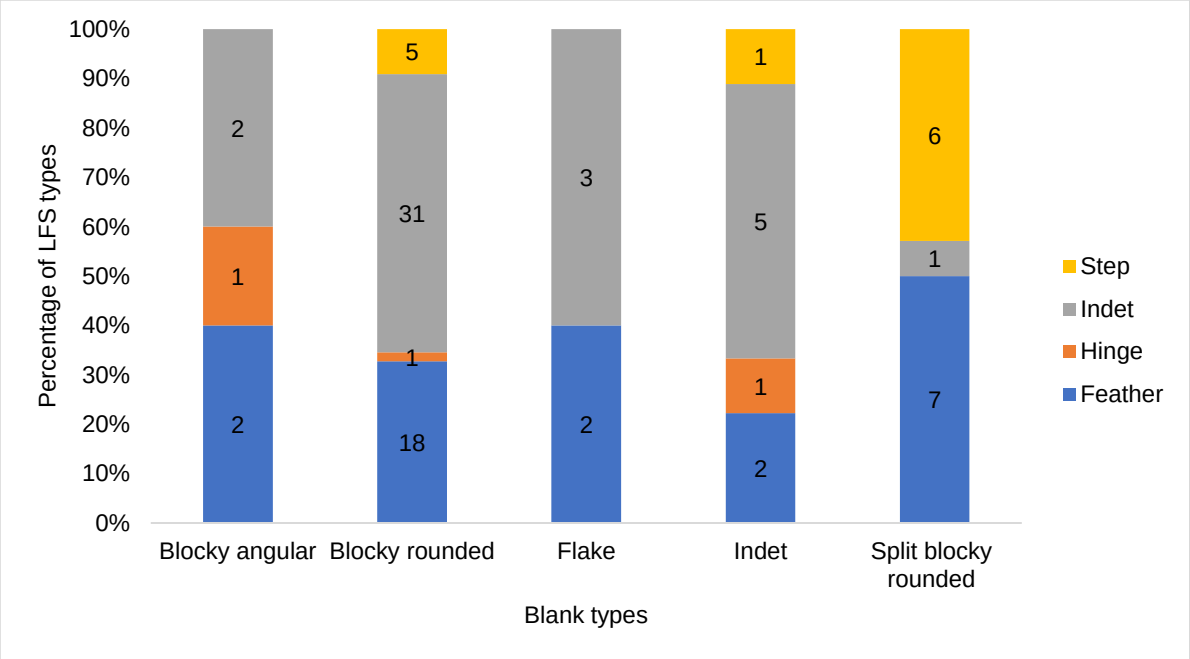


Figure 5.13: Percentage of LFS types in the blank types

The correlation between the maximum length and width of LFS types gives a R^2=0.5819 in the first scatterplot graph (Figure 5.14). This scatterplot presents evidence of some significance between the measurements, meaning that flakes get wider as they get longer, leading to a squarer shape in flakes. The second scatterplot graph (Figure 5.15) presents data showing that core size (as demonstrated by weight) and LFS size (as demonstrated by maximum

length) do not correlate, and thus a larger core will not necessarily have a large LFS. Cores of different weights can have different scar lengths in the core reduction strategies.

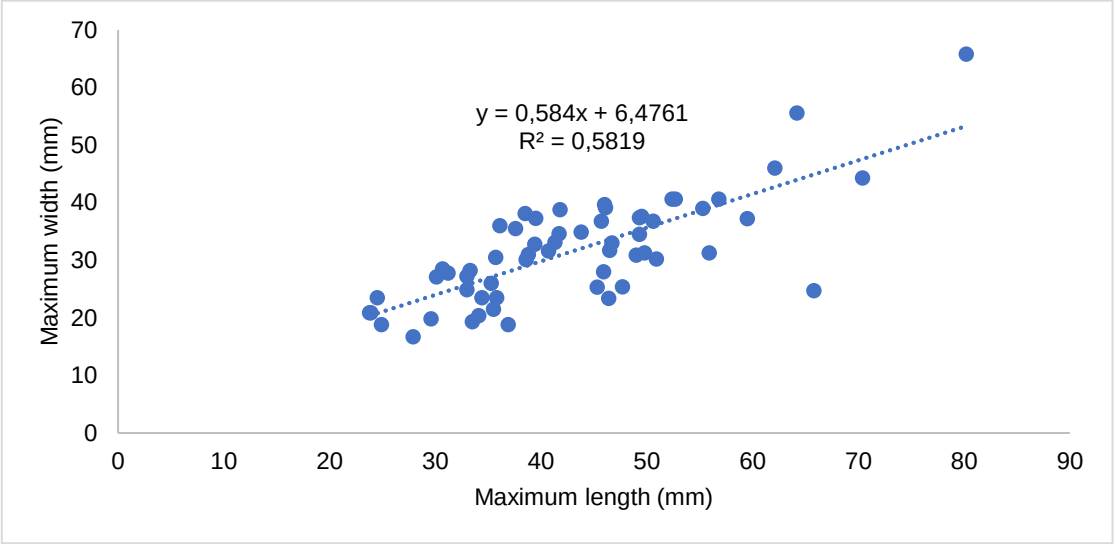


Figure 5.14: Correlation of maximum length and width (mm) of largest flake scars (LFS)

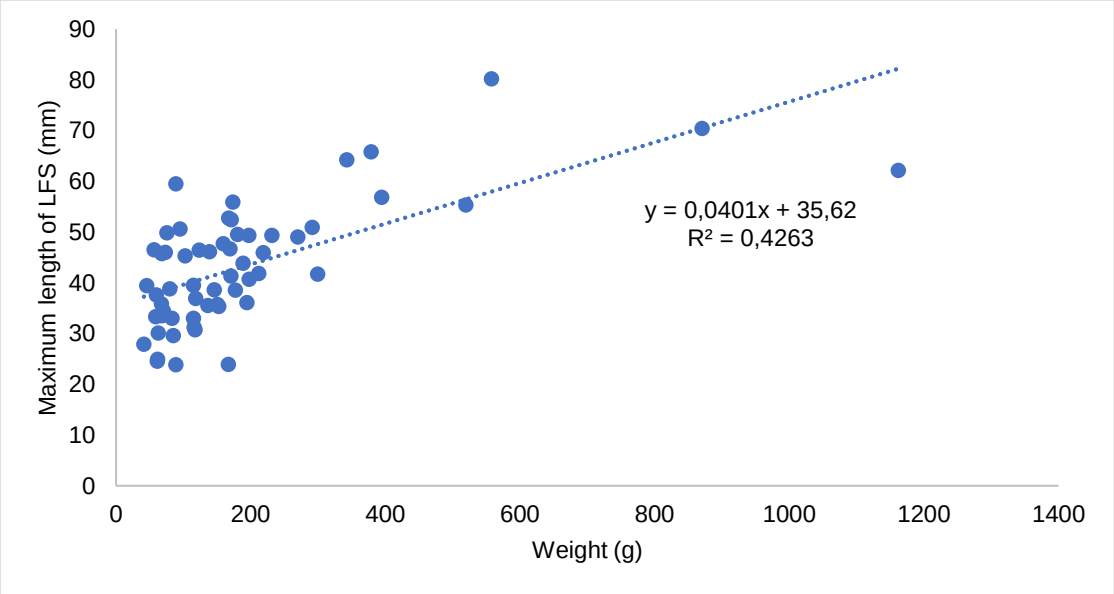


Figure 5.15: Correlation between the maximum length (mm) and weight (g) of LFS

5.2.9 Diacritical analyses of cores

The following diacritical descriptions are examples of individual cores from the assemblage. They represent a portion of the core reduction strategies described in the above data, as well as the variety of core shapes within each idealised scheme of core reduction. Not every

scheme is thus presented, as they are intended to give an overall idea of the ACP assemblage at Rietputs 15.

BALT cores

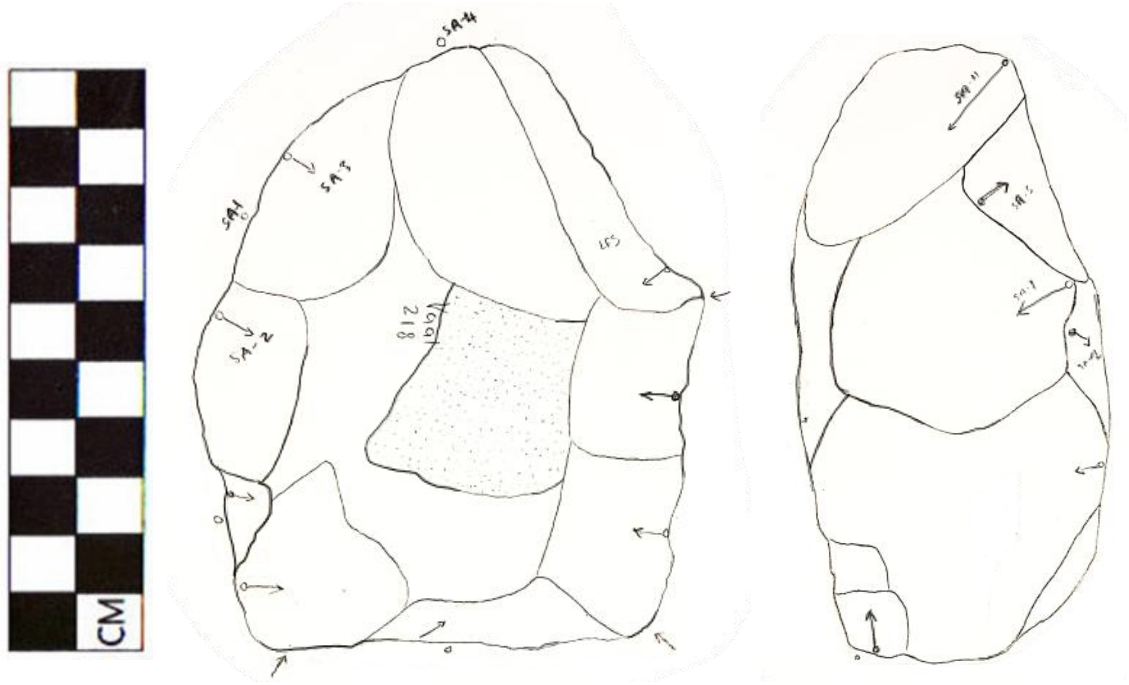


Figure 5.16: Artefact Vaal 218

Figure 5.16 is a BALT core made on a Ventersdorp lava blocky rounded clast and has <25% cortex remaining on one face. The BALT sequence demonstrates a continuous exploitation and rotation of the blank with multiple flips between flake scars. The order of four of the scars (SA 1-4) can be identified. If the core is orientated with the cortex surface facing forward and SA-4 and the top, the SA sequence travels up from the left lateral medial edge and creates a tapered and partly elongated core. The final product is asymmetrical, with larger removals, excluding the LFS, on the surface opposite the cortex.

BSP cores

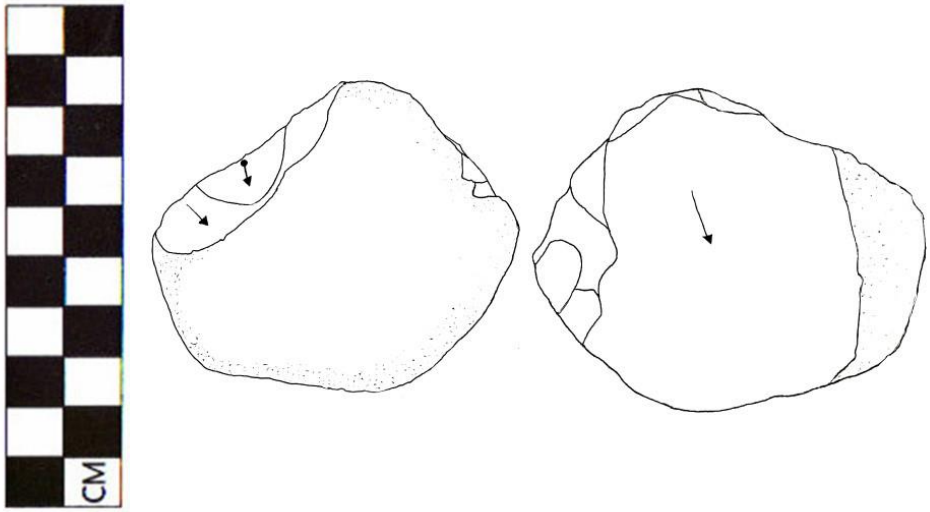


Figure 5.17: Artefact Vaal 285

Figure 5.17 is a quartzite core made on a rounded clast, probably a cobble with a BSP reduction on one side of the piece. There are three removals, with a possible fourth that may also be a break. A large flake removal created a platform for the removal of 2 unidirectional scars on the adjacent surface. The angle between the platform and surface is <90°, so it is classified as a simple bifacial exploitation of a partial section of the core.

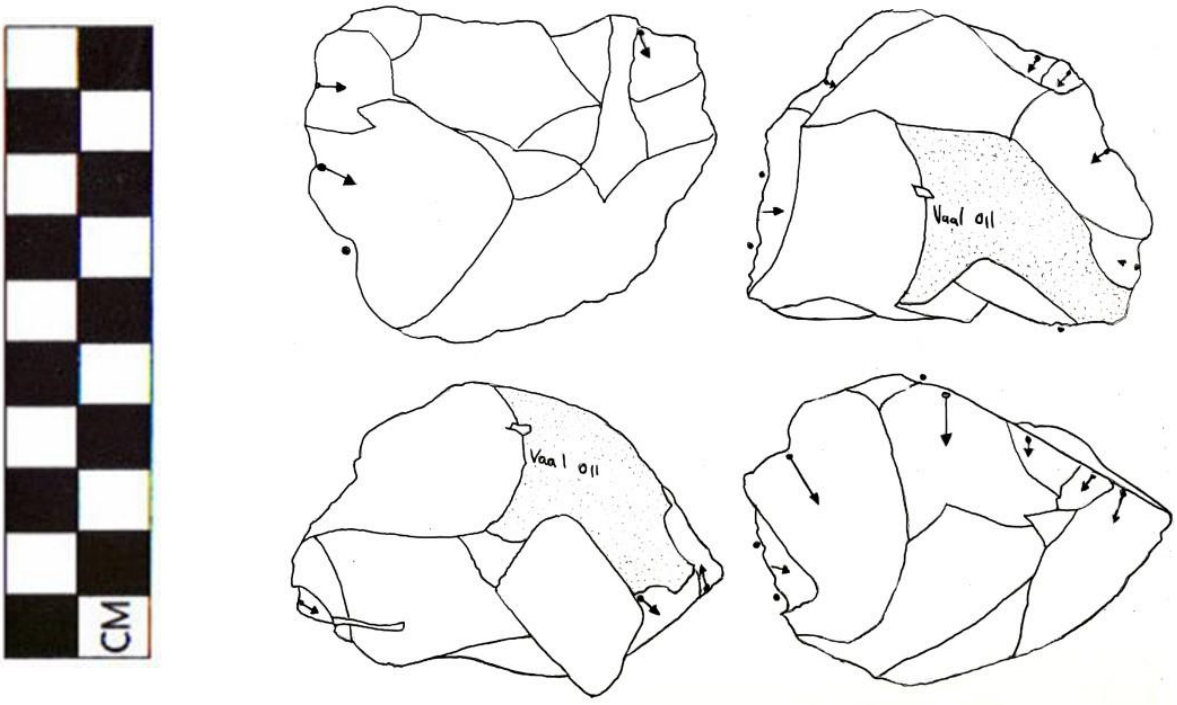


Figure 5.18: Artefact Vaal 011

Figure 5.18 is a core that was made on a CCS blank and is the one example of a core with two idealised reduction schemes, namely BSP and BALP. Remaining cortex is <25% of the surface, and the 10 flake scars are located around three quarters of the edge between the two surfaces, so it is unclear whether the blank was a whole or split rounded clast. The BALP sequence consists of four scars and is located on the bottom views seen in the image, and the BSP sequence at the top. The BSP sequence consists of five scars on a straight platform edge which was created by a broken facetted surface. The core was left with asymmetrical surfaces, and evidence of an almost full rotation around the edge between the surfaces.

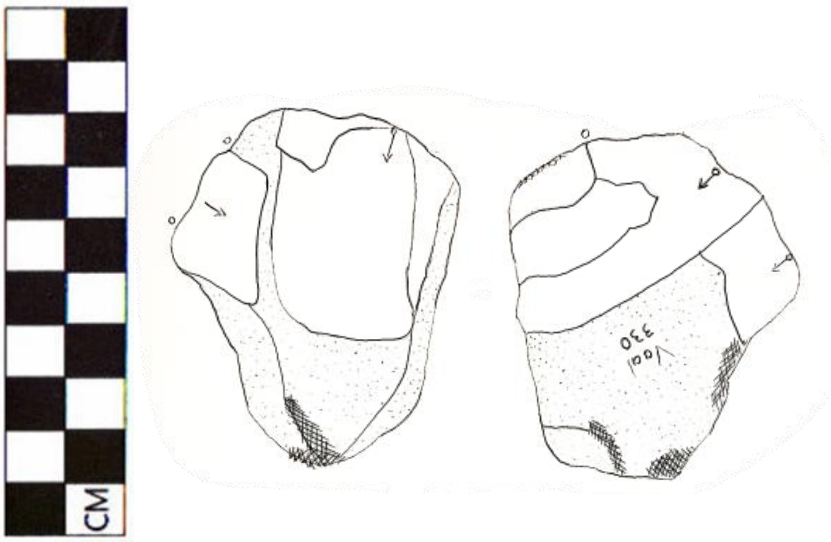


Figure 5.19: Artefact Vaal 330

Figure 5.19 is a BSP core made on an angular clast with rounded edges, which was also used a hammerstone. The BSP sequence has four scars opposite the battering marks, which are indicated by the darker crosshatches. The obtuse and rounded edges of the angular clasts were used for percussive actions in these specific spots.



Figure 5.20: Artefact Vaal 314

Figure 5.20 is a BSP core made on a hornfels rounded clast with possible evidence of battering opposite the worked edge. The percussion marks are localised on a very rounded and obtuse section of the surface. There are seven scars in the BSP sequence. Two scars extended over half the length of the core and removed a section of the surface area. These scars were used as a platform for the further five removals which wrapped around one end of the clast and were much smaller than the initial two removals.

Multifacial cores

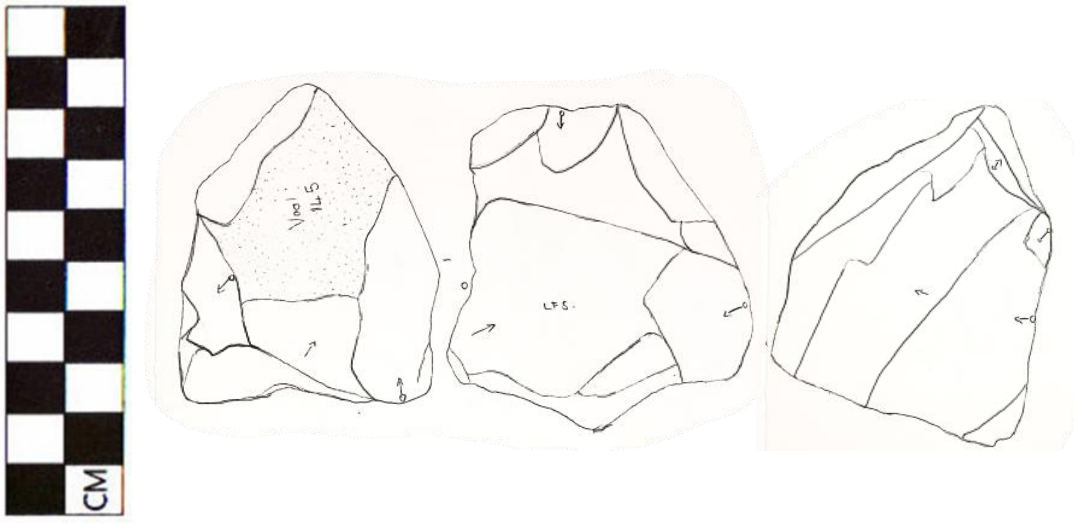


Figure 5.21: Artefact Vaal 145

Figure 5.21 is a multifacial core made on a quartzite river cobble, but the shape of the blank is indeterminate as too little remains to identify if it was facetted or rounded. There are 11 identifiable flake scars arranged over three surfaces of the core. The LFS has been used as a platform for the further removal of at least one flake and has been partly removed by another scar. The knappers were able to remove most of the cortical surface and part of the central volume before abandoning it.

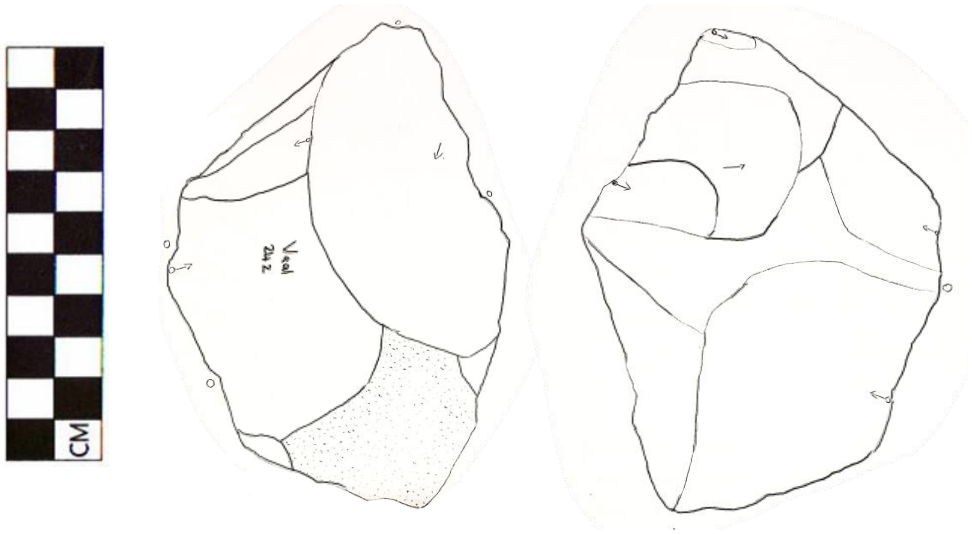


Figure 5.22: Artefact Vaal 242

Figure 5.22 is a multifacial core made on a blocky and rounded Ventersdorp lava clast, with <25% remaining cortex. There are eight flake scars, some which are relatively large compared to the core size. The LFS measures 80.2 x 65.8mm and the core measures 116.8mm in maximum length. Three platforms and three surfaces are exploited, but some scars follow a bifacial edge management on two edges, including one alternating sequence.

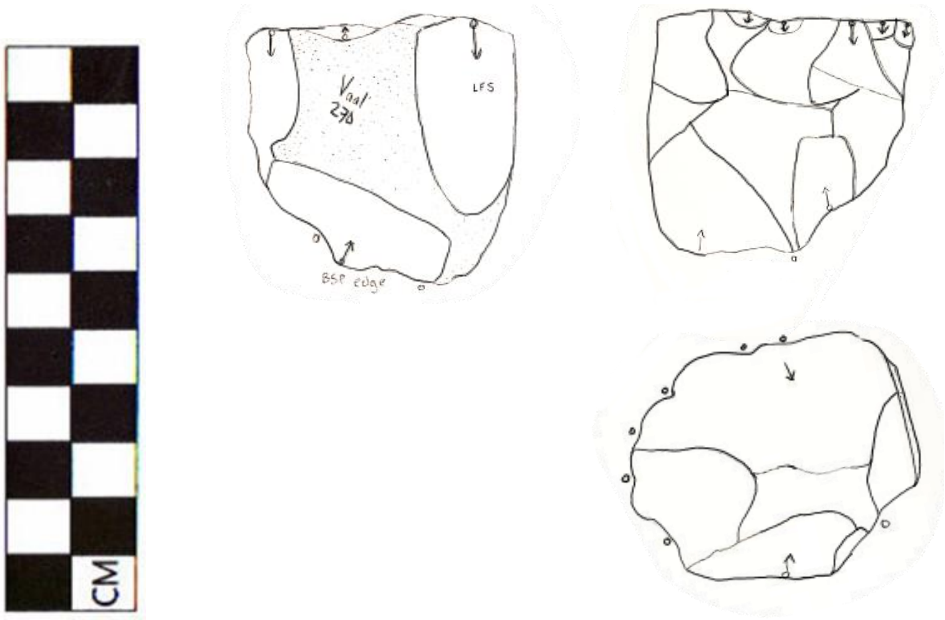


Figure 5.23: Artefact Vaal 274

Figure 5.23 is another quartzite core which has been classified in the multifacial idealised core scheme with 12 flake scars and <25% remaining cortex. Two opposing faces of the core have

been managed using different sequences, a simple bifacial one and an abrupt unifacial sequence with six scars. The piece has been classified as multifacial because, prior to the unifacial removals, there were a few removals on the adjacent surface. The bifacial sequence was applied to an acute core edge, while the unifacial sequence was applied to an abrupt edge. The knapper applied different edge management techniques to best exploit the two kinds of platform angles.

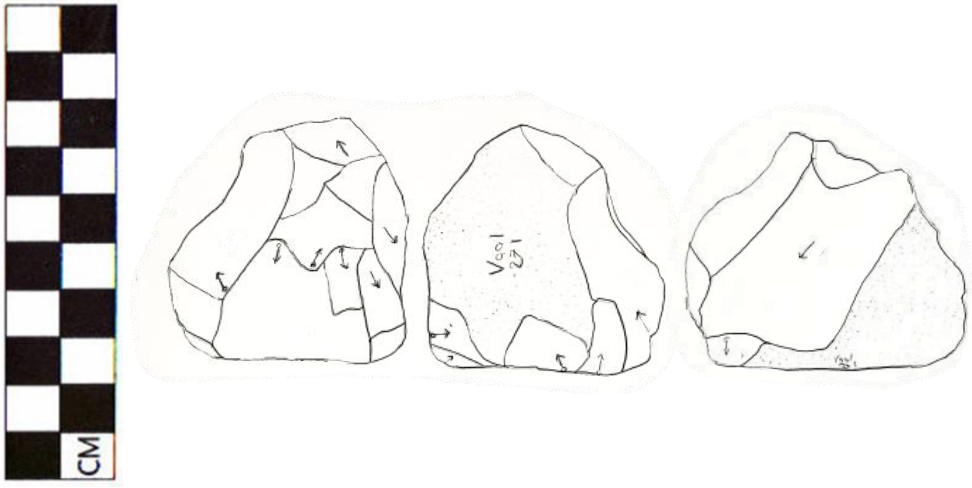


Figure 5.24: Artefact Vaal 271

Figure 5.24 is a multifacial Ventersdorp lava core made on a blocky shaped angular clast with rounded edges. There are a total of 12 scars focused around three quarters of the surface, and a few flake scars were used as platforms for further removals. One edge has a partial bifacial alternating scheme of three scars, as seen in the left image. The platform of the LFS was one of these these scars, indicating it was removed later in the reduction of the core. This core is an example of knappers exploiting the naturally more acute edges on clasts, as well as the platforms created through other flake scars.

5.3 Large cutting tools

The data and analyses presented in this section are from two assemblages of LCTs at Rietputs 15, Pit 5 dating to ca. 1.3 Ma and the undated ACP trench. The data from both will be presented individually, to understand any differences in trends between the collections. The data will be combined where appropriate to understand the general site patterns in LCT production. In the ACP assemblage, two of the LCTs presented have been reclassified, as they were previously described as cores. These pieces are included in the artefact descriptions below.

5.3.1 Raw material

Figures 5.25 A and B present the raw material types present in both the LCT assemblages from ACP and Pit 5 at Rietputs 15. Compared to the raw material types in the ACP core assemblage (Figure 5.1), there is a clear difference in raw material distributions, as Ventersdorp lava dominates for both LCT assemblages, but only makes up 11% of core assemblage. The raw material types as broken down by each LCT assemblage also have Ventersdorp lava as the dominant type, but it is much more prominent in the ACP collection, where it makes up 83% of the pieces (Figure 5.25 A). Specifically within the ACP, there is a clear separation in raw material choices for core and LCT production. In the Pit 5 assemblage (Figure 5.25 B), there is more variety in the raw material, with hornfels and quartzite used for roughly a quarter of the material each. CCS also appears in the assemblage, unlike in the ACP, but at a low rate. This could denote a change in raw material selection between the pits, or different local types.

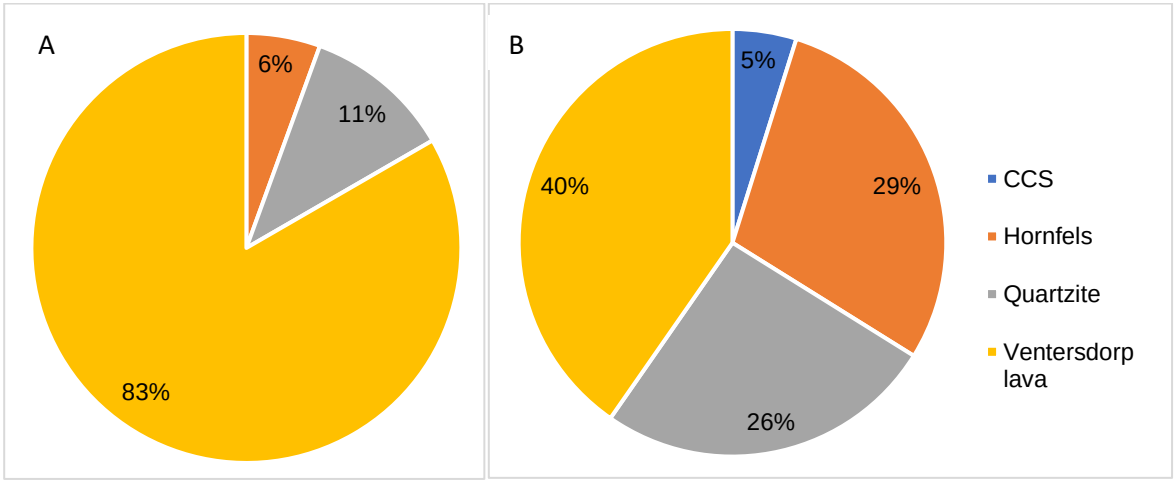
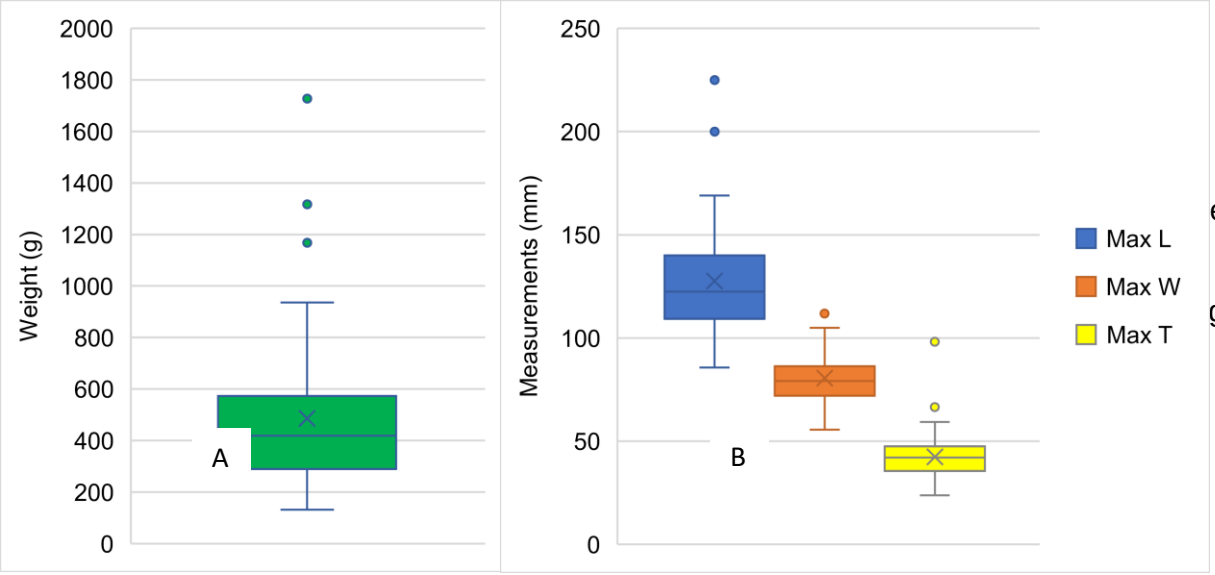


Figure 5.25: Raw material types in the ACP (A), and (B) Pit 5 at Rietputs 15

Following Leader (2009) who described the Pit 5 material in entirety for his MSc, the dominant raw material types are hornfels and Ventersdorp lava for both LCTs and cores. In the LCT assemblage, these two types dominate (40% for Ventersdorp lava, and 29% for hornfels), but quartzite is also fairly common at 26%. Between the two assemblages, there is a preference of Venterdorp lava for LCT production, but hornfels and quartzite are more porminent in the Pit 5 assemblage.

5.3.2 Weight and dimensions of LCTs

The weight of LCTs in the ACP is primarily grouped between roughly 244.6 and 816.6g, with a mean of 362.4g (Figure 5.26 A). The mean measurements of maximum length, width, and thickness in the ACP are 109.6mm, 75mm, and 40mm, respectively (Figure 5.26 B). Mean



e 5.27 A). The
80.6mm, and
ger than those

Figure 5.26: Weight (g) range (A), and range of maximum length, width, and thickness (mm) (B) of LCTs from the ACP

A B

Figure 5.27: Weight (g) range (A), and range of maximum length, width, and thickness (mm) (B) of LCTs from Pit 5

The correlation between weight and the maximum length, width, and thickness of the LCTs is not highly significant in either collection, except for the relationship of weight and maximum width in the ACP (R^2=0.8296). The weight and length are somewhat significant in the ACP

(R^2=0.5396), but the thickness is relatively insignificant (R^2=0.3416). Width (primarily) and length increase with increased weight, but thickness does not change as much (Figure 5.28). In Pit 5, the correlation of weight with all the dimensions is somewhat significant, with length having the highest R-value of R^2=0.6733 (Figure 5.29). Overall, LCT dimensions are not always determined by the volume or weight of a piece.

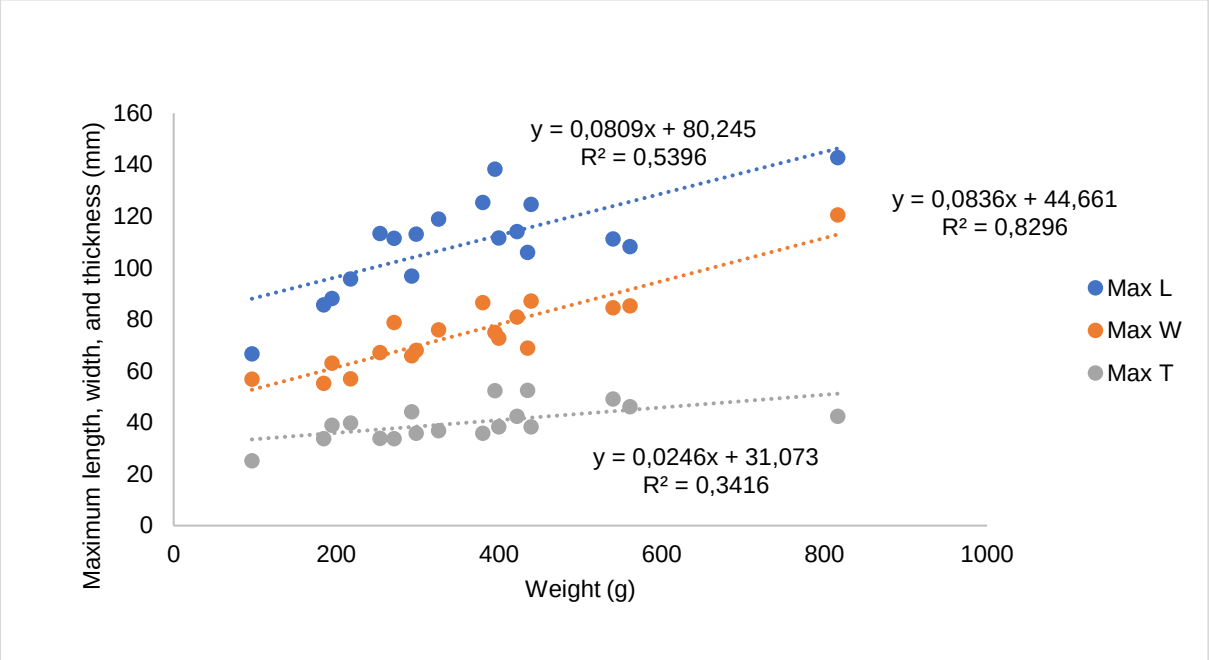


Figure 5.28: Correlation between weight (g) and maximum length, width, and thickness (mm) in ACP

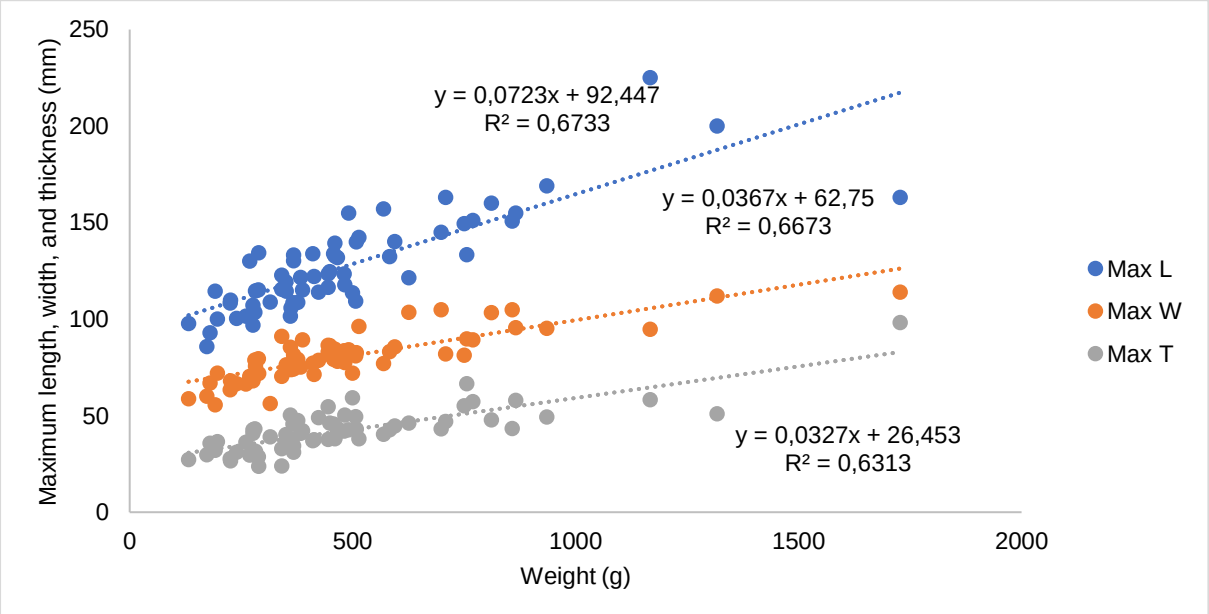


Figure 5.29: Correlation between weight (g) and maximum length, width, and thickness (mm) of the LCTs in Pit 5

5.3.3 Refinement Index

A Refinement Index test following Roe (1969) was performed on the LCTs from both assemblages. The average thickness divided by weight result in the ACP is 0.55 and 0.53 for Pit 5. Both assemblages have LCTs that are relatively thick to their width, which indicates pieces were quite refined and shaped on the lateral sides. These data will be compared with other sites in the discussion chapter to compare the site with other early Acheulean assemblages.

5.3.4 Blanks

Figure 5.30 is a bar graph of the blank types found in the LCT assemblages for both collections. Flakes are the most common types in both (11 in the ACP, and 28 in Pit 5). Both have examples of rounded clast blanks like cobbles, along with 16 flat and six split rounded clasts in Pit 5. Within the ACP there are two possible Kombewa flake blanks but this is a minor occurrence so have been analysed within the general flake blank category. Flake blanks are most used in LCT production, but various rounded clasts like cobbles became more prominent in Pit 5, especially rounded clasts with flat surfaces (flat cobbles).

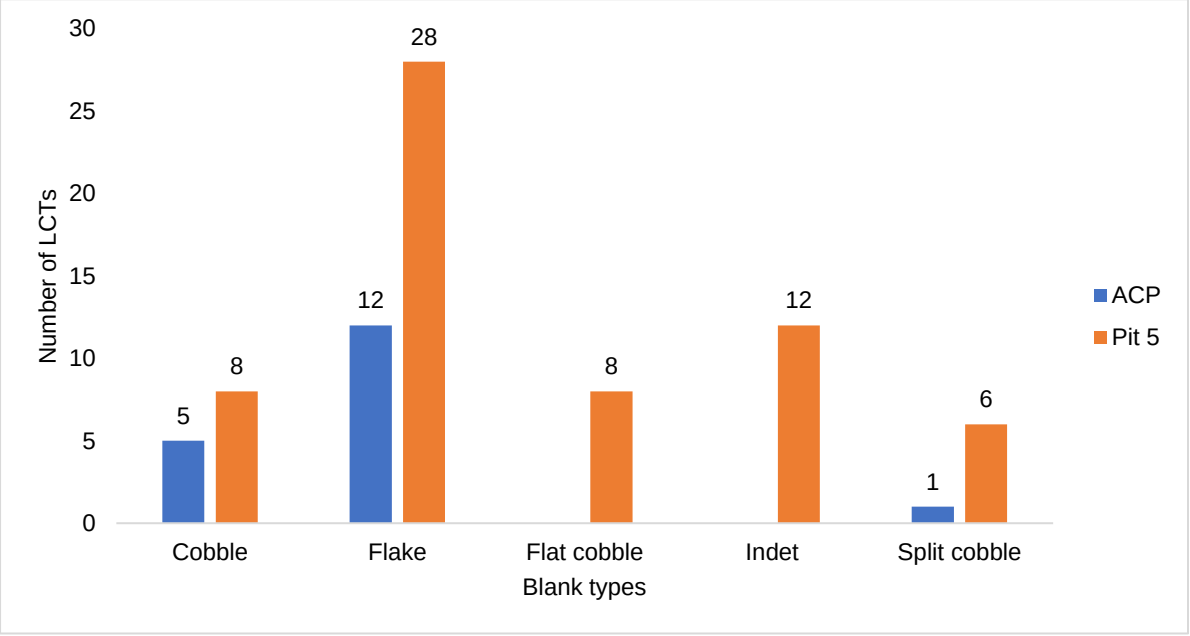


Figure 5.30: Blank types of LCTs in ACP and Pit 5 combined

5.3.5 Shaping strategies

In total, there are more bifacial LCTs than unifacial in the ACP (Figure 5.31). The bifacial strategy of exploiting one side and then flipping the piece once was applied to 50% of the assemblage, while alternating bifacial shaping was applied to 38.9% of LCTs. There is one

example each of a unifacial and rhomboid shaping strategy (5.6% each), meaning bifacial shaping strategies were applied on 88.9% of the LCTs in the assemblage.

Similarly, to the ACP assemblage, bifacial shaping strategies are dominant in the assemblage, with 45.2% of LCTs being shaping using a bifacial alternating sequence, and 41.9% using the standard bifacial strategy. Overall, 87.1% of the LCTS are shaped using some type of bifacial edge management, while only 9.7% are unifacially shaped.

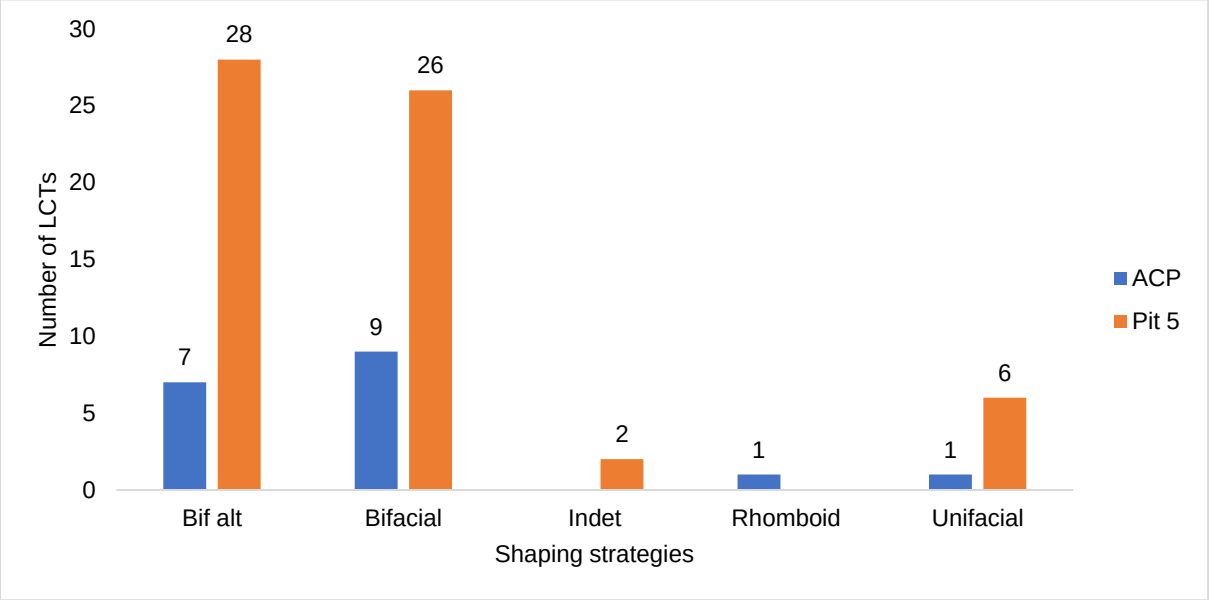


Figure 5.31: Shaping strategies of LCTs in the ACP and Pit 5 combined. ('bif alt' stands for 'bifacial alternating'; 'indet' stands for 'indeterminate')

As mentioned, most of the LCTs in the ACP are made on Ventersdorp lava, which is used for all the shaping strategies. Quartzite, with only 2 examples, is only used for bifacial alternating reduction and the hornfels piece is bifacially shaped (Figure 5.32). In the Pit 5 assemblage all the raw material types are used in similar amounts for both forms of bifacial shaping, and three quartzite LCTs were shaped unifacially (Figure 5.33). The LCT with an indeterminate shaping strategy was made on a Ventersdorp blank. Overall, Ventersdorp lava was most widely used in each assemblage, and all the combined raw materials were used primarily for bifacial shaping.

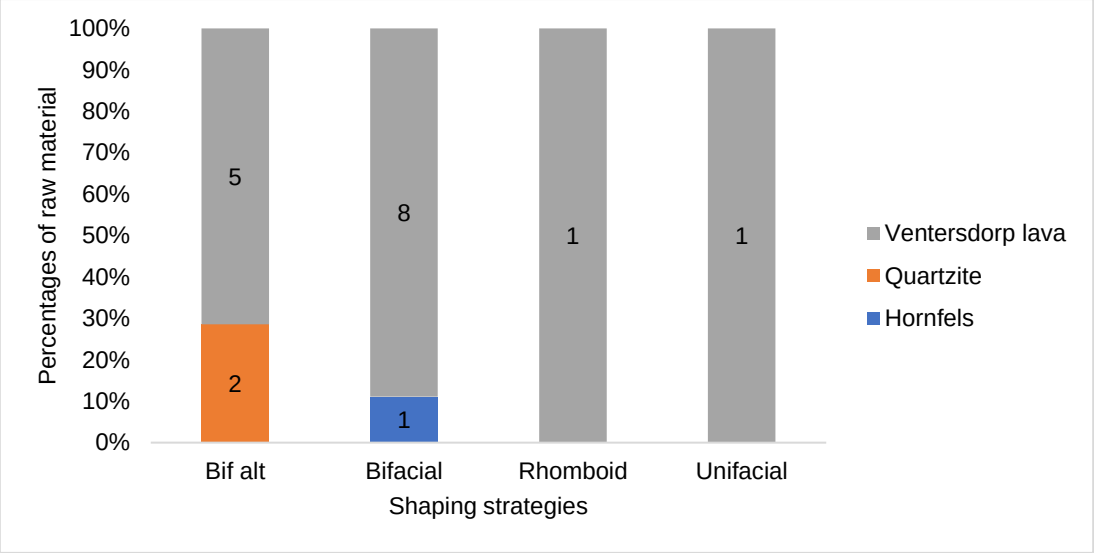


Figure 5.32: Percentage of raw material in shaping strategies in LCTs of ACP ('bif alt' stands for 'bifacial alternating')

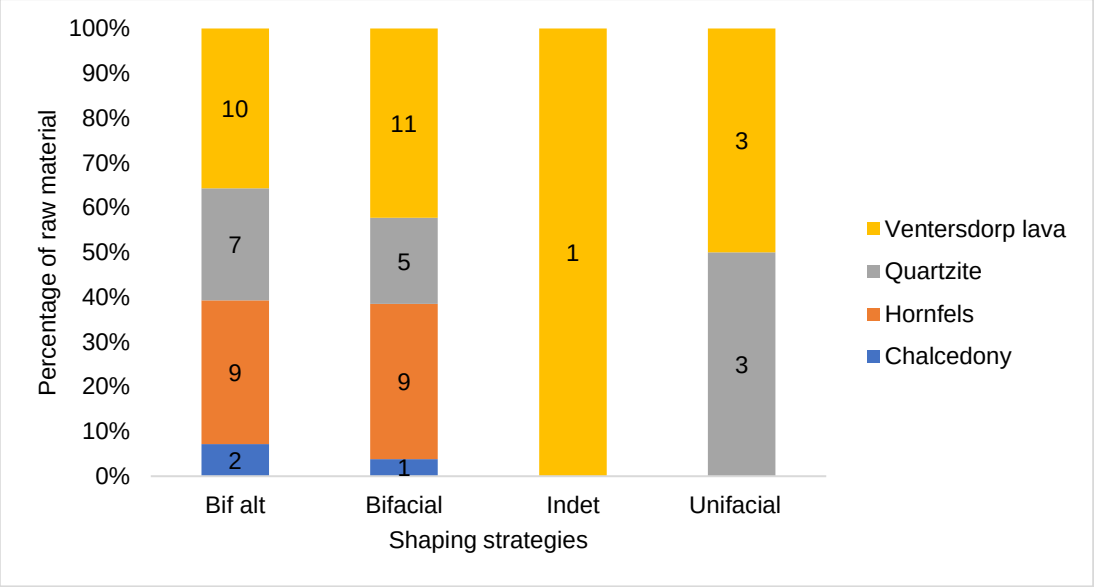


Figure 5.33: Percentage of raw material in the shaping strategies of the LCTs in Pit 5 ('bif' alt stands for 'bifacial alternating')

Flake blanks in the ACP (Figure 5.34) are shaped using all the strategy categories. For interests' sake, the Kombewa flake was separated for this graph to see what strategy was applied to it, which is bifacial shaping. Bifacial shaping was also applied to whole and split rounded clasts. In Pit 5 (Figure 5.35), both forms of bifacial shaping are applied to all blank types, with the most done on flake and indeterminate blank types. Unifacial shaping was applied to flake and flat cobble blanks which have more acute angles compared to the cobbles which are rounded with more abrupt edges.

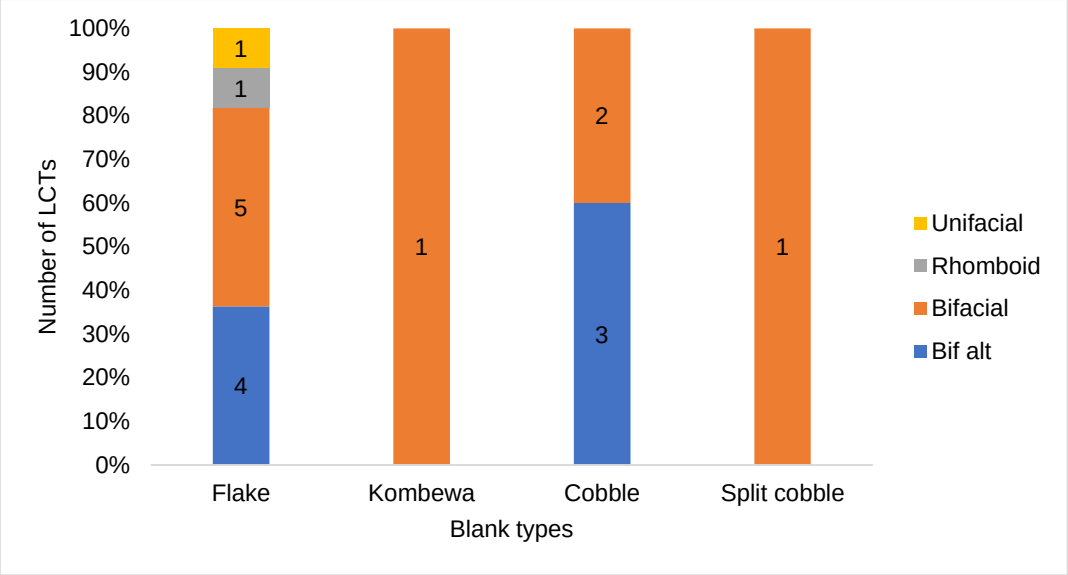


Figure 5.34: Blank types and shaping strategy on the LCTs from the ACP ('bif alt' stands for 'bifacial alternating')

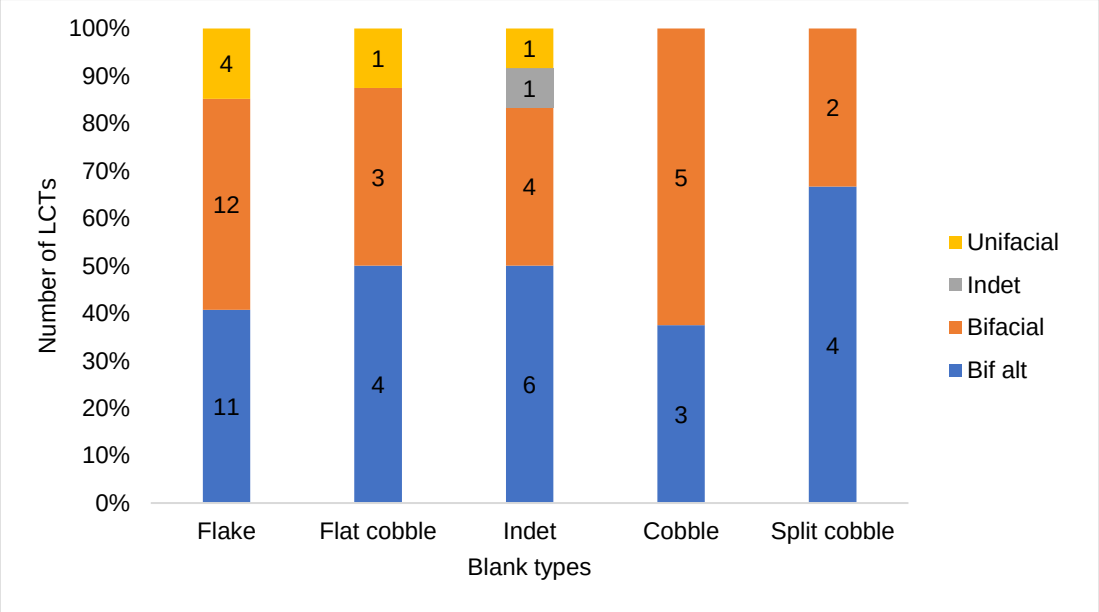


Figure 5.35: Blank type and shaping strategy on the LCTs from Pit 5 ('bif alt' stands for 'bifacial alternating')

5.3.6 Flake scars

Figure 5.36 is a bar graph of the number of flakes scars used to shape the LCTs from both collections. Only a sample of 53 pieces from Pit 5 could be properly counted. On average the ACP LCTs have 10.6 scars each and the Pit 5 LCTs have 8.7 scars each.

Most LCTs have between 7-10 flake scars for both the ACP and Pit 5, though there is a higher percentage in the Pit 5 assemblage (47.2%, 25 examples), whereas six pieces (22.2%) from the ACP fit in that range. In Pit 5, there 15 examples of LCTs with 4-6 scars, and 10 examples of LCTs with 11-13 scars. In total these three groups make up 94.3% of the Pit 5 assemblage. There are four examples each of the LCTs with 4-6 scars and 11-13 scars in the ACP. The larger assemblage size of Pit 5 LCTs could explain the differences in flake scars ranges, but the general pattern from both pits shows that most pieces have just under 10 scars.

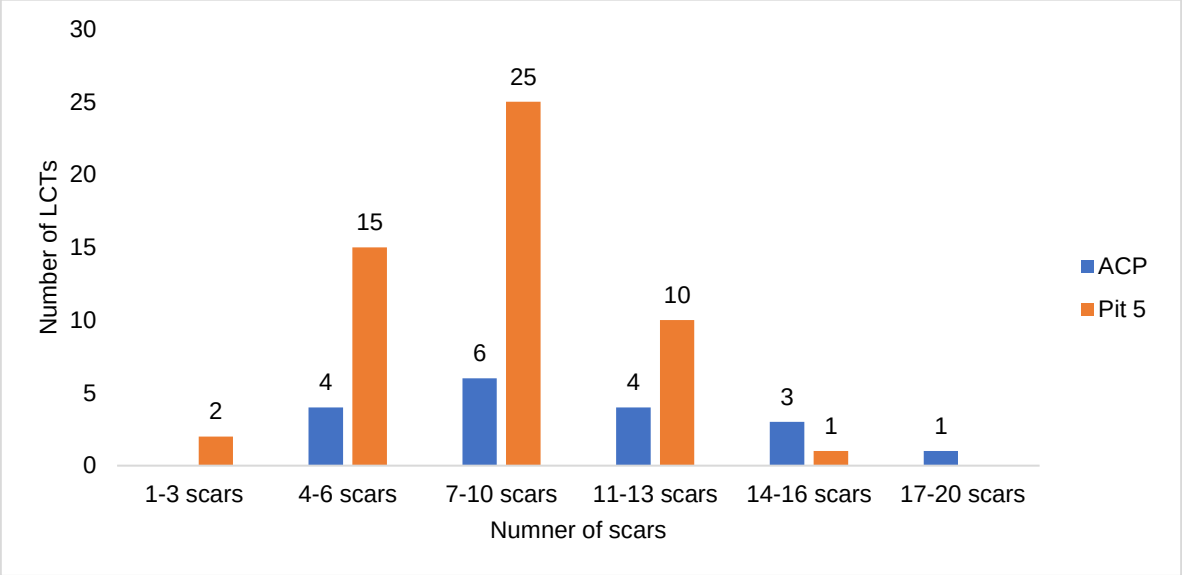


Figure 5.36: Number of flake scars on the LCTs from the ACP and Pit 5

Shaping intensity on LCTs can be studied through the number of scars evident in the sequence, and how many there are in relation to the overall size of the piece, as measured by weight. In the ACP, the correlation between these features has a relatively low significance (R^2=0.1036) (Figure 5.37 A), and no significance in Pit 5 (R^2=0.0211) (Figure 5.37 B). Generally, larger LCTs had slightly more flake scars than smaller pieces, but they were not heavily reduced through shaping.

A t-test for equal for means was run on the scars and number of times a piece was flipped. For the ACP, the resulting t-value is (p=0.05): 1.983. For Pit 5, the resulting t-value is (p=0.05): 2.0369. In both cases there is a correlation between the means, indicating that LCTs with higher flake scar numbers were flipped multiple times. This is even more pronounced in the Pit 5 assemblage, where LCTs were flipped multiple times during the entire process of reduction.

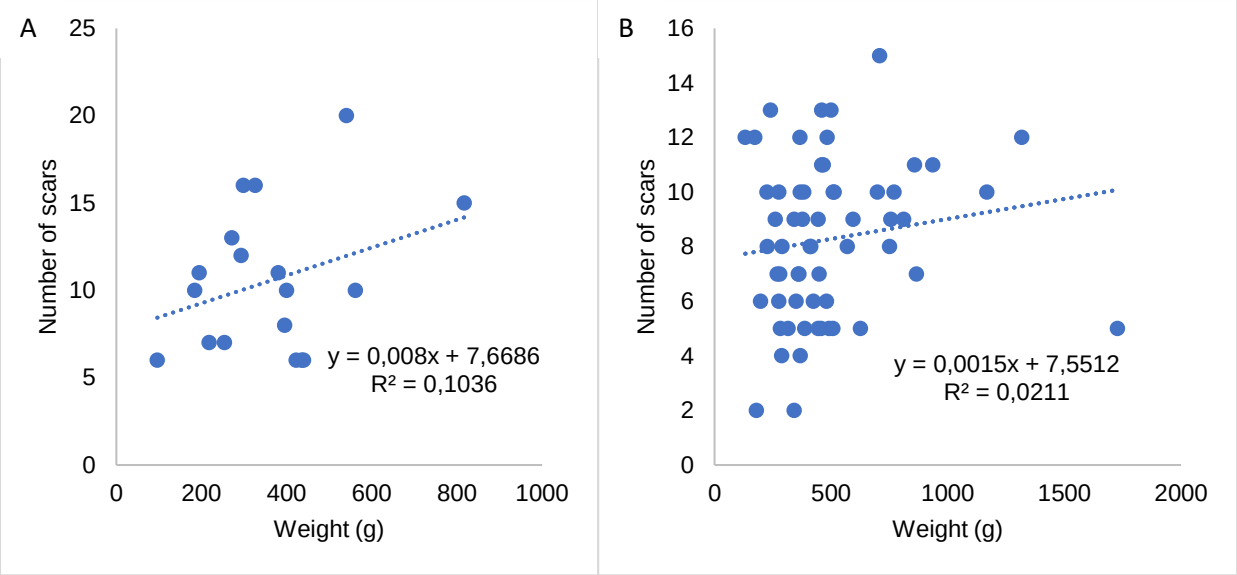


Figure 5.37: Correlation of weight (g) and number of scars on LCTs from the ACP (A)and Pit 5 (B)

5.3.7 Diacritical analyses of LCTs

ACP

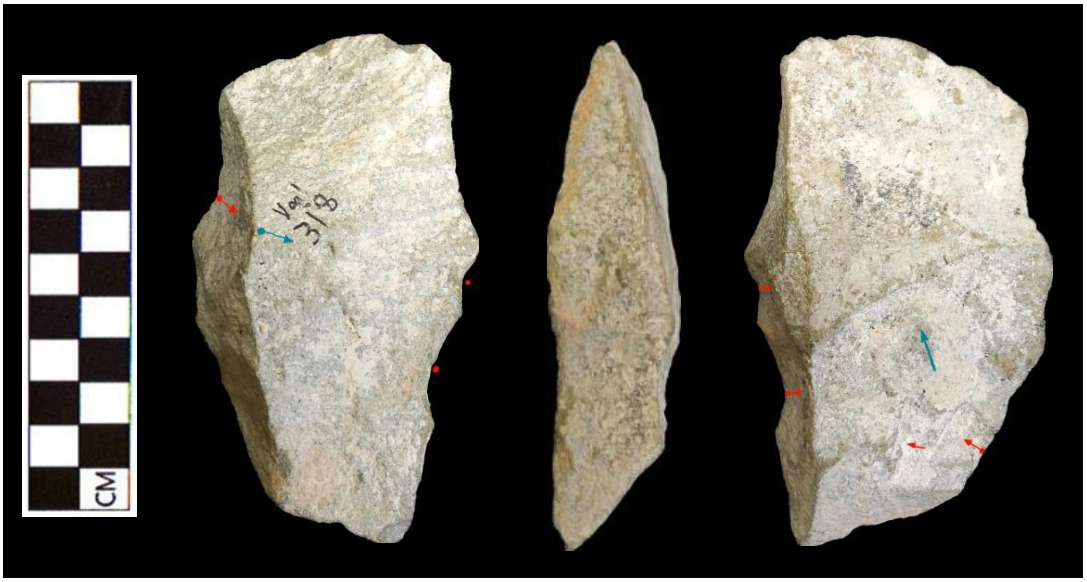


Figure 5.38: Artefact Vaal 318

Figure 5.38 is a cleaver, shaped with four in a rhomboidally organised scars. There are two scars on the flake blank platform going from the dorsal to ventral surfaces, and three scars on the other lateral going from the ventral to dorsal sides. On the dorsal face of the cleaver is one discernible debitage scar, as well as a flat surface that could have also been a flake scar. The

piece was minimally shaped as there were sharp edges created by the flake blank including the oblique traversal cutting edge.

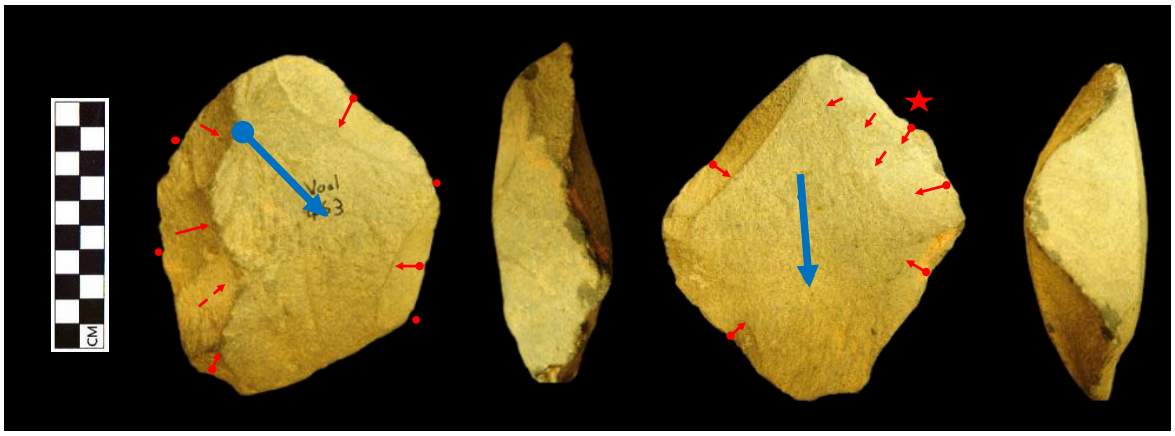


Figure 5.39: Artefact Vaal 463

Figure 5.39 is one of the reclassified pieces from the ACP. It was originally labelled as a radial core, but I think it is a knife made on a Kombewa flake blank. Because it is a Kombewa flake, the sides have been randomly labelled as ventral and dorsal. The edge is shaped around the entire piece with a bifacial alternating sequence of 15 scars. One section of the dorsal surface has been retouched with small overlying scars (indicated by the red star). I think these scars are meant to create a cutting edge, hence the classification of the piece as a knife.

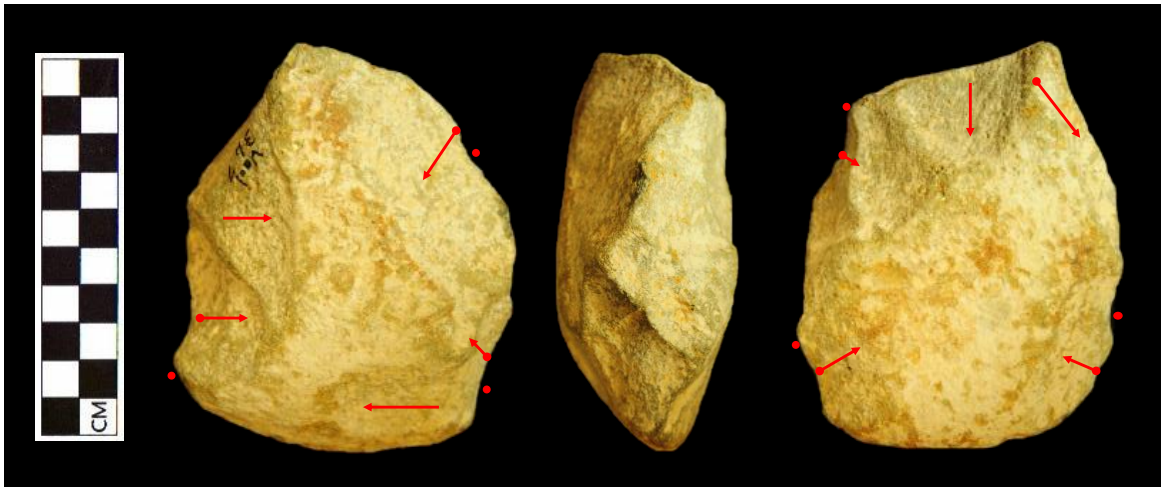


Figure 5.40: Artefact Vaal 347

Figure 5.40 is the other reclassified piece originally from the core assemblage. It is a handaxe with a broken tip which was made on a flat cobble clast. There are 10 scars in an alternating bifacial pattern on both lateral edges. the broken tip surface is flat with no markers of a flake scar. Through discussion with another archaeologist, Carmen Martín-Ramos who works on LCTs from multiple sites in Olduvai Gorge, Tanzania, it was confirmed that tip breaks can be quite deep and are visible on multiple examples in her ongoing study (Martín-Ramos *pers. comm.*). The similarity between this piece and those from Olduvai Gorge further confirms this piece to belong in the LCT category.

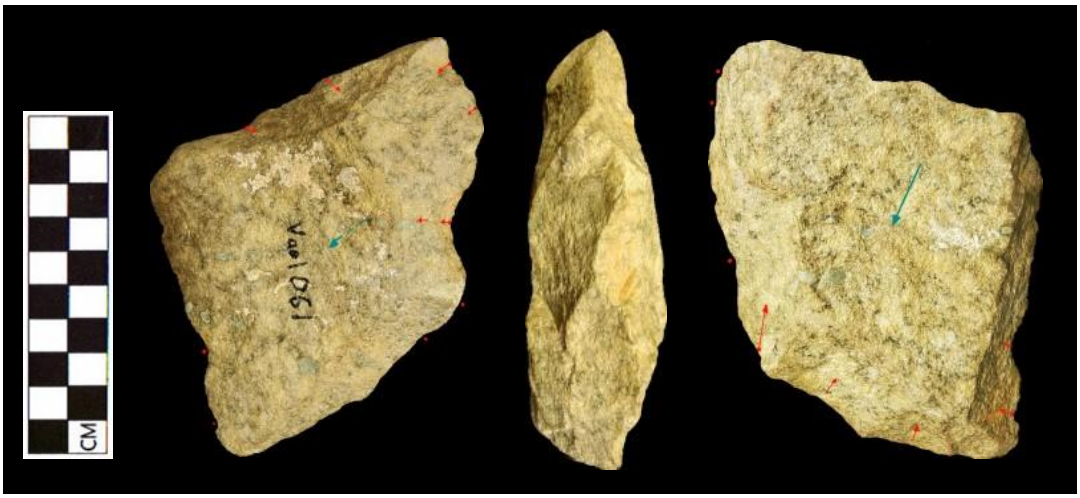


Figure 5.41: Artefact Vaal 061

Figure 5.41 is a quartzite knife which is made on a Kombewa flake blank. The blue arrows on either face indicate the possible ventral surfaces, but the removals around the edge of the piece have obscured the impact points. The low frequency of Kombewa flakes means it was not a common knapping practice but will be discussed at the end of the chapter. There are 12 shaping scars around the edge organised in a bifacial sequence.



Figure 5.42: Artefact Vaal 460

Figure 5.42 is a pick made on a flat angular clast with eight scars, four on either side. The piece was flipped consistently between flake removals, with little evidence of volume reduction. It could be argued that the knappers were taking advantage of the blank shape and edge thickness to create a heavy-duty working tip, while maintaining a cortical surface to handle the piece possibly.

Pit 5

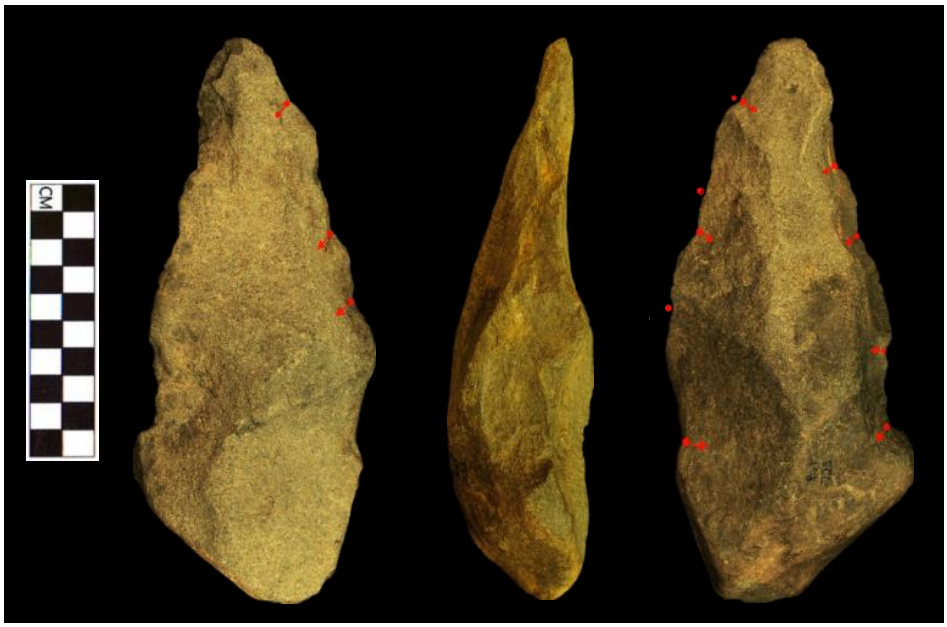


Figure 5.43: Artefact Riet 723

Figure 5.43 is a large bifacial handaxe made on a Ventersdorp lava angular clast with rounded edges and cortex around the base. There are 10 flake scars, seven of which are on the

asymmetrical side. The piece has been slightly rolled and has damage on the edges. The scars on the bulkier side do not reduce the central volume on that surface, resulting in obtuse edge angles on the lateral sides.

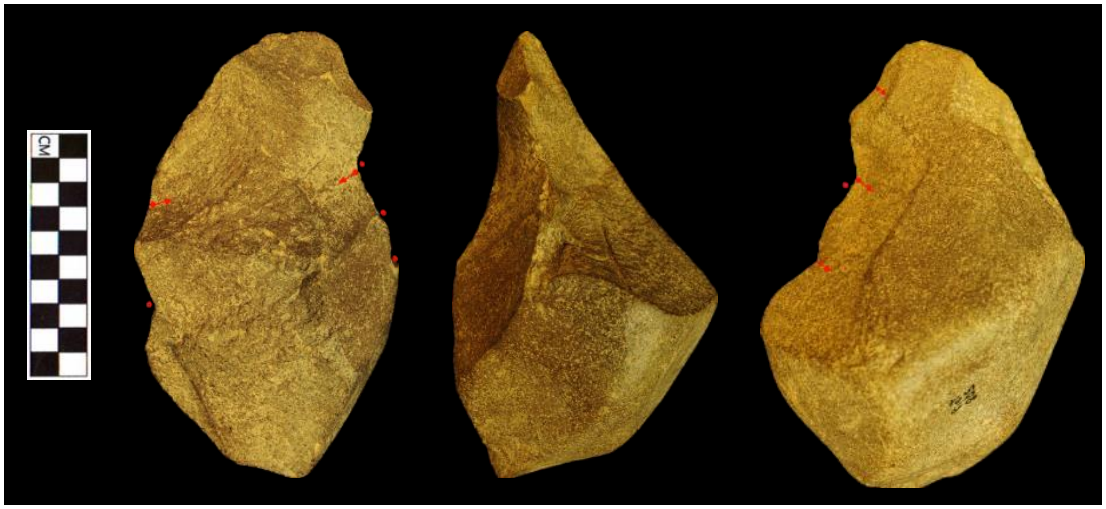


Figure 5.44: Artefact Riet 805

Figure 5.44 is a handaxe which has been made on a large split rounded quartzite river cobble. The base is wide and the medial and distal sections have been shaped with five large bifacial flakes. The acute edges are exploited while the abrupt and rounded angles on the cortical surface remains untouched. The flat side of the asymmetrical handaxe is used as the platform, but those flake scars end in step fractures and the shaping sequence may have been abandoned as a result.



Figure 5.45: Artefact Riet 388

Figure 5.45 is an LCT which is a handaxe made on a hornfels flake blank. The piece is abraded with damage along the edges. The ventral surface has multiple scars organised in a radial pattern, which created the platforms for removals on the dorsal surface. Four scars on the dorsal surface are visible and three end with hinge and/or step fractures. These scars did not reduce the volume on that surface and the resulting piece is an asymmetrical handaxe.

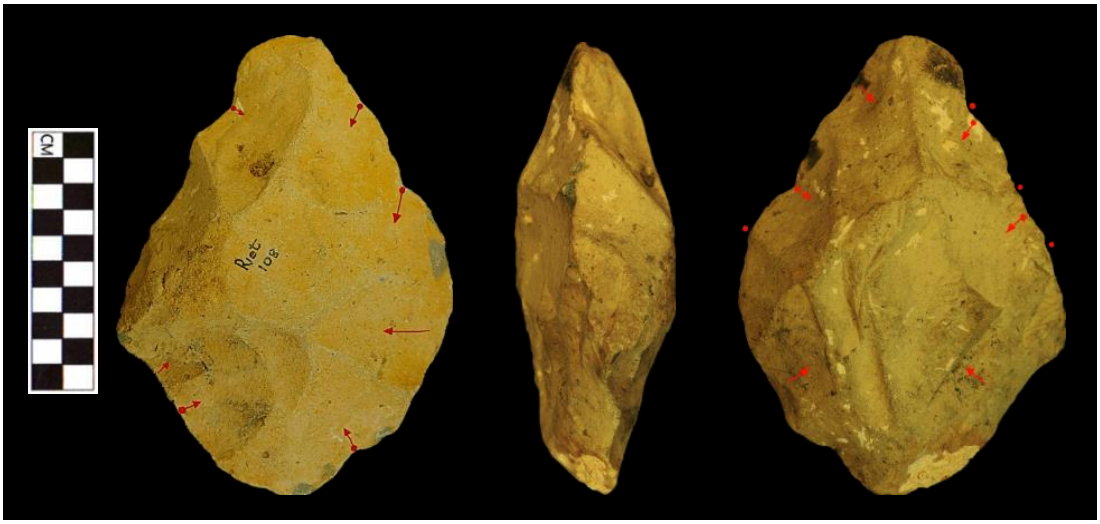


Figure 5.46: Artefact Riet 108

Figure 5.46 is a hornfels handaxe made on an indeterminate blank. There are 10 scars in two sequences of bifacial alternating edge management. Two scars on the proximal end have abrasion and damaged edges so the points of impact are unknown. The piece is symmetrical, and the scars on either side are of a similar size.

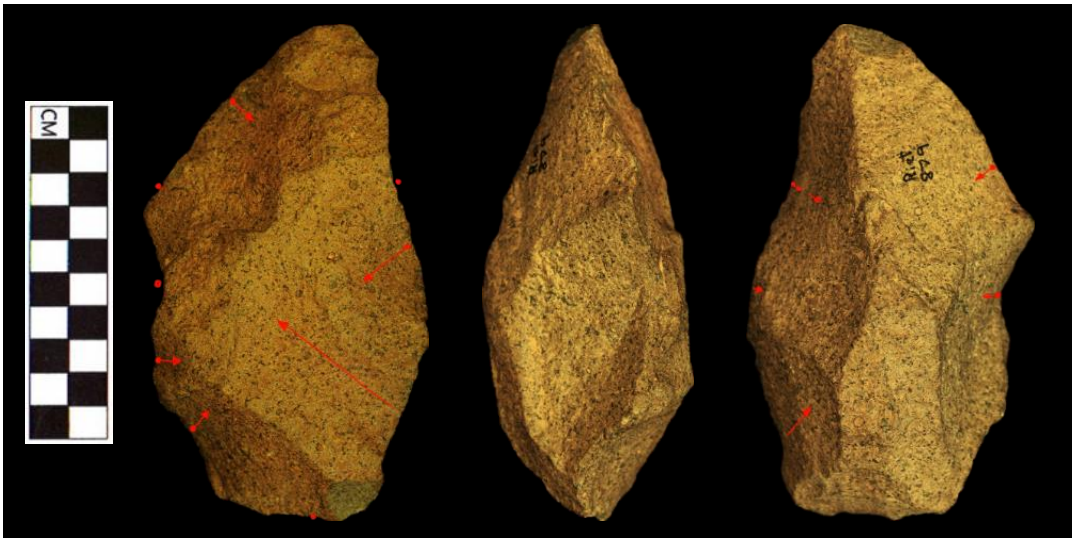


Figure 5.47: Artefact Riet 879

Figure 5.47 is a LCT which is made on a quartzite flake blank and is shaped with a bifacial alternating sequence. The piece is asymmetrical and there are 9 scars, 5 of which are located on one lateral edge. A large removal on the ventral surface reduced the central bulk on that side, while flake scars on the dorsal side were too steep and left a portion of cortical surface.

5.4 Comparing the core reduction strategies and LCT production

The main difference between the two assemblages in terms of LCT production is the number of artefacts per collection and the number of flake scars on the LCTs. On average, Pit 5 has more LCTs with between 7-10 flake scars and fewer examples of pieces within the other flake scars groupings. In the ACP, the gaps between these groups are smaller and could indicate the assemblage was less shaped than the Pit 5 LCT assemblage.

Bifacial alternating and bifacial shaping on the same edge are most prominent in each assemblage but there are two more examples of bifacial alternating shaping in Pit 5, and two extra bifacial LCTs in the ACP. There is also slightly more variety in the blank types and shapes in the Pit 5 sample, and the shaping strategies could be related to various adaptations to those shapes.

Kombewa flakes

There are two examples of Kombewa flake blanks being used in the LCT production. Owen (1938) first described the flake types from the area of Kombewa in Kenya. The flake is defined by having two ventral surfaces, as the blank is a flake removed from a large flake used as a core (Dag and Goren-Inbar 2001). This technological flake category can be found throughout the African continent and the ESA, as well as in Europe and the Middle East (Beshkani *et al.* 2017) but can easily be obscured in the record due to the shaping and retouch from tool production (Masojć *et al.* 2021). The site of Gesher-Benot Ya'aqov in Israel has many examples of Kombewa flakes, as do many sites in the African middle Pleistocene (Sharon 2010; Masojć *et al.* 2021), but this technology is not well understood in the South African context. The Kombewa aspect of this assemblage would be on interest to study further as it appears in an assemblage >1 Ma but further work would be needed to analyse the production of the LCT blanks in order to understand if this was a common feature at Rietputs 15.

5.5 Technological trends at Rietputs 15

In conclusion, the deposits at Rietputs 15 offer an interesting perspective into the differences in LCT shaping of two nearby assemblages during the earliest phase of the Acheulean technocomplex. If the hypothesis of progressive change between the ACP and Pit 5 is accepted, the changes could confirm the hypothesis and knappers were using a wider variety

of raw materials for LCTs, and well as on average using more scars to shape them in the later parts of the early Acheulean at Rietputs 15. The core technology at ACP shows a high percentage of bipolar reduction, which could be a result of the raw material types, and their generally small size. Once the data from Pit 5 is reanalysed to include the cores and compared to the ACP, it may also offer insights into the technological changes within the early Acheulean.

Chapter 6: Results: Canteen Kopje

Canteen Kopje is a site complex with multiple historic diamond mining pits containing archaeological deposits. In this thesis I focus on the material from two layers in Pit 6 (Figure 3.9), named the Basal Early Acheulean and the Organised Core Technology layers. These terms and stratigraphic units were defined by George Leader in his PhD thesis titled "New Excavations at Canteen Kopje, Northern Cape Province, South Africa: A techno-typological comparison of three earlier Acheulean assemblages with new interpretations on the Victoria West phenomenon," completed in 2014. The descriptions of the layers are outlined in chapter 3. This material is of interest in this thesis because of the discussion of 'organised' core reduction strategies at the site as a precursor to the Victoria West prepared core industry (discussed in chapter 2). As this thesis aims to assess the specific patterns within core reduction strategies from multiple sites with early Acheulean material, it is of interest to include Canteen Kopje because of its unique technological signatures, as well as its overlying stratigraphic relationship with the material from the basal assemblage.

6.1 General observations

The first major feature to note about the sampled artefacts from Pit 6 is their size, especially the larger cores. One of the studied core weighs 23000g, with some others weighing just under 20000g. These core sizes are unlike any other site in this study. The assemblage also has many LCTs, and it is possible to link the core and LCT production processes, as the flake scars on larger cores match the size range of LCT flake blanks. This point will be explored in this chapter, along with the analysis of core reduction, LCT production and edge management.

Generally, the condition of the material is poor, as the artefacts come from coarse alluvium and gravels (Lotter 2020), and pieces have been rolled. This can create some issues in analysis, and occasionally specific information about pieces is labelled 'indeterminate' in order to remain as objective as possible. Furthermore, as was discussed in chapter 3, the core assemblage is housed at the McGregor Museum in Kimberley in the Northern Cape, and I was not able to analyse every core and LCT from both layers due to various government lockdown restrictions during the Covid-19 pandemic, as well as financial limitations on travel and accommodation.

Therefore, I have analysed a sample of 40 cores and 52 LCTs from the Organised Core Technology layer, and 39 cores and 33 LCTs from the Basal Early Acheulean layer. In total this makes up 11.5% of the cores 58.4% of the LCTs in Organised Core Technology layer, and 23.2% of the cores and 100% of the LCTs from the Basal Early Acheulean layer. The full assemblages from the two layers are presented in Leader (2014), and the table of the artefacts

from his thesis is available in Appendix 2. The sampled material was selected randomly from the collections in the museum. Boxes labelled ‘cores’ were chosen and up to five pieces per box were studied. Many of the larger boulder cores are not in boxes due to their size and these were also studied. It would be ideal to have re-analysed all the data presented by Leader (2014) to test the claims made in his thesis, but given the logistical challenges noted, I have had to rely on substantial samples.

6.2 Raw material

Andesite is the dominant raw material in the sampled core assemblages for both layers. In the Basal Early Acheulean layer, andesite makes up 92% of material, while the remaining 8% is quartzite (Figure 6.1 A). Quartzite proportions remain consistent in the Organised Core Technology layer at 8%, but the proportion of andesite decreases by 20% with the introduction of CCS and hornfels (Figure 6.1 B). The material is sourced from the nearby Vaal River, so the large clasts were not transported far. The details of the blank types with regards to the raw material is presented later in the chapter.

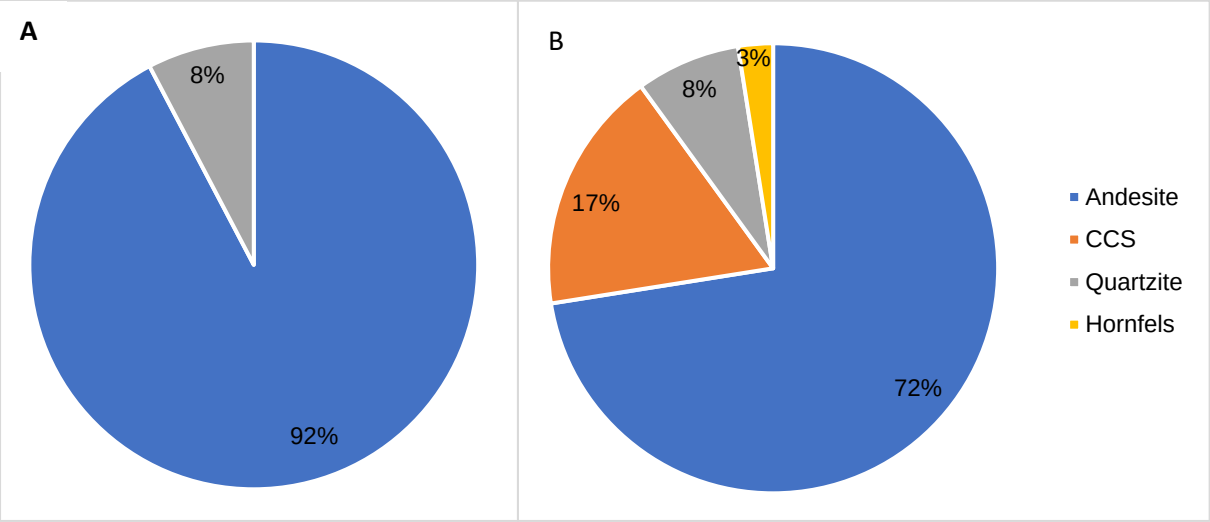


Figure 6.1: Raw material distributions of the A: Basal Early Acheulean layer, and B: the Organised Core Technology layer

6.3 Cores

6.3.1 Idealised core reduction schemes

Figure 6.2 lays out the distribution of the idealised core reduction schemes by each layer. In the Organised Core Technology and Basal Early Acheulean layers there are 40 and 39 cores analysed, respectively. The majority of multifacial cores come from the Basal Early Acheulean layer (n=11), and BALP cores are most dominant in the Organised Core Technology layer

(n=8). The other categories are more evenly distributed between layers, except for test cores, with double the amount in the Basal Early Acheulean layer (n=6) than in the Organised Core Technology layer (n=3). The only BHC and bipolar cores are found in the Organised Core Technology layer, while the discoid is found in the Basal Early Acheulean layer.

Twenty-one of the bifacial cores (56.8% of all bifacial cores) are found in the Organised Core Technology layer and 16 in the Organised Core Technology layer (43.2% of all bifacial cores). Ten unifacial cores are found in the Organised Core Technology layer, and six in the Basal Early Acheulean layer. Overall, this is logical as 17 cores in the Basal Early Acheulean layer (43,6% of that layer) are either multifacial or TC, suggesting that core technology shifts to be slightly more structured in the superior layer, as argued by Leader (2014).

In total, 35 cores have a single exploited face (BALP, BAP, BSP, UAU1, and USP), 13 in the Basal Early Acheulean layer, and 22 in the Organised Core Technology layer. There are also 35 cores with more two or more faces exploited, 20 in the Basal Early Acheulean layer, and 15 in the Organised Core Technology layer. This does not include the TC cores (n=9), as these cores can have up to two scars on up to two different faces/ surfaces of a core. Overall, it appears knappers were exploiting core blanks more completely in the Basal Early Acheulean layer, but core reduction strategies became more structured in the Organised Core Technology layer.

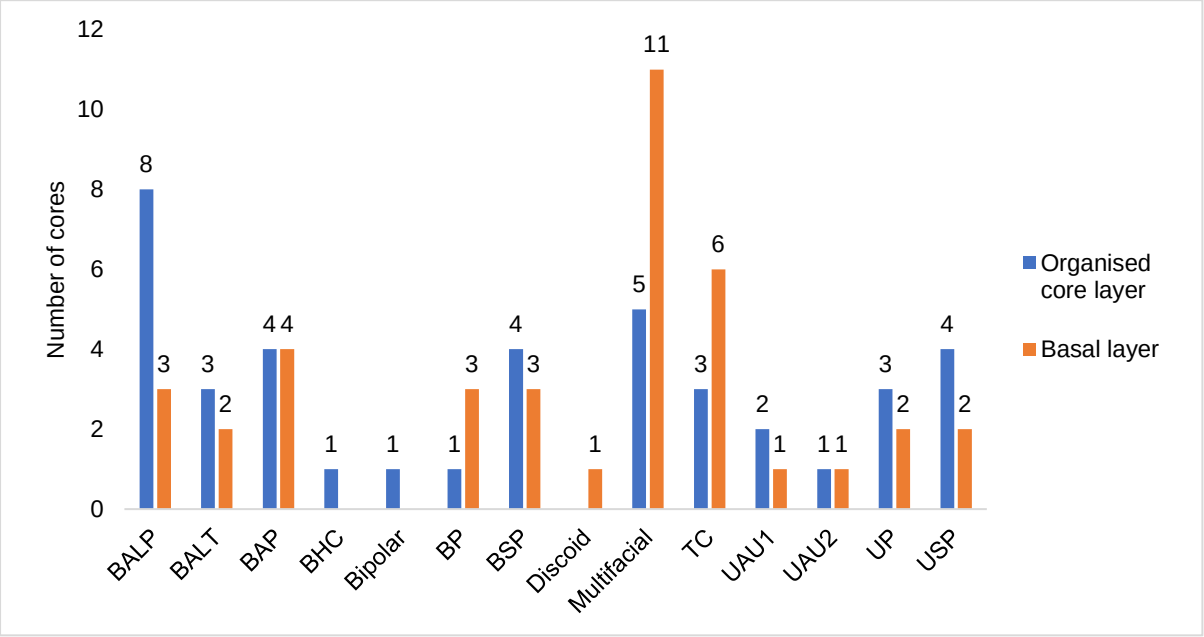


Figure 6.2: Idealised core reduction schemes by layer

6.3.2 Cores with multiple idealised schemes

Both layers have examples of cores with multiple idealised schemes. There are two examples in the Basal Early Acheulean layer (5.1% of assemblage), while there are eight in the Organised Core Technology layer (20%). The Basal Early Acheulean layer examples include a core with a dominant BSP strategy and a BP component, and the other core has a dominant BP scheme with a multifacial component. In the Organised Core Technology layer, all the examples have dominant bifacial schemes except for one core with a UP and multifacial scheme. Three of the cores have a secondary unifacial scheme, while the other four cores have bifacial schemes for both. More intensive exploitation of core blanks increases in the Organised Core Technology layer, especially in cores with a bifacial idealised scheme.

6.3.3 Raw material distribution by idealised scheme

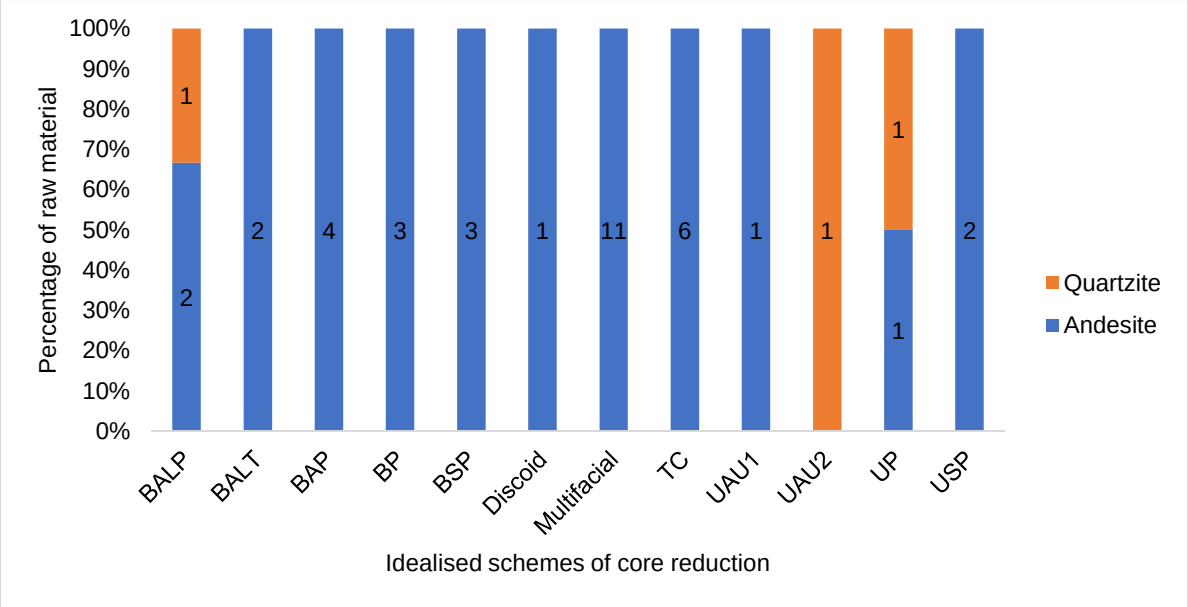


Figure 6.3: Raw material in the Basal Early Acheulean layer idealised schemes of core reduction

As mentioned, andesite dominates both layers, and within the Basal Early Acheulean layer, there are only three quartzite pieces across the 12 categories of core reduction: one BALP, USP, and a UAU2 piece (Figure 6.3). Andesite was clearly used in multiple ways, and various core edge management strategies were applied to the blanks. This trend continues in the Organised Core Technology layer and only the bipolar category has no andesite examples, while the other minor raw materials fall within different categories (Figure 6.4). Multifacial and TC strategies were applied to quartzite pieces, with one BALP example, while CCS was only used across six categories, and hornfels was used in a UP strategy only.

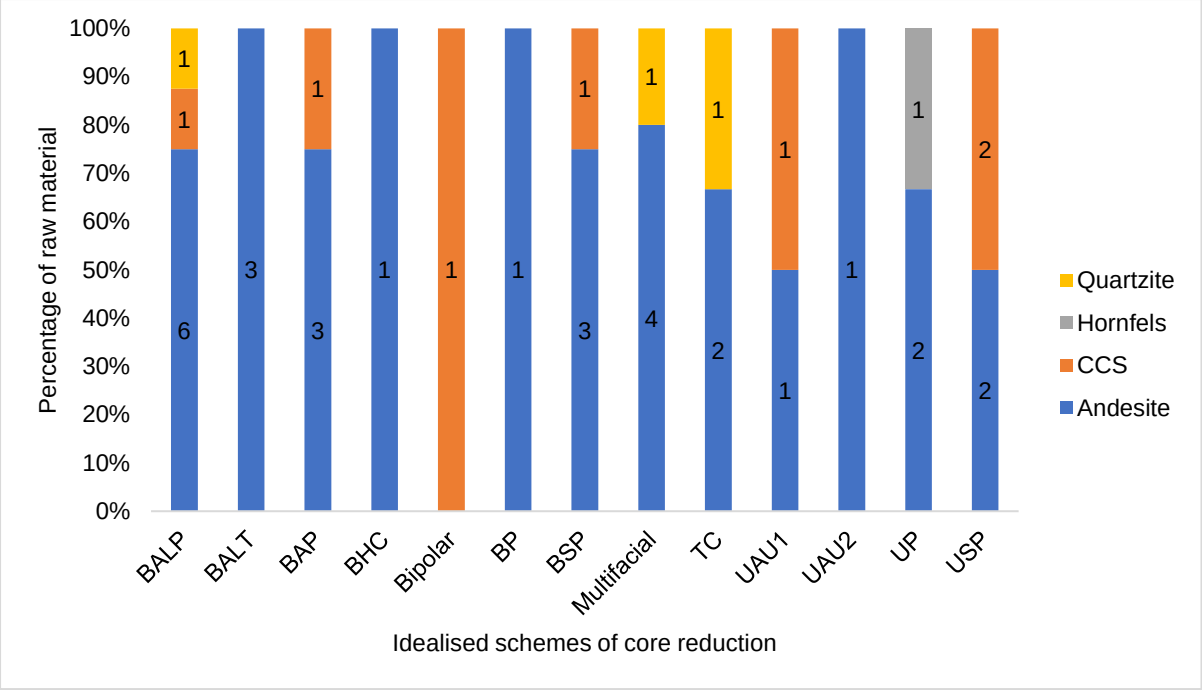


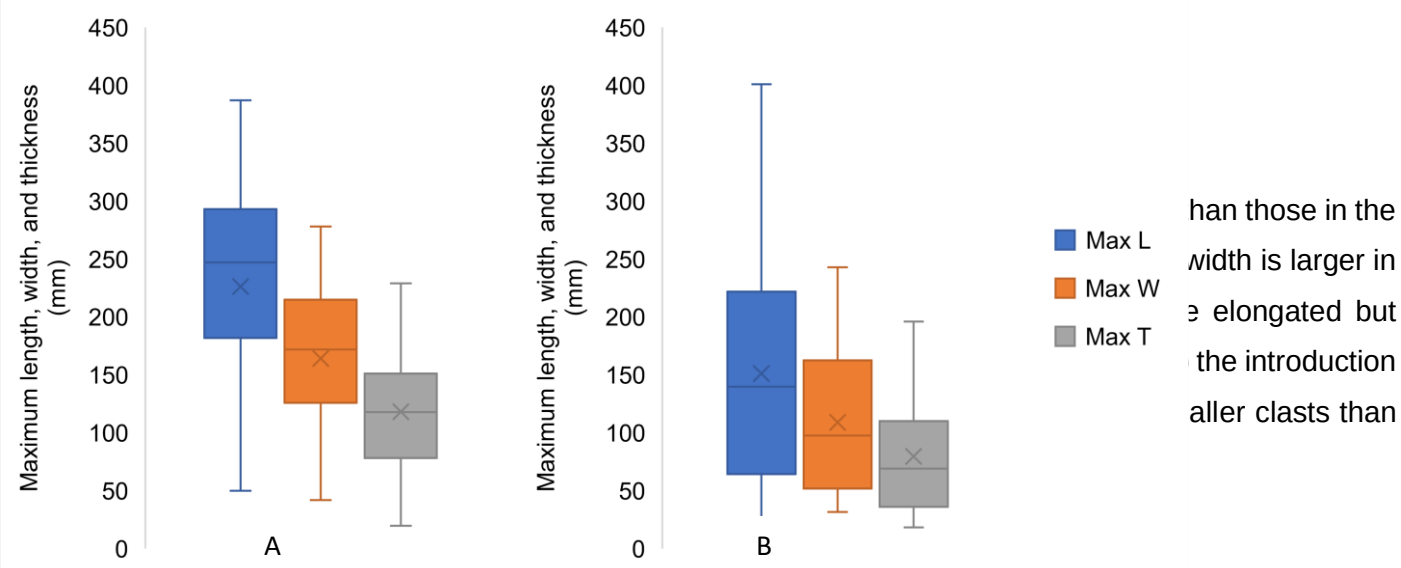
Figure 6.4: Organised Core Technology layer raw material frequency by idealised scheme

CCS becomes more prominent in the Organised Core Technology layer and was used in a few different core edge management strategies, including the only bipolar example, and with an equal distribution between bifacial and unifacial strategies. One example of BALP, BAP, BSP, and UAU1 each are made on CCS, indicating the material was managed in various ways. Overall, knappers from both layers were able to manipulate andesite and CCS variably but were slightly more restricted with other types. However, the low representation of these types needs to be considered and could be a result of less testing and selection of these materials.

6.3.4 Dimensions

Figures 6.5 A and B show the range of weights for both the Basal Early Acheulean and Organised Core Technology layers, with one artefact up to 23000g in the former. The total weight of the Basal Early Acheulean layer is 280707.7g, and 125750.7g in the Organised Core Technology layer. In general, the bulk of material is slightly heavier in the Basal Early Acheulean layer (A) and has a higher mean and median weight. As time progressed there was a selection of smaller clasts, even though they were relatively large compared to the standards seen in other early Acheulean assemblages.

Despite the difference in weight between the layers, the maximum length of cores is the similar (Figures 6.6 A and B), while the maximum width and thickness of cores in the Basal Early Acheulean layer are larger than those recorded in the Organised Core Technology layer. The



han those in the
width is larger in
e elongated but
the introduction
aller clasts than

Figure 6.5: Weight (g) ranges of the Basal Early Acheulean (A) and the Organised Core Technology (B) layers

A B

Figure 6.6: Range of maximum length, width, and thickness (mm) of the Basal Early Acheulean layer (A) and the Organised Core Technology layer (B)

The data presented in Figures 6.6 A and B are further confirmed when correlating the data with the weight of cores. Figure 6.7 is a scatterplot of the relationship between the increase of dimensions to volume in the Basal Early Acheulean layer, as there is an increasing correlation from length to thickness, showing how cores get bigger on all these fronts, especially thickness, as they increase in weight. The Organised Core Technology layer scatterplot in Figure 6.8 also shows a correlation between all the features, however they are more consistent and stay within the R^2 range of 0.7. The maximum length increases more steadily as the weight increases, with an R^2=0.781, confirming the trend that cores became more elongated in the layer.

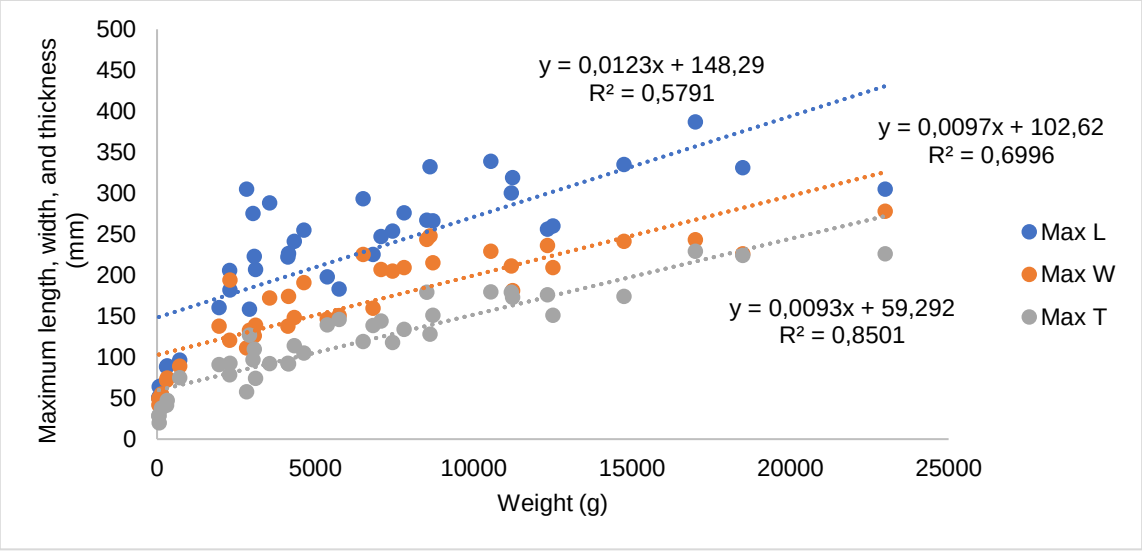


Figure 6.7: Correlation between the Basal Early Acheulean layer weight (g) and the maximum length, width, and thickness (mm) of cores

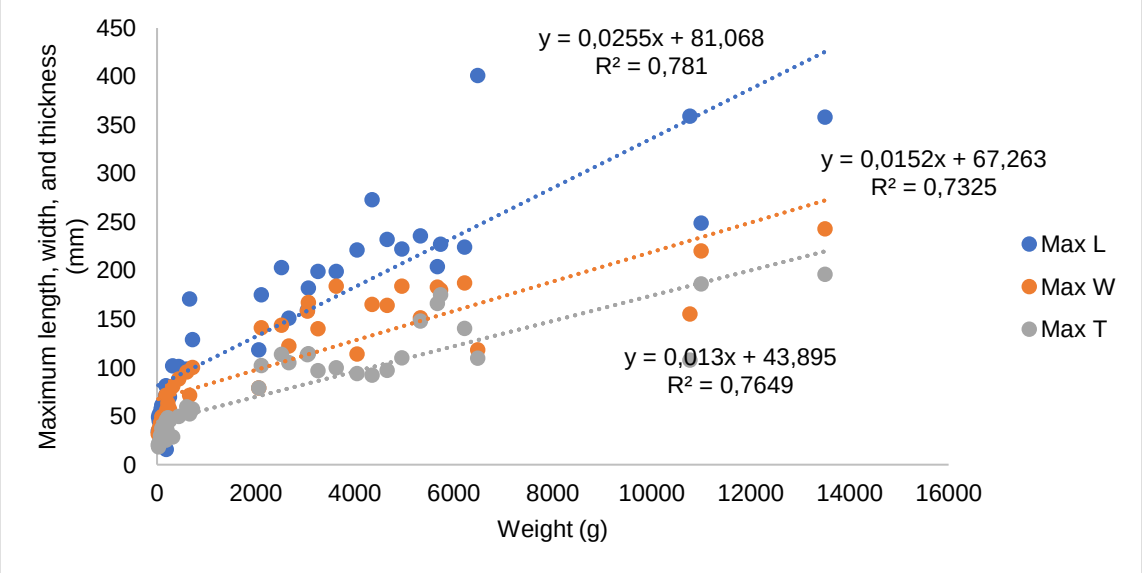


Figure 6.8: Correlation between the Organised Core Technology layer weight (g) and the maximum length, width, and thickness (mm) of cores

6.3.5 Core weight and idealised schemes

Figure 6.9 presents the weight ranges of the core reduction schemes in the Basal Early Acheulean layer. Most cores in the layer weigh >15000g with an average weight of 6351.2g. The widest variation in volume is the bifacial category, with a range of >20000g between the smallest and largest pieces and an average weight of 6195.7g. within the bifacial cores, BSP and BAP cores are the largest, with an average weight of 10591g and 11820.8g, respectively. BALP, BALT, BP, discoid, UAU2 and UP cores are smallest, and all pieces in those categories group <5000g, except for one BALP core. The largest categories of multifacial and TC cores tend to group <15000g, except for one multifacial core. Generally, there is a large variety of core size and volume in the Basal Early Acheulean layer and cores with more structured core edge management strategies tend to be smaller in volume but can also have the largest range in size. The layer appears to have been subject to periods of high energy forces which would explain the size range of clasts in the deposit (see Leader 2014, Figure 5.2.5: 196).

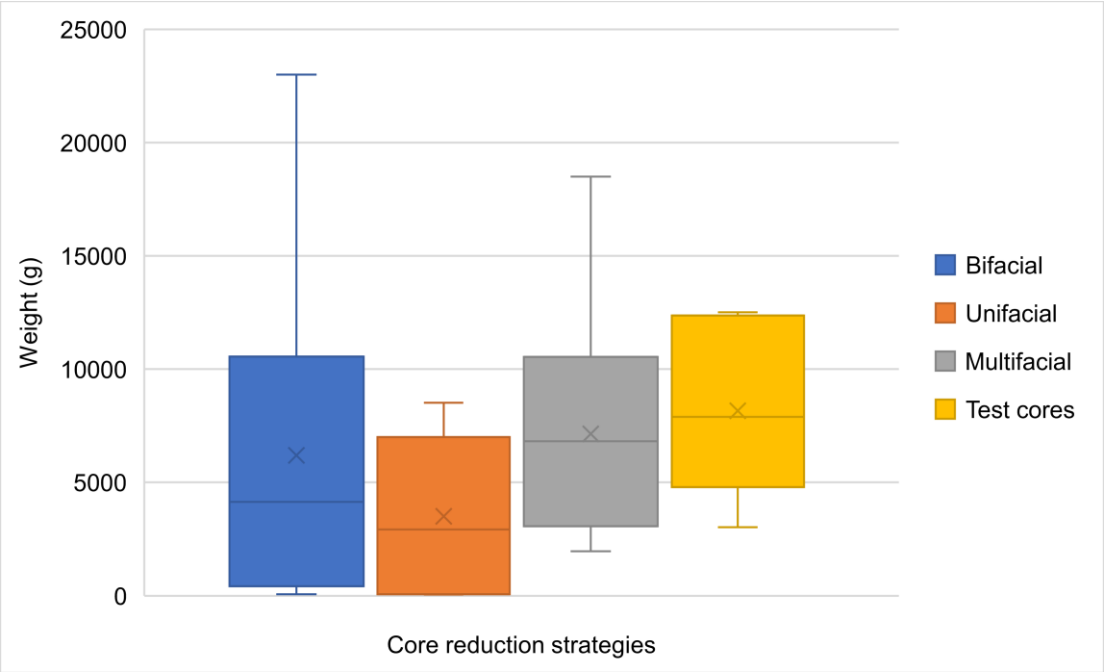


Figure 6.9: Basal Early Acheulean layer weight ranges of core reduction strategies

In the Organised Core Technology layer, the range of weight is much smaller than the Basal Early Acheulean layer, with most cores weighing <8000g and an average of 2740.3g (Figure 6.10). There is a fairly similar upper range in the categories BALP and USP, while BAP, BSP and multifacial have the heaviest pieces in the layer with an average weight of 3297.9g and three cores >10000g. The closest ranges of categories with more than one piece are BP and UP, with all pieces <5000g. Overall, the range of core volume is smaller in the Organised Core Technology layer.

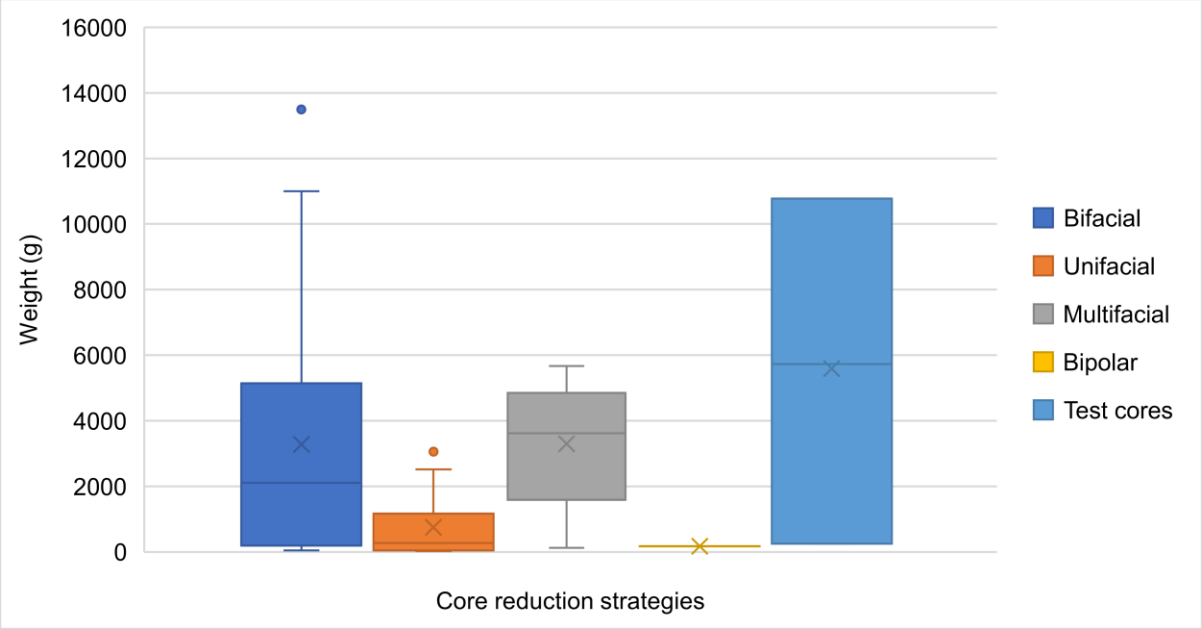


Figure 6.10: Organised Core Technology layer weight ranges of idealised schemes

6.3.6 Flake scars

The Basal Early Acheulean layer has an average of 5.8 scars per core and a highest scar count of 14 on a BALP core. In total there is an average of 5.8 scars per core in the Basal Early Acheulean layer. Within the sampled assemblage from this layer, bifacial cores have an average of 7.6 scars and unifacial cores average 2.8 scars. The discoid category has one piece with 12 scars, while the BP category has the highest average of 11 scars. BALT and BALP have 9.5 and eight scars on average, respectively, multifacial cores have 7.3 scars, and the three combined cores have an average scar count of 11.

In the Organised Core Technology layer, there is an average of 5.9 scars on all the scars, with two multifacial cores with 14 and 15 scars. The bifacial cores have an average of 6.5 scars and the unifacial scars have 4.2 scars. Overall, there is a decrease in scars on bifacial cores, but an increase on unifacial cores. BALT cores have the highest average of 10.3 scars, followed by multifacial cores with 9.4.

The relationship of core weight and number of flake scars is negatively correlated in the Basal Early Acheulean layer, as flake scars decrease as cores increase in size (Figure 6.11 A). LFS size is explored below, but it should be noted that large flakes are removed from boulders, often as blanks for LCT production. Thus, knappers were focusing more on creating these flake blanks than heavily exploiting the cores. In the Organised Core Technology layer, there is no correlation between core size and flake scar numbers, as there are multiple examples of smaller cores with more scars, and larger cores with fewer scars (Figure 6.11 B).

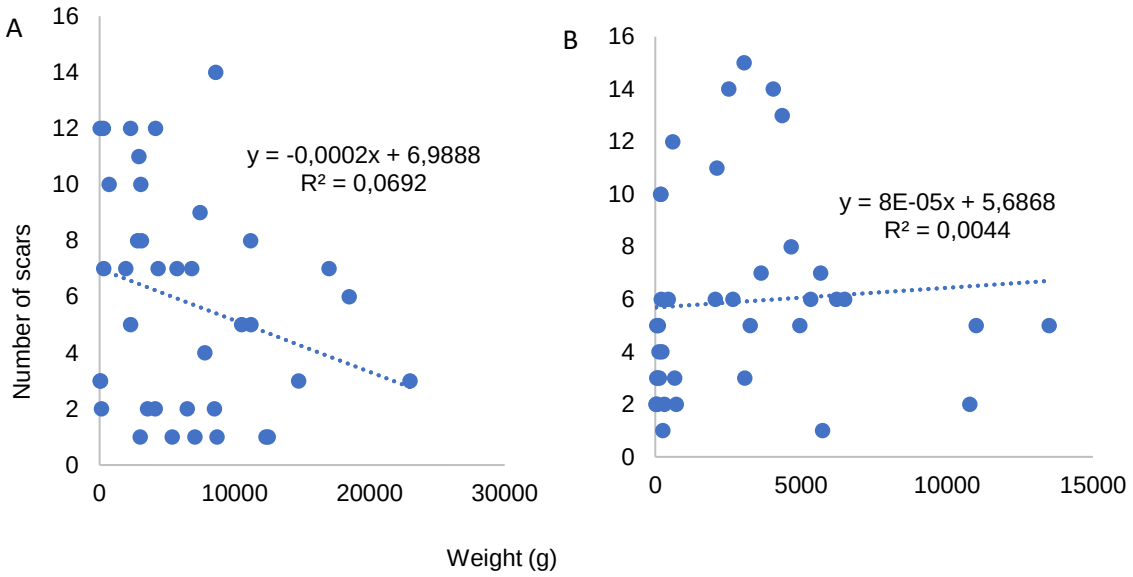


Figure 6.11: Correlation between the weight (g) and number of flake scars for the Basal Early Acheulean layer (A) and the Organised Core Technology layer (B)

6.3.7 Core blanks

Compared with the underlying layer, more core blank types appear in the Organised Core Technology layer, as do raw material types (Figure 6.12). The majority of blank types in the Basal Early Acheulean layer are boulders, followed by cobbles, which agrees with the data on the large size of cores in the layer. Boulders and cobbles are defined here by the Wentworth scale. Cobbles become dominant in the Organised Core Technology layer, which includes blanks with more angular edges such as chunks, and facetted cobbles. The average for the Basal Early Acheulean layer is 6351.17g and 2740.34g Organised Core Technology layer core blanks.

Figure 6.13 is a bar graph representing the raw material distribution of blanks for both layers. In the Basal Early Acheulean layer all pieces are made on andesite, except for the three quartzite cores, which are all made on split cobble blanks. The other raw materials in this graph (hornfels and CCS), are all found in the Organised Core Technology layer.

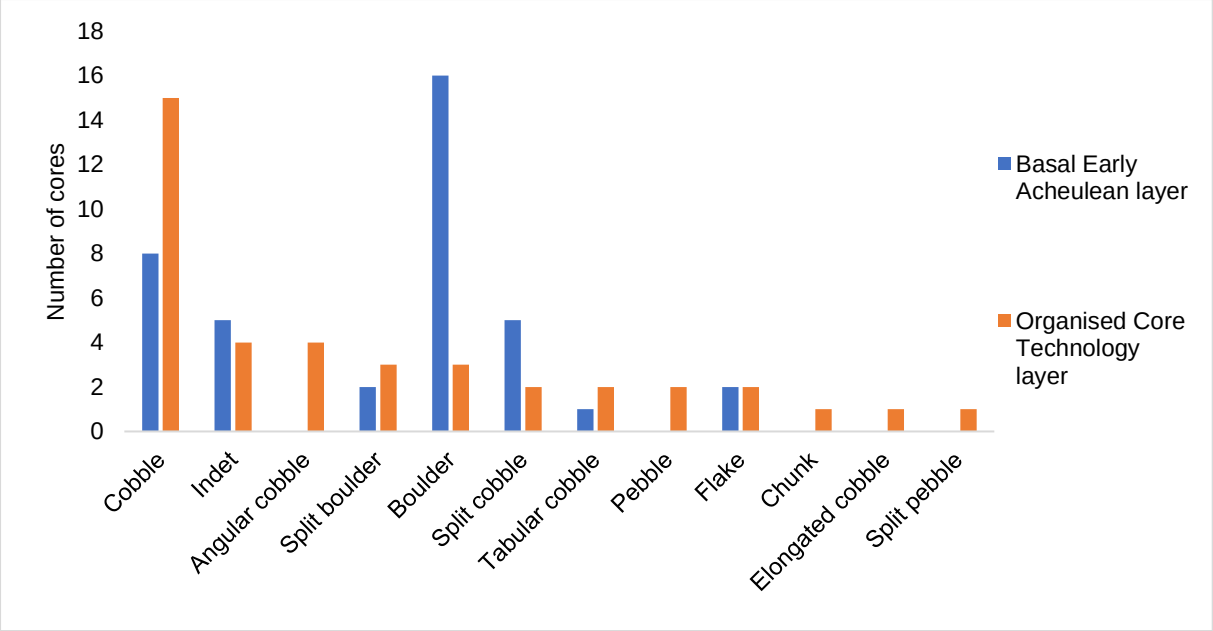


Figure 6.12: Core blanks for Basal Early Acheulean and Organised Core Technology layers

The distribution of raw materials between blank types is less varied than between idealised schemes. Apart from the hornfels piece and a CCS flake, all the non-andesite blanks are either cobbles (sometime split cobbles), or pebbles. These pieces would have had rounded edges and be smaller in size, while knappers had a larger variety of blank types in andesite, which itself came in different shapes. The presence of boulders in the assemblage means that there would also naturally be a larger range in the weight of blank types (see Sharon 2009 for discussion around large cores), but the other categories tend to have similar ranges.

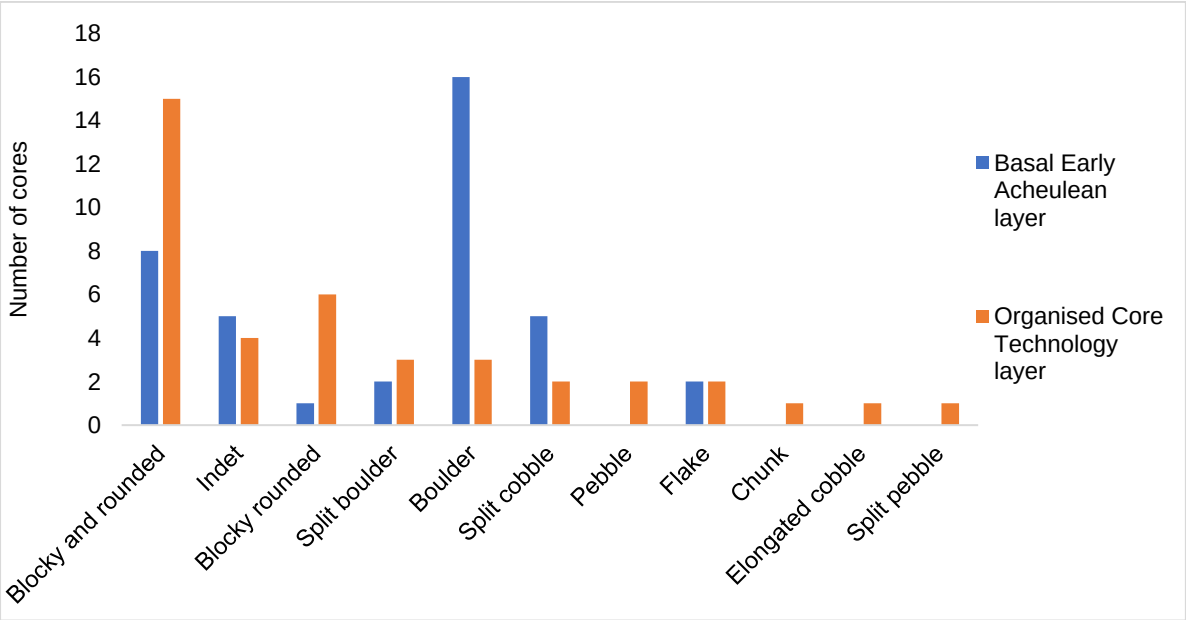


Figure 6.13: Raw material distribution by blank type for Basal Early Acheulean and Organised Core Technology layers combined

Figures 6.14 and 6.15 presents the percentage of blank types for core reduction strategies. in the Basal Early Acheulean layer, boulders are most common and spread between all the strategies, with only one example in the unifacial group. In the Organised Core Technology layer, most of the various blank types are either bifacial or unifacial, but more boulders are exploited bifacially.

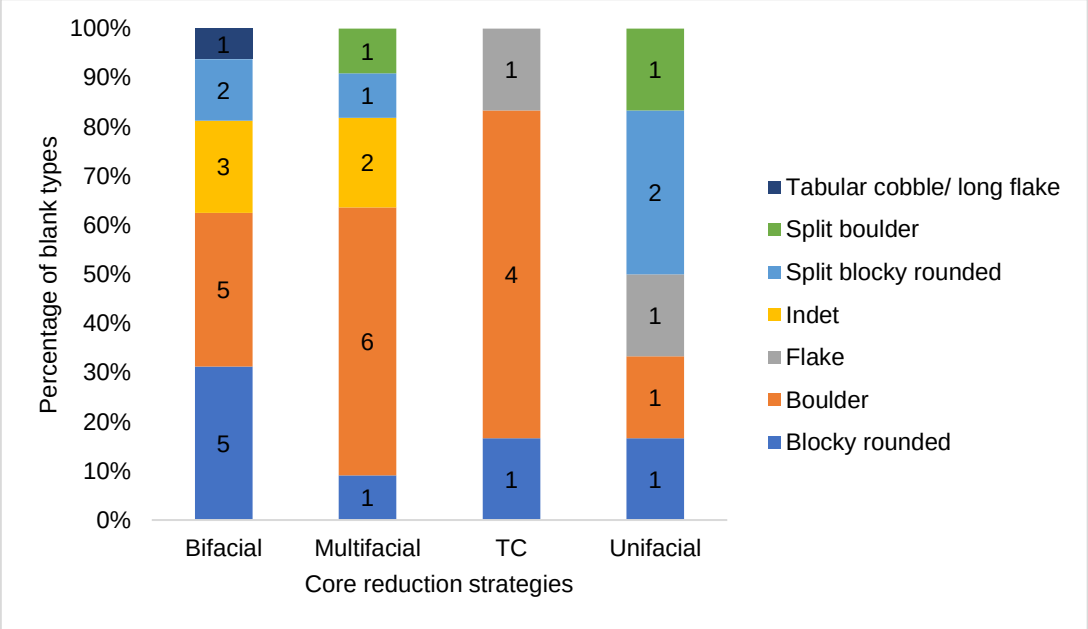


Figure 6.14: Percentage of blank types in the core reduction strategies in the Basal Early Acheulean layer

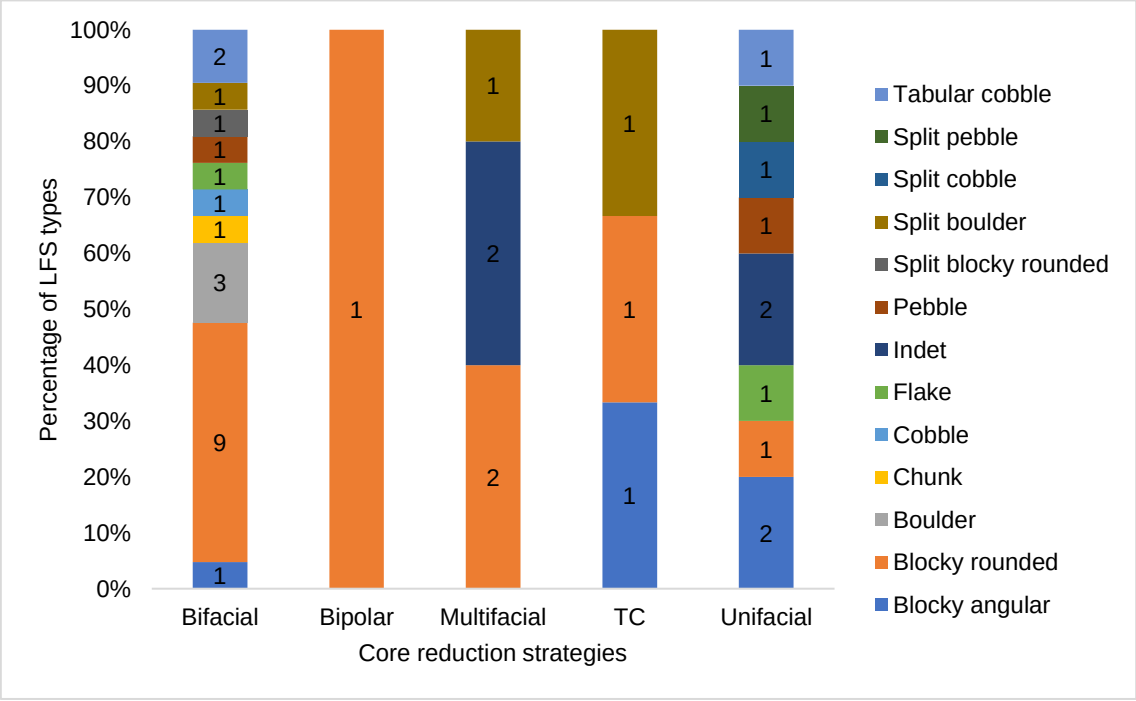


Figure 6.15: Percentage of blank types in the core reduction strategies in the Organised Core Technology layer

6.3.8 Largest flake scars

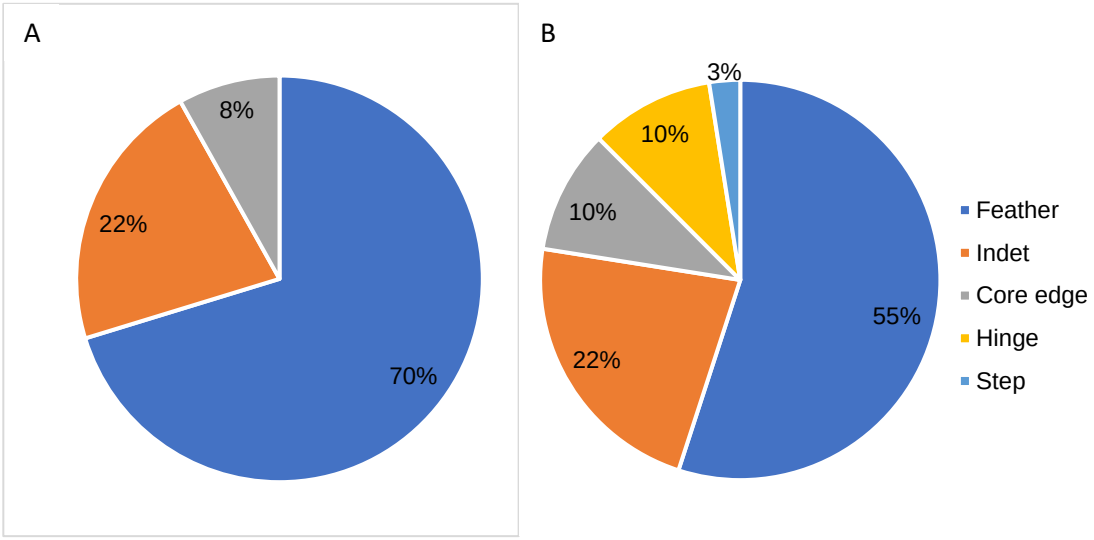


Figure 6.16: Frequency of largest flake scar types in the Basal Early Acheulean layer (A) and Organised Core Technology layer (B)

Feather terminations (Figures 6.16 A and B) are most common in cores from both layers (70% in Basal Early Acheulean layer, and 55% in Organised Core Technology layer). However, as with other features discussed, more types emerge in the Organised Core Technology layer. Due to the level of weathering on the artefacts, 30% of LFS types in the Basal Early Acheulean layer and 32% in the Organised Core Technology layer could not be identified. With the appearance of hinge and step terminations in the Organised Core Technology layer, feather terminations decreased, but the persistent types from the Basal Early Acheulean layer did not reduce much. This could be related to the change in the raw material types, or idealised scheme applied to the core, which in explored below.

In the Basal Early Acheulean layer (Figure 6.17), feather terminations occur in every idealised scheme, meaning knappers were successful at removing sharp flakes with all strategies. Feather and indeterminate scars evenly occur in BALT, BAP and USP cores, but again this does not infer anything specific because it could be due to weathering.

In the Organised Core Technology layer (Figure 6.18), there are no feather terminations in BALT and UP cores, and the singular bipolar core. Overall, there are more feather terminations in the bifacial cores than the unifacial ones. There are also more flakes with mistakes (step and hinge) in the bifacial categories. This could be due to the fact that the bifacial cores have a higher average scar count and so there would be more opportunity for flaking mistakes. Again, this is a sampled assemblage and only represents 11.5% of the cores. This would have to be tested against the rest of the cores to confirm if knappers were normally as successful in producing sharp flakes with bifacial strategies.

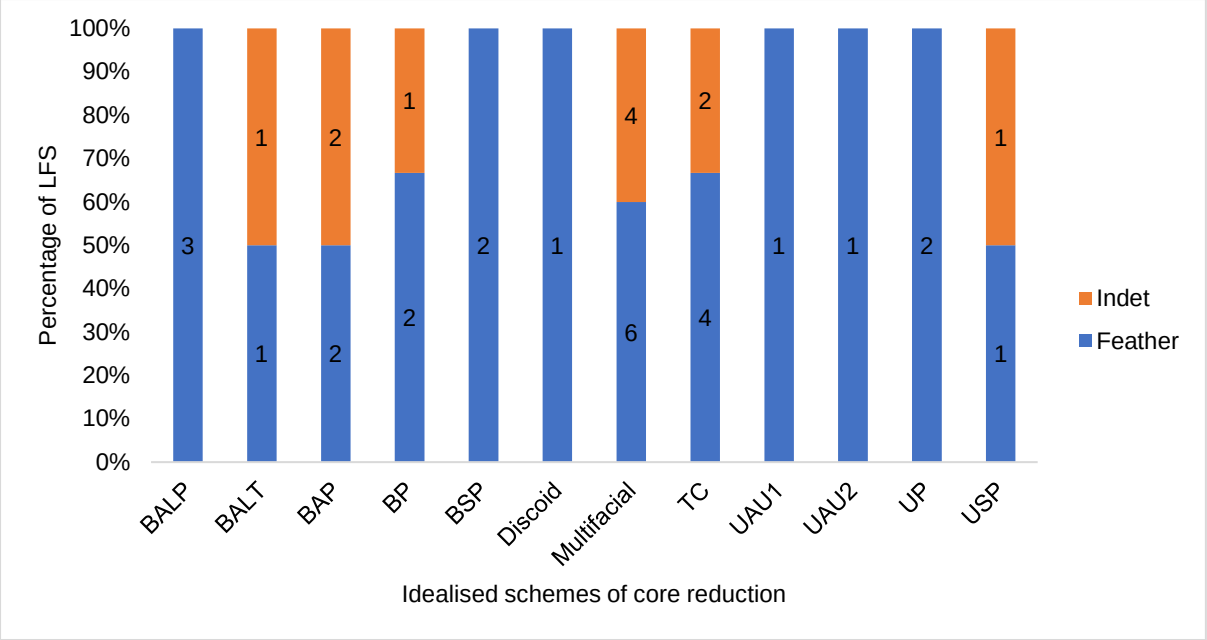


Figure 6.17: Distribution of the largest flake scar by idealised scheme in the Basal Early Acheulean layer

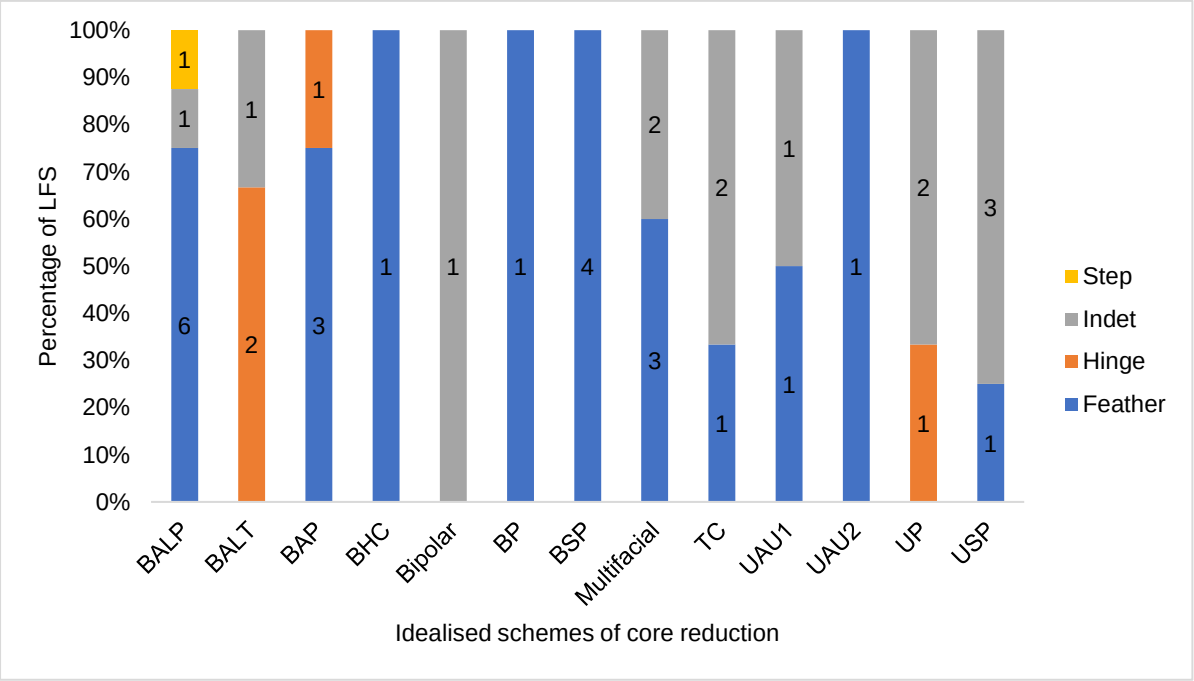


Figure 6.18: Distribution of the largest flake scar by idealised scheme in the Organised Core Technology layer

Figure 6.19 presents the raw material types for the LFS data. Within the Basal Early Acheulean layer, there are only two raw materials, and the three quartzite pieces from the layer all have feather terminations, so they were grouped together for an overall picture. Feather terminations occur in every raw material type, except for the singular hornfels piece with a

hinge fracture. Indeterminate scars do not occur on any quartzite pieces, only andesite and CCS. This could be because the quartzite does not weather the same and therefore scars are more obscured on the other raw material types. Despite the level of weathering across the assemblage, knappers were able to produce sharp edged flakes more regularly than other termination types.

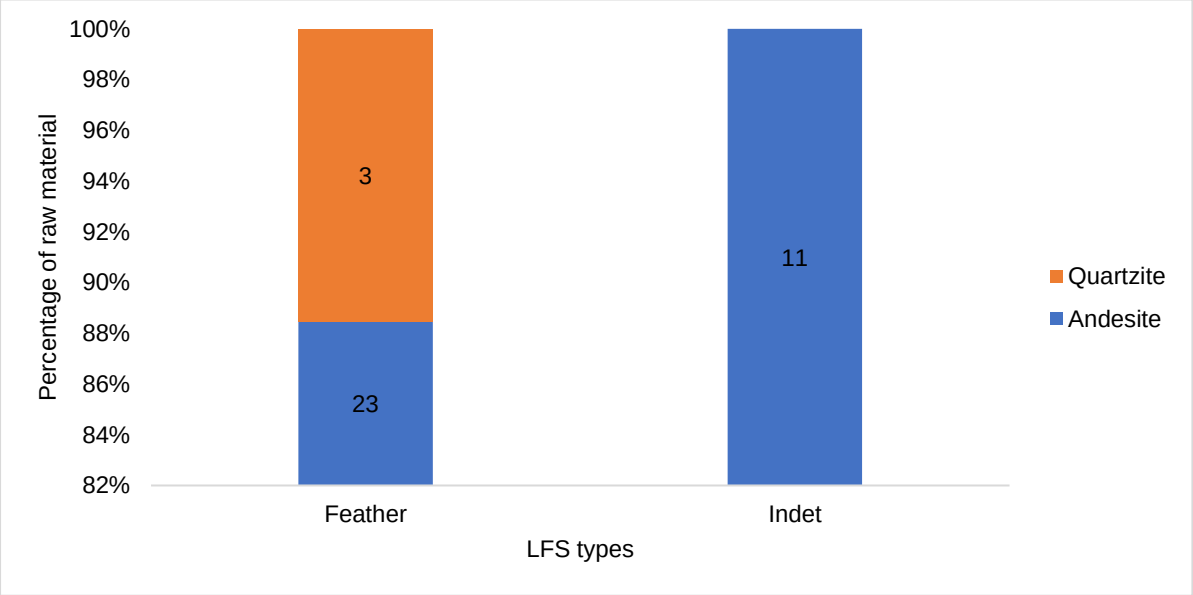


Figure 6.19: Largest flake scar types by raw material for the Basal Early Acheulean layer

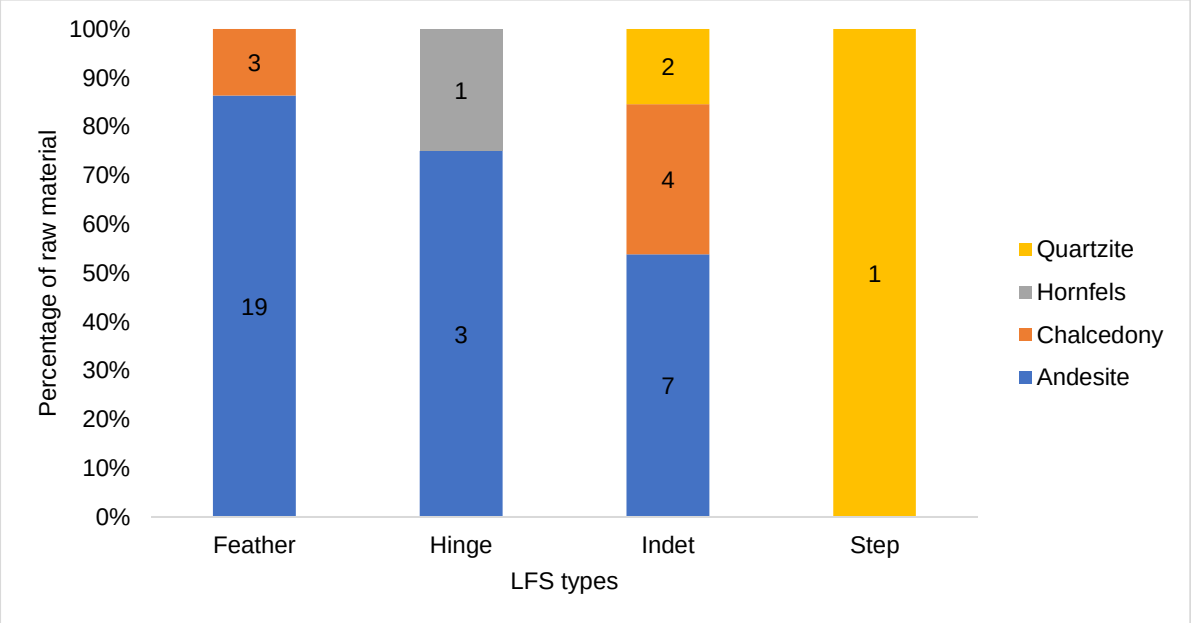


Figure 6.20: Largest flake scar types by raw material for the Organised Core Technology layer

The LFS sizes are consistent across both layers, with a significant correlation between LFS length and width (R^2=0.7902 for the Basal Early Acheulean layer and R^2=0.7613 for the Organised Core Technology layer) (Figures 6.21 A and B). Flake scars are longer and wider in larger cores, and it could be argued that overall flakes are wide relative to their length and have sharp edges. These would all be factors that could be useful to LCT production.

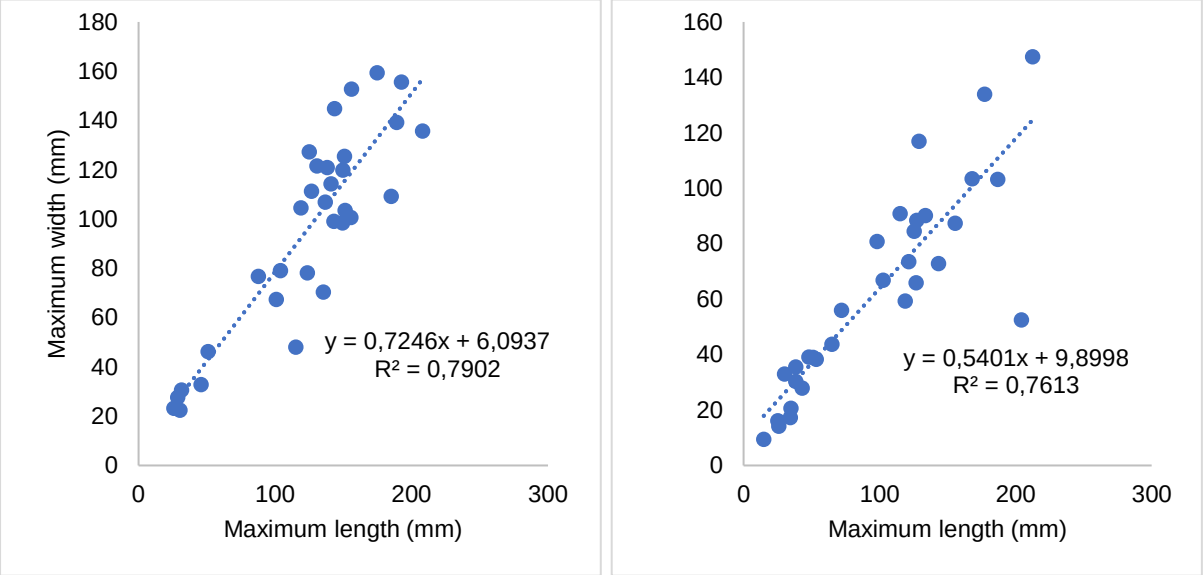


Figure 6.21: Correlation between the maximum length and width (mm) of the largest flake scars for the Basal Early Acheulean layer (A) and Organised Core Technology layer (B)

6.3.9 Diacritical analyses of cores

Basal Early Acheulean layer

BALT core

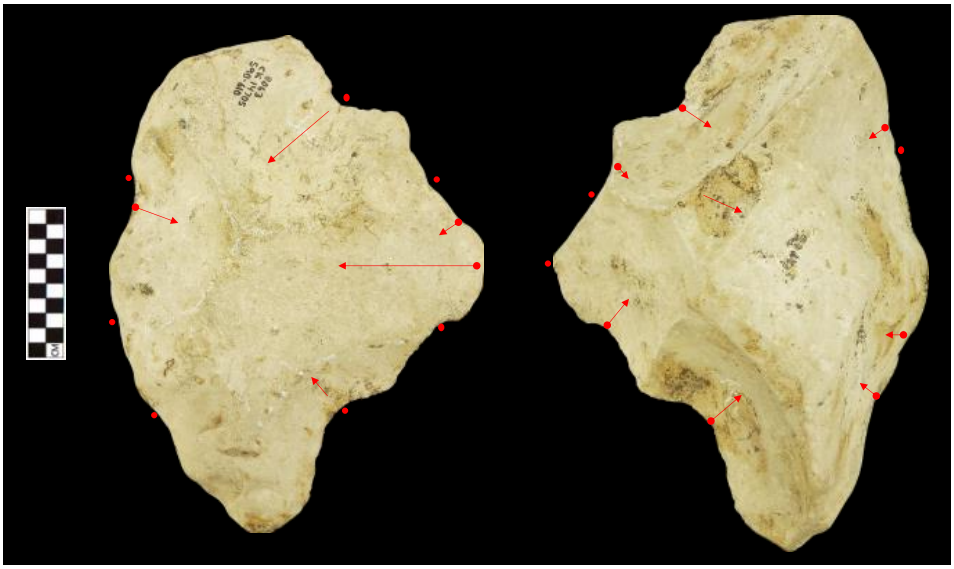


Figure 6.22: Artefact CK 14705

Figure 6.22 is a large core made on an andesite boulder blank. It has removals all around the edge, but the most and largest scars are focused on one side. The scars are organised in an alternating bifacial pattern, and thus the core is categorised as BALT. The LFS on this piece is 151.4 × 103.5mm, which fits within the LCT dimensions (described in section X) and means it is likely an LCT core.

BP cores



Figure 6.23: Artefact CK 14883

Figure 6.23 is a BP andesite core with 12 scars made on an indeterminate blank. The view on the right image of Figure 6.26 is possibly a split surface but the level of weathering makes it hard to discern. This piece is not likely an example of an LCT core because it is under 10cm in length, and the flake scars are smaller than the LCT size range. Also, higher numbers of flake scars are associated with smaller cores in the Basal Early Acheulean layer, as indicated in Figure 6.14.

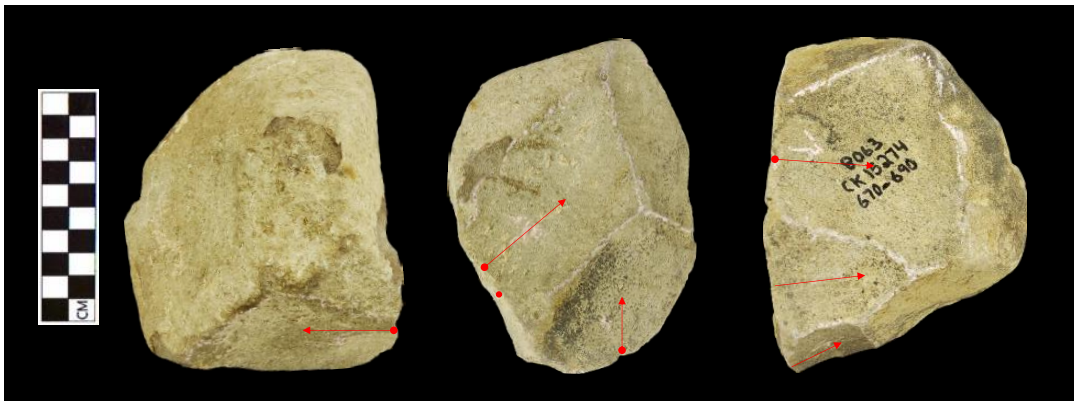


Figure 6.24: Artefact CK 15274

Figure 6.24 is a large BP core made on an andesite cobble blank with large flake scars and between 25-50% remaining cortex. The LFS ends in a feather termination and is indicated on

the left image. It measures 103.9 × 79.1mm which fits the LCT size range. This is another example of a core with flake scars large enough to be considered an LCT core.

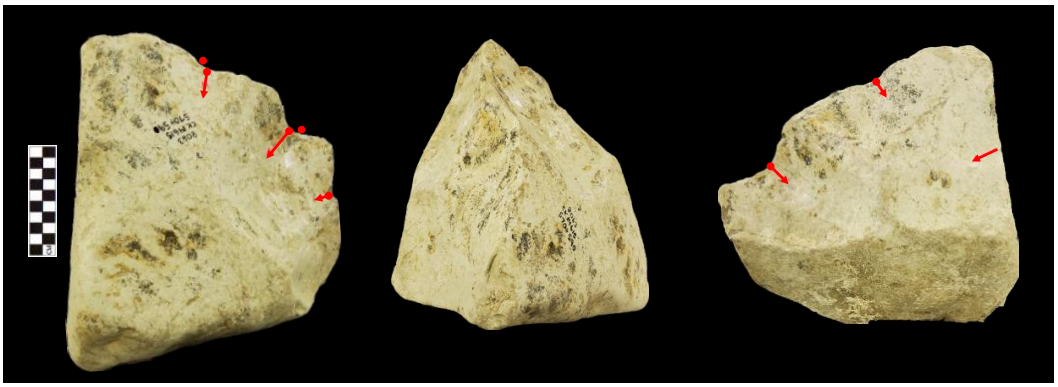


Figure 6.25: Artefact CK 14615

Figure 6.25 is the largest core in the Canteen Kopje Pit 6 assemblage and weighs 23000g (the exact weight could not be read on a digital scale and a regular bathroom scale was used). It is made on an angular andesite boulder which had a rough pyramid shape and flat surfaces. There are six large flake scars in a BSP sequence along the 'crest' of the boulder blank. Flakes were first removed along the surface presented on the right side of Figure 6.31, followed by the opposite surface. Despite the large size of the piece, the worked edge is <90° so does not have an abrupt angle. The LFS measures 192.7mm × 155.6mm, which is much larger than the 10cm flake blanks needed for LCT production (following Isaac 1969), and so this piede is classified as an LCT core.

Discoid core

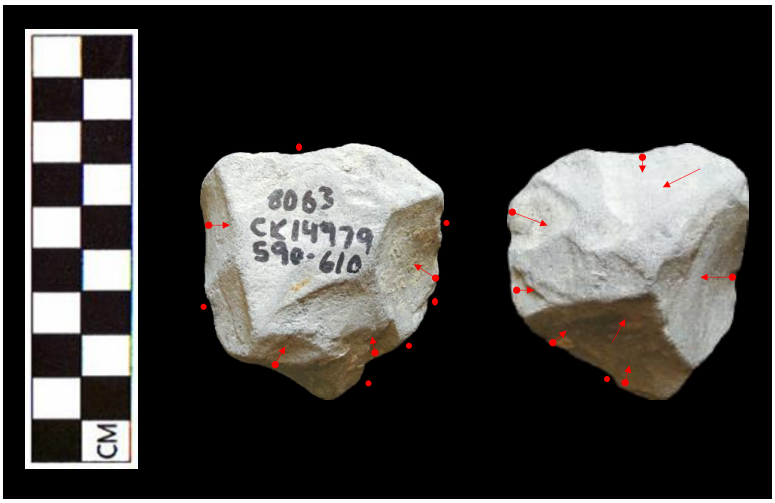


Figure 6.26: Artefact CK 14979

Figure 6.26 is an andesite discoid core with an unknown blank as it has been heavily reduced. There are 12 scars in total going around the entire edge, and some scars overlap previous removals, so the scar count is likely smaller than the full extent of reduction. The edge management shows a continuous rotation of the piece and reduction of the central volume. The alternation of flake scars means this piece also falls into the BALT category of idealised schemes but has been classified as discoid because the central volume is successfully reduced.

USP core



Figure 6.27: Artefact CK 15327

Figure 6.27 is a small USP core made on a split quartzite rounded cobble blank with three scars on the split surface. The core appears heavily weathered and there are no clear indications of battering except for the faint remnants of pounding activity to split the piece (indicated by the red circle).

Organised Core Technology layer

BALP cores



Figure 6.28: Artefact CK 12247

Figure 6.28 is BALP core and one of the few CCS artefacts in the Organised Core Technology layer. The blank is a split clast, or possibly a flake. There are 10 flake scars focused around one side in an alternating bifacial sequence. The scars are small and do not travel far into the central mass of the blank.

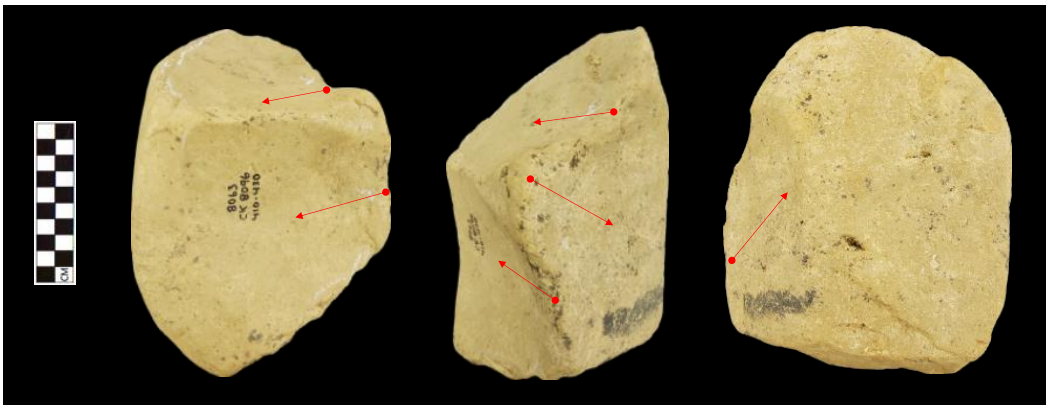


Figure 6.29: Artefact CK 8096

Figure 6.29 is a large BALP core made on an andesite boulder with three large removals on one side. All the scars are large with the LFS measuring 129 × 117mm, which is well within the range of LCT flake blank dimensions, and this piece is therefore an LCT core. There are no further attempts at knapping, and it follows the pattern that larger cores generally have fewer flake scars.

BALT cores

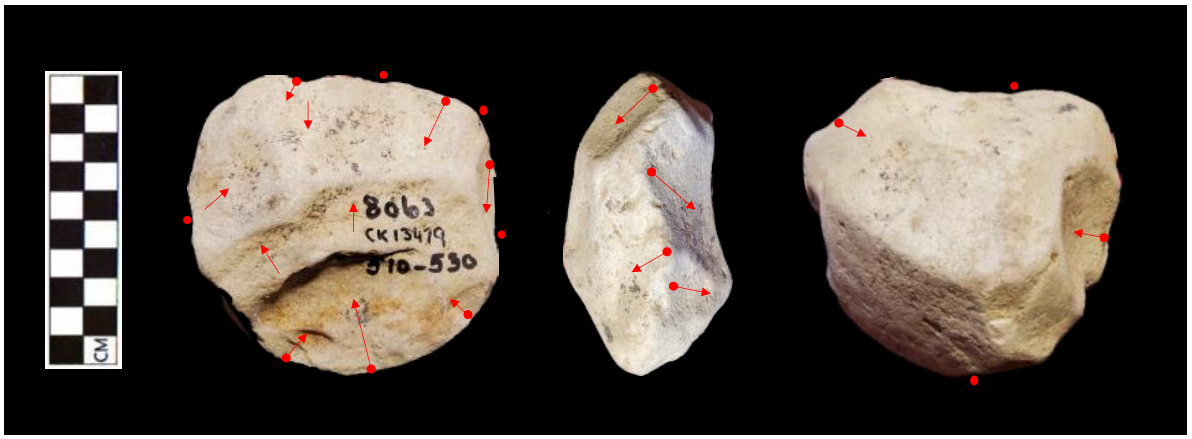


Figure 6.30: Artefact CK 13479

Figure 6.30 is a BALT core made on an andesite cobble with 12 scars. The surface presented on the far left is flat and has no cortical surface, whereas some remains on the opposing surface. The cortex indicates that the knappers were unable to remove the full central volume resulting in an asymmetrical core. It fits into the classification of 'organised core' as defined by Leader (2014). The LFS was removed towards the end of the reduction sequence on the preferential surface, right before a small scar on its left side. The LFS terminates in a hinge fracture and was unable to remove a section of the central volume on the flat surface, after which the core was abandoned. Similar to the discoid and BALT cores in the Basal Early Acheulean layer, the core is too small to be part of the LCT production and has a higher scar count.

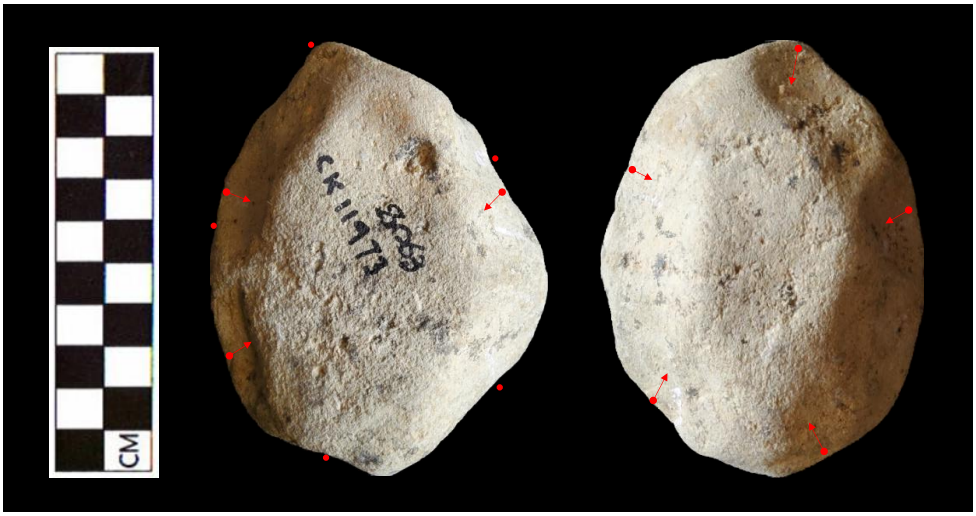


Figure 6.31: Artefact CK 11973

Figure 6.31 is a heavily rolled BALT core made on an andesite blank. Due to the level of weathering, not all flake scars are evident, but the shape of the edge indicates a continuous removal of alternating flakes on both surfaces. The six scars with arrows are the most evident examples. Like other cores with continuous reduction strategies, it is small and cannot be part of the LCT production process.

BHC core

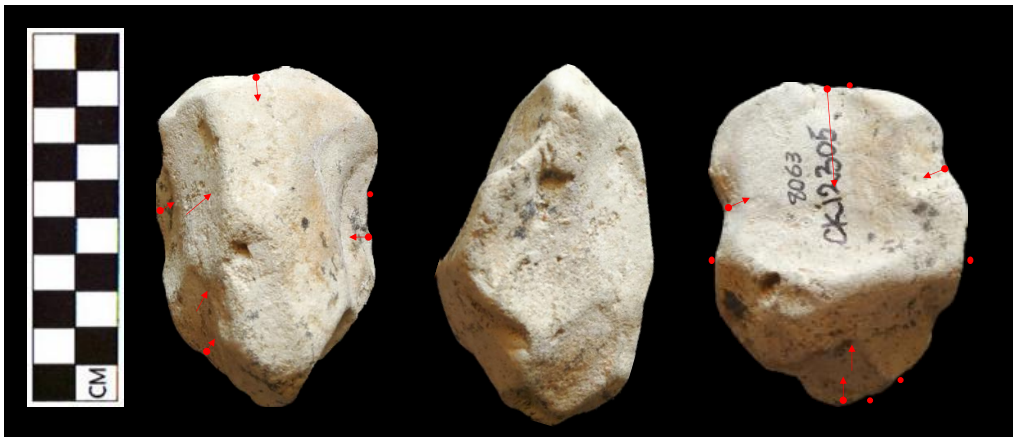


Figure 6.32: Artefact CK 12305

Figure 6.32 is a BHC core with a preferential removal on one surface. The core is small and quite rolled, but there are multiple scars on both surfaces and the final product is asymmetrical. This classifies as an organised core as defined by Leader (2014), as well as a BHC in the idealised core reduction scheme. The final removal (indicated by the artefact number) is the LFS and the preferential flake scar, which ends in a feather termination. The core edge management in structured and continuous, with a full rotation of the piece.

BP core

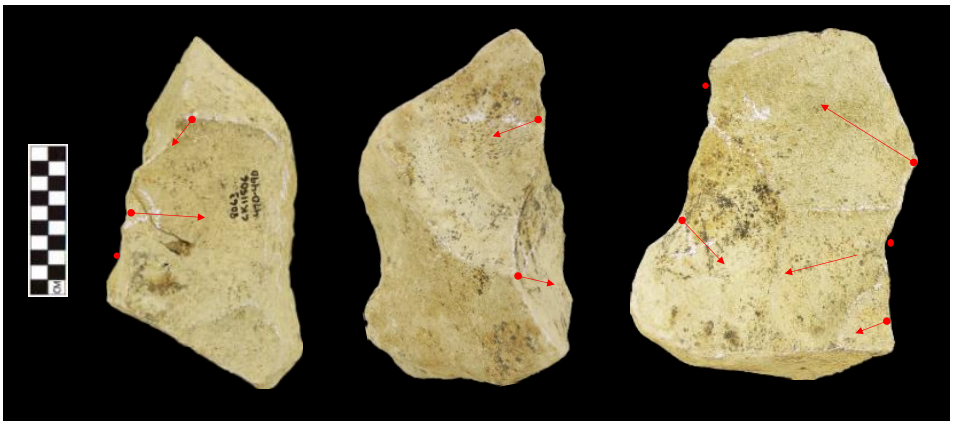


Figure 6.33: Artefact CK 11506

Figure 6.33 is a large andesite BP core made on a boulder blank with six flake scars, four of which are on one surface. The final product is an asymmetrical core with large removals on the flat surface and again fits into the organised core group defined by Leader (2014). One side of the flat surface has two scars removed in an alternating sequence, while the other side has four scars, three of which are on the flat surface. The flake scars are large, and the LFS is 133.8 × 90.2mm which fits with the LCT dimensions. Therefore, this is most likely an LCT core.

Multifacial cores



Figure 6.34: Artefact CK 12132

Figure 6.34 is made on a small quartzite rounded cobble blank and is very fresh, unlike most of the assemblage. A large section of the clast was removed and used as a platform for three scars, two large and a small scar ending in a step fracture. Despite the creation of a platform with multiple scars, the piece is classified as multifacial core because there are also two scars overlaying the large first removal. In total there are three platforms and surfaces exploited with five removals if you include the original scar. The platform is also the LFS which removed a large portion of the blank.



Figure 6.35: Artefact CK 13481

Figure 6.35 is a large andesite multifacial core with 14 scars. The blocky nature of the blank means that multiple surfaces had a few unidirectional flake scars, but this is not consistent throughout the piece, as some surfaces only have one removal, or they go in different directions from the same platform. The core is over 20cm in length with large flake scars and could be an LCT core, but the LFS was not measured because the weathering on the piece made the edges hard to discern.

6.4 LCTs

6.4.1 Raw material

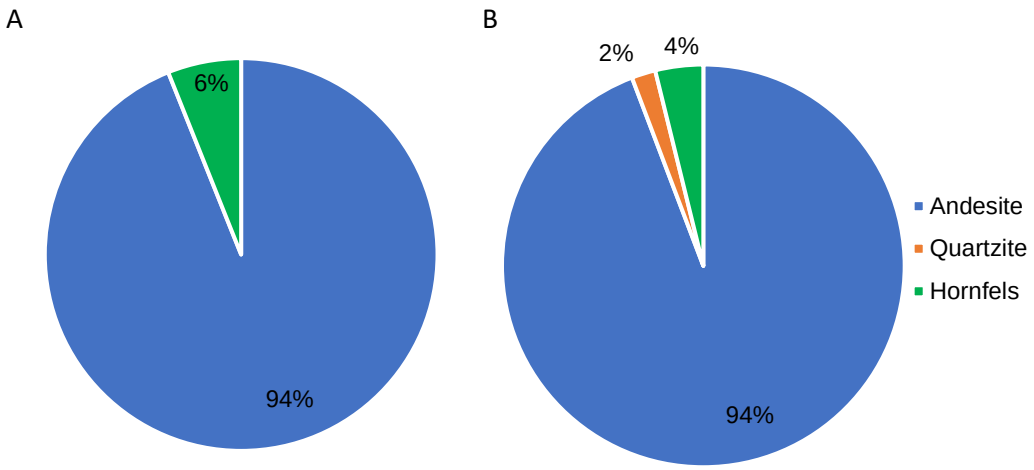


Figure 6.36: Raw material representation in the LCT assemblages for the Basal Early Acheulean layer (A) and the Organised Core Technology layer (B)

The raw material distribution of the sampled LCTs is dominated by andesite, representing 94% in each category (Figures 6.36 A and B). The main difference between the LCT and core assemblages is that the Organised Core Technology layer has three examples of LCTs made on quartzite and hornfels, while the Basal Early Acheulean layer has none. The sampled Organised Core Technology layer has multiple raw material types in the core assemblage, while the Basal Early Acheulean layer has only andesite and quartzite. This dataset is a sample of the total collection, and Leader (2014) describes the whole assemblage consisting of andesite and hornfels, except for three 'other' pieces in the Organised Core Technology layer.

6.4.2 Weight and dimensions of LCTs

The total weight of the Basal Early Acheulean layer LCT assemblage is 19554g and the total weight in the Organised Core Technology layer is 23924.2g (Figure 6.37). The mean weight is higher in the Basal Early Acheulean layer (592.5g) compared to the Organised Core Technology layer (469.1g). Overall, the LCT assemblages follow the same trend as the cores, with smaller blanks and final products in the Organised Core Technology layer compared to the Basal Early Acheulean.

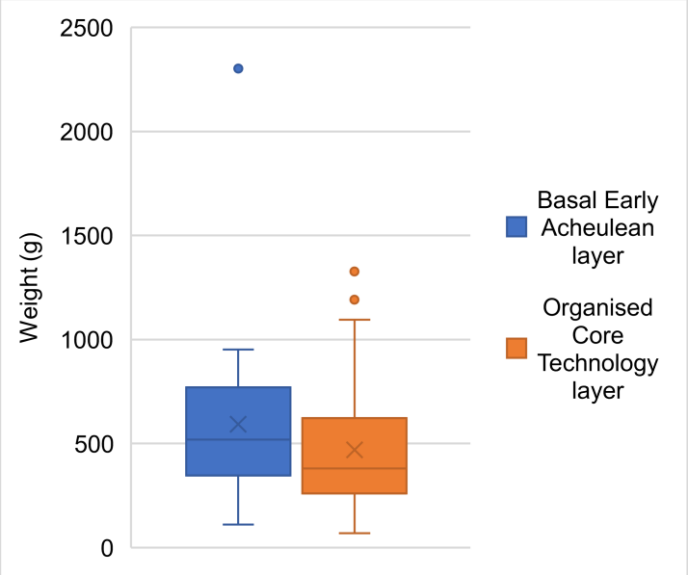


Figure 6.37: Box and whisker graph of the weight (g) range of LCTs in the Basal Early Acheulean and Organised Core Technology layers

The maximum length, width, and thickness of LCTs from both layers is presented in boxplot format in Figures 6.38 A (Basal Early Acheulean layer) and 6.38 B (Organised Core Technology layer). While the Basal Early Acheulean layer is heavier, the maximum length of LCTs is separated by only 0.5mm (182mm in the Basal Early Acheulean layer and 181.5mm in the Organised Core Technology layer). The means and medians are also similar in both (138mm and 138.1mm respectively in the Basal Early Acheulean layer and 129.7mm and 130.5mm respectively in the Organised Core Technology layer).

The Organised Core Technology layer width range is larger than the Basal Early Acheulean but still has a lower mean and median (78mm and 76.1mm) than the Basal Early Acheulean layer (86.4mm and 86.5mm). The thickness range is also similar between the layers, with means of 39.8mm and 38.2mm for the Basal Early Acheulean and Organised Core Technology layers, respectively. Even though the overall weight of the Basal Early Acheulean layer surpasses the Organised Core Technology layer, the dimensions of the LCTs are not too dissimilar.

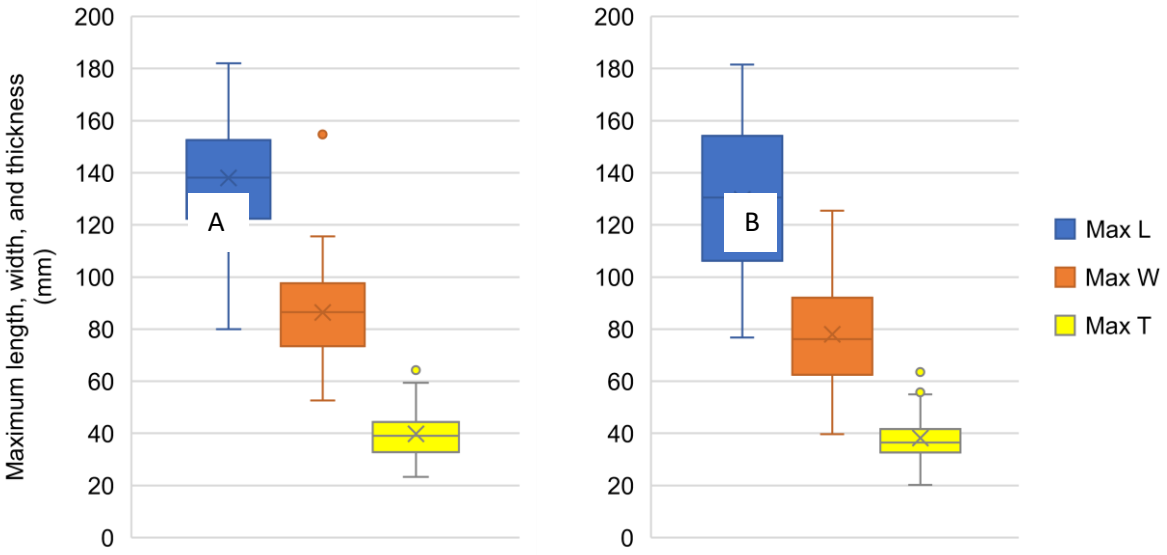


Figure 6.38: Box and whisker graph of the maximum length, width, and thickness (mm) of LCTs in the Basal Early Acheulean layer (A) and the Organised Core Technology layer (B)

The correlation of weight to maximum length, width, and thickness (Figures 6.39 and 6.40) is strong in both layers. Maximum width is most correlated to weight increase in both layers (R^2=0.7319 in the Basal Early Acheulean layer and R^2=0.8485 in the Organised Core Technology layer). Other Organised Core Technology layer dimensions are also more significant than the Basal Early Acheulean layer with a length correlation of R^2=0.5548 and R^2=0.7573, and a thickness correlation of R^2=0.6282 and R^2=0.7609, respectively. Therefore, LCTs were smaller in the Organised Core Technology layer, but LCTs were more consistent in the increase of all dimensions in relation to each other.

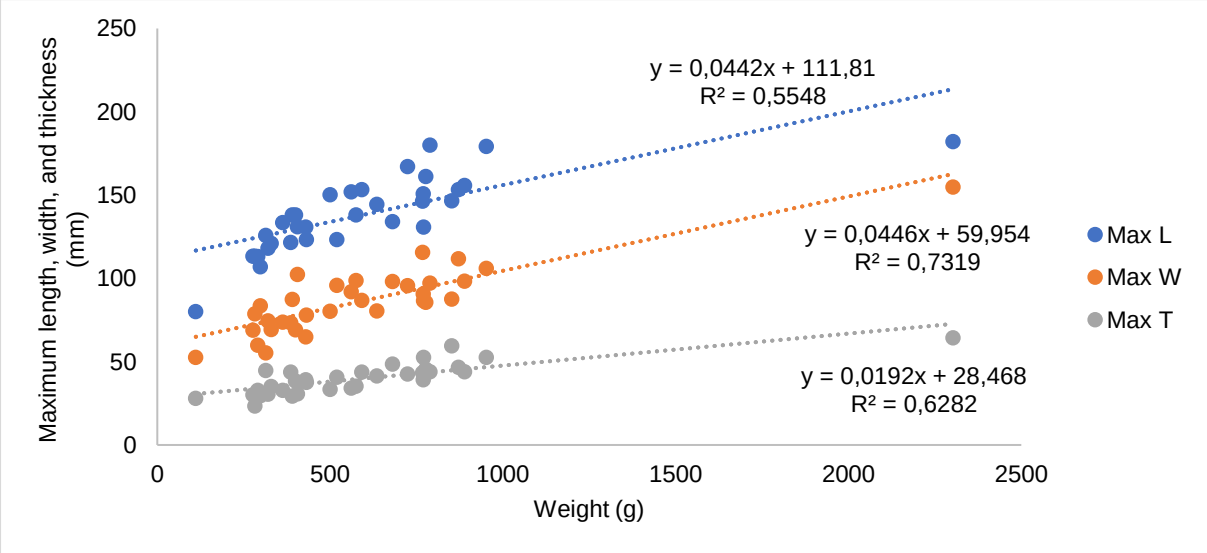


Figure 6.39: Correlation between weight (g) and maximum length, width, and thickness (mm) of LCTs in the Basal Early Acheulean layer

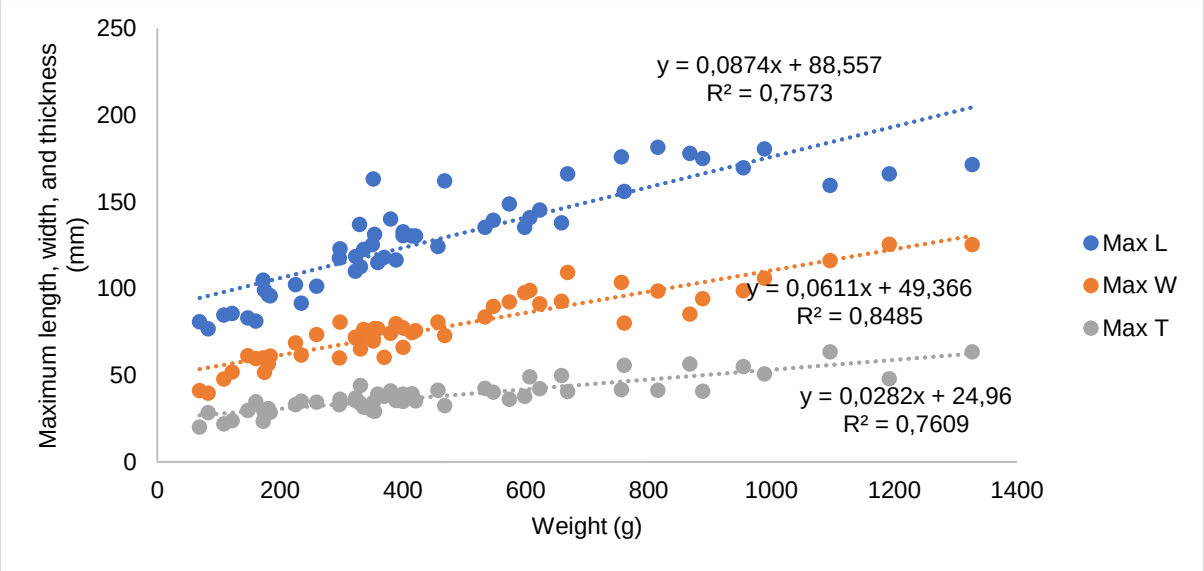


Figure 6.40: Correlation between weight (g) and maximum length, width, and thickness (mm) of LCTs in the Organised Core Technology layer

6.4.3 Refinement Index

To understand the extent of thinning in the LCT assemblage, a Refinement Index was calculated (following Roe 1969). The maximum thickness was divided by the maximum width of all the pieces in each layer (T/W). In the Basal Early Acheulean layer, the Refinement Index is 0.47, and in the Organised Core Technology layer the result is close at 0.50. Refinement in LCTs is thus the same across both layers. The average thickness of LCTs in both assemblages is just under half the maximum width. Therefore, the thickness of LCTs in both layers could be due to the shape of the flake blanks. This data will be compared with the other sites in the discussion to understand these patterns between assemblages.

6.4.4 LCT blanks

Flakes are the most common blank type in the LCT assemblages of both layer (Figure 6.41). There are also many cobble blanks in the Organised Core Technology layer, which are described here as blocky with rounded edges. The amount of flake blanks in the assemblages could be related to the high number of boulder cores with large flake removals.

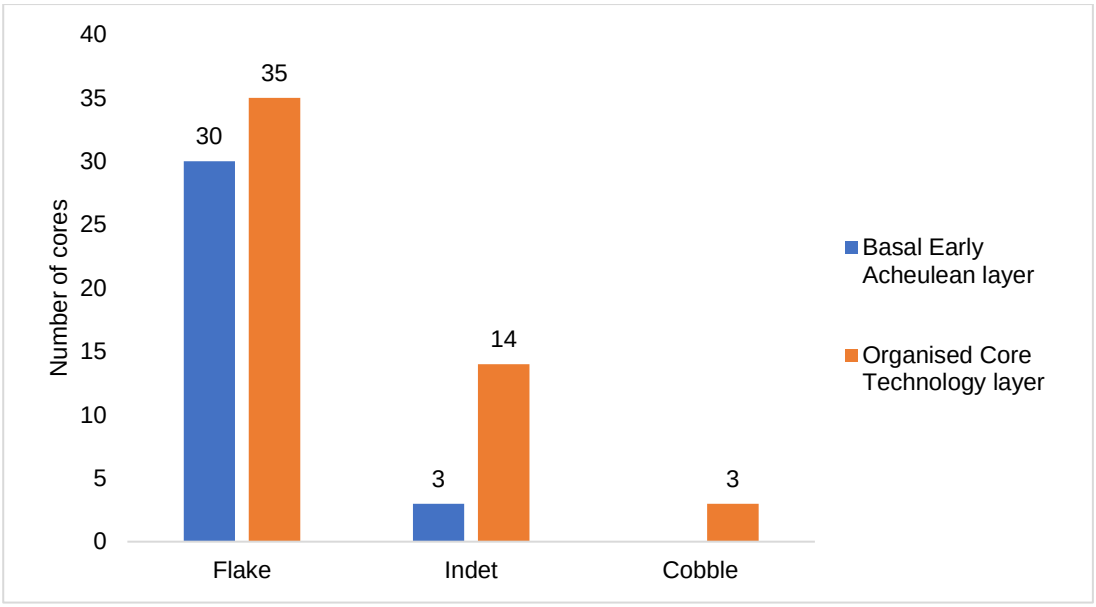


Figure 6.41: The blank types for LCTs in the Basal Early Acheulean and Organised Core Technology layers ('Indet' means 'indeterminate')

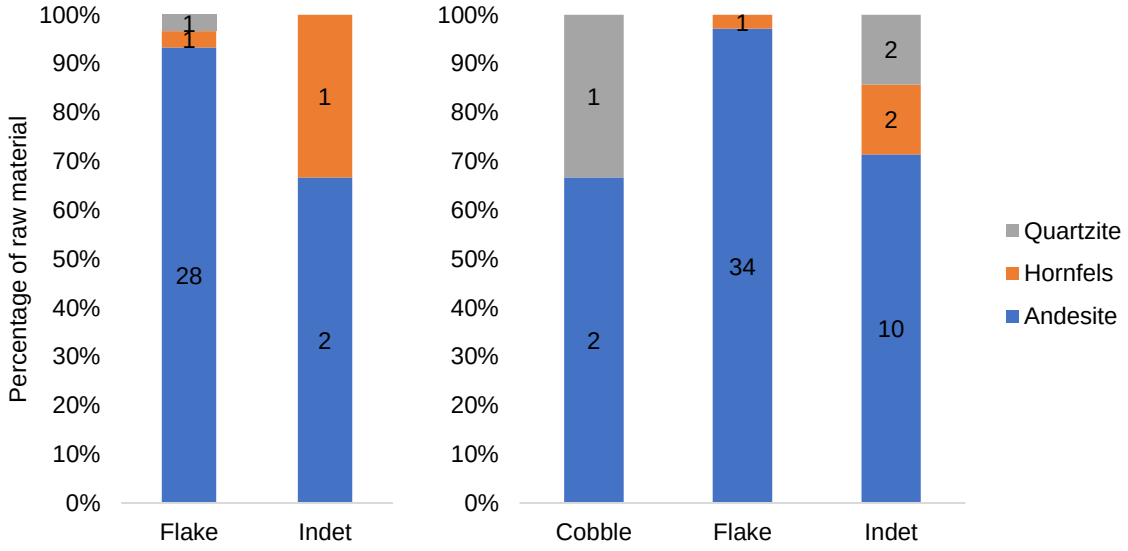


Figure 6.42: Percentages of raw material by blank types in the Basal Early Acheulean layer (A) and the Organised Core Technology layer (B) ('Indet' means 'indeterminate')

6.4.5 Flake scars and shaping strategies

Due to the nature of the weathering on artefacts in both layers, it is difficult to fully assess the scar counts and shaping strategies on all the pieces. In the Basal Early Acheulean layer, there is a range of 4-17 clear scars on seven artefacts, while the range is 8-14 scars on 10 LCTs from the Organised Core Technology layer. The clearest pieces have been described below in the diacritical analyses.

6.4.6 Diacritical analyses of LCTs

All LCTs are orientated with the ventral surface on the left side of the image and the dorsal surface on the right. Red markers indicate the scars left by shaping flakes removed after creation of the blank, and blue arrows are debitage flake scars from removals prior to the creation of the blank. Pieces that are not made on a flake blanks are discussed with reference to left or right in the image.

Basal Early Acheulean layer

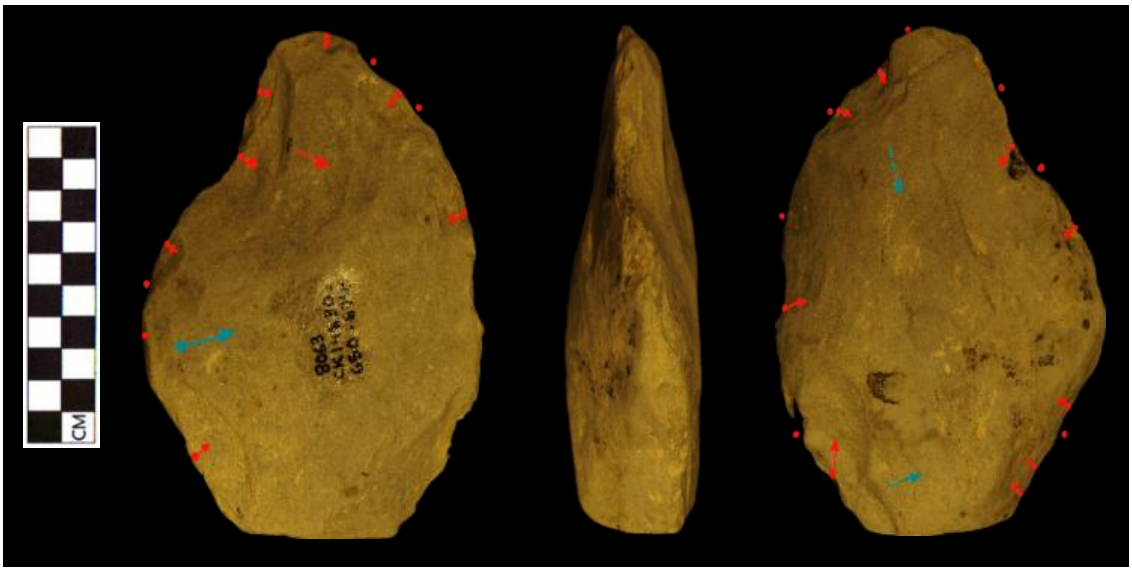


Figure 6.43: Artefact CK 14830

Figure 6.43 is a hornfels handaxe made on a large flake with 15 shaping scars around the entire piece in a bifacial alternating sequence. There are two definite scars on the dorsal surface that could be included in the debitage sequence of the core prior to the creation of the flake blank. The tip has been notched through the extraction of multiple removals on the left lateral edge on the ventral surface. Cortex remains on the base leaving evidence of a flat clast shape.

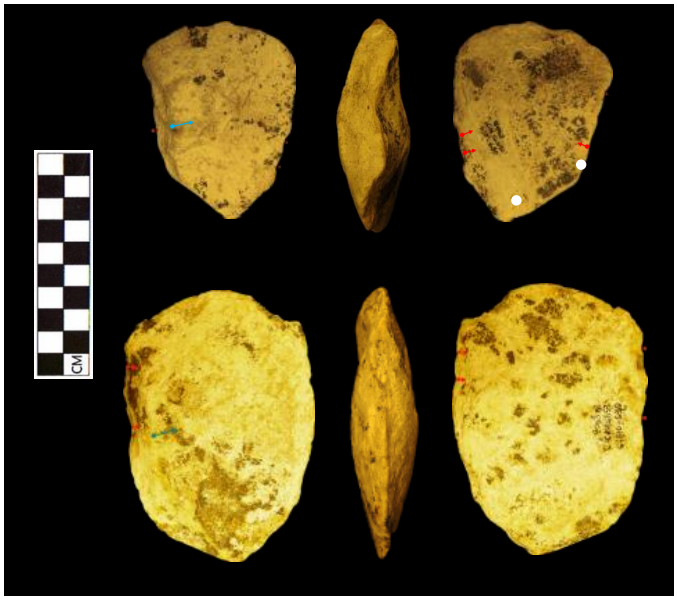


Figure 6.44: Artefacts CK 14691 (top) and CK 14659 (bottom)

Figure 6.44 shows two pieces, CK 14691 and CK 14659. They will be discussed together as they are similar. Both pieces are andesite cleavers, with four shaping scars each in a rhomboid sequence. From the profile view it is possible to see that the flake blank is quite thin for CK 14659, so not much shaping was needed to thin the edges. The blue arrow indicates the ventral surface and impact point of the flake blank. CK 14691 has two scars in an alternating pattern on the right lateral edge of the ventral surface and two unidirectional scars on the opposite edge. Both of these examples are cleavers that required little shaping after production of the flake blank.

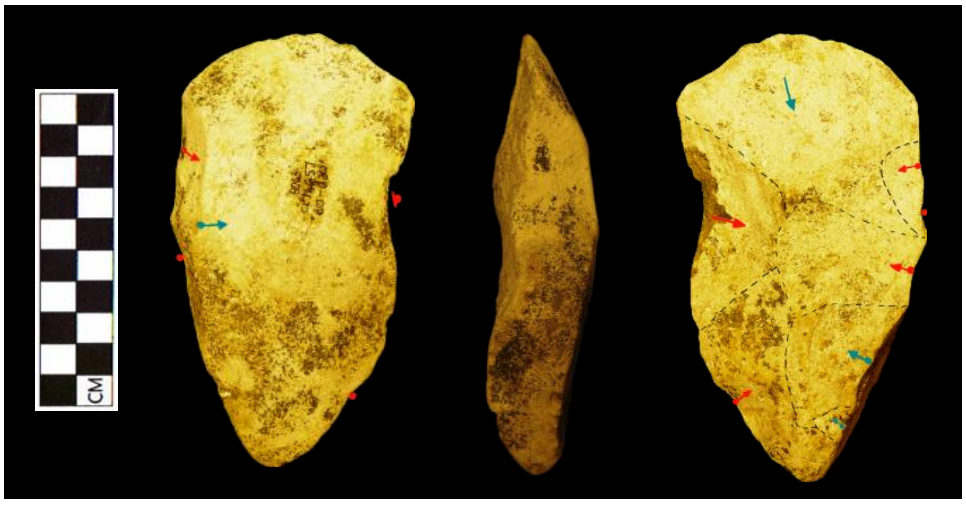


Figure 6.45: Artefact CK 14657

Figure 6.45 is a cleaver made on a large side-struck andesite flake blank. There are three debitage scars visible on the dorsal surface. The red dot on the right side of the ventral surface with a red line indicates the position of a flake scar without an impact point on the opposite

surface which was removed by post-depositional damage. The shaping scars on the platform of the flake blank are orientated in an alternating sequence, while the two scars on the opposite lateral edge follow a unifacial pattern. In total there are five shaping scars in a predominantly bifacial sequence.

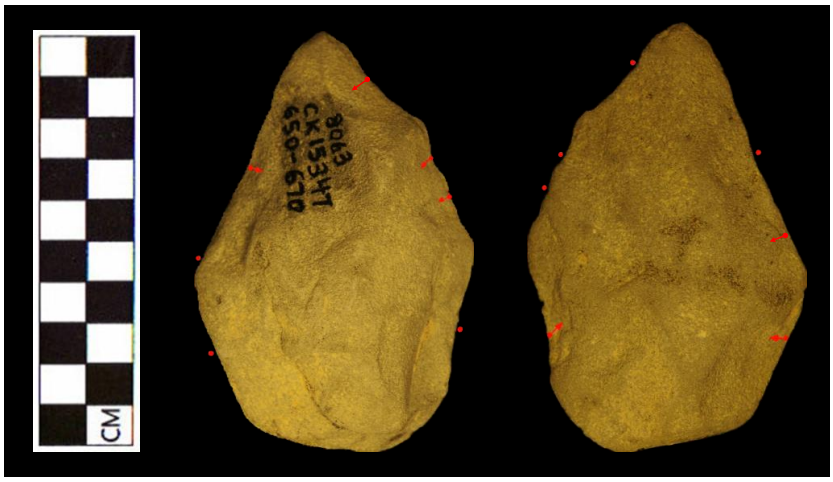


Figure 6.46: Artefact CK 15437

Figure 6.46 is a handaxe made on an andesite blank which fits into the size range of a small cobble. There are seven shaping scars in no particular order on both surfaces of the piece, except for two scars that sit next to each other on the right medial lateral edge on the left image. These two scars create a shallow notched section.

Organised Core Technology layer

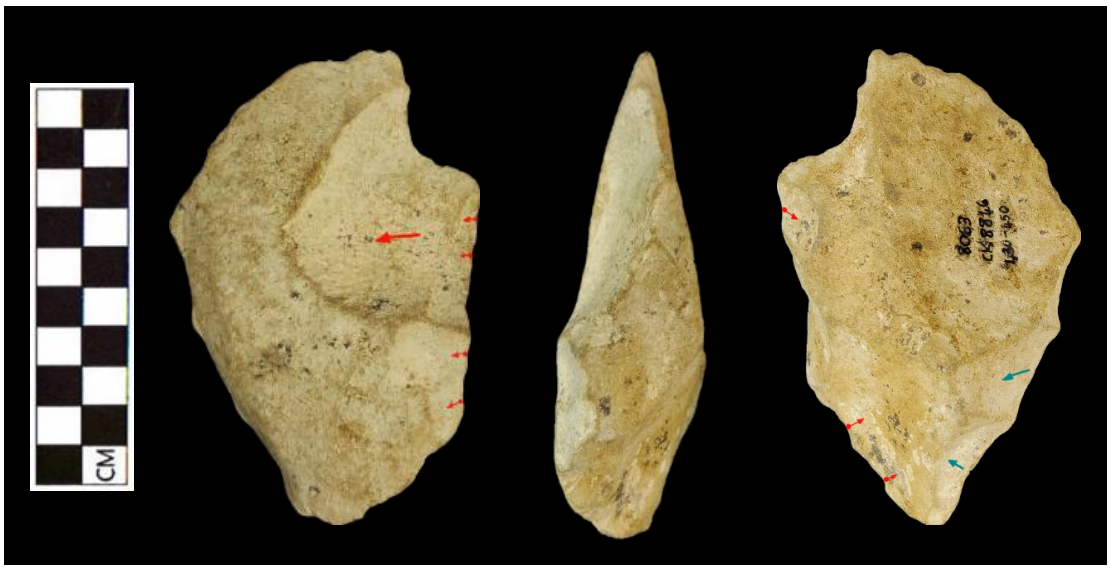


Figure 6.47: Artefact CK 8846

Figure 6.47 is an LCT made on a large flake blank and has eight shaping scars in a bifacial sequence along the left lateral edge of the ventral surface. One of the scars is large and removed the platform and bulb of percussion of the blank. There are two smaller shaping scars taken from this large flake scar. There is an unretouched oblique edge opposite the shaped side that appears to have some use wear damage. This could classify this piece technologically as a cleaver, but the shaped edge and notch could also classify it as a knife.

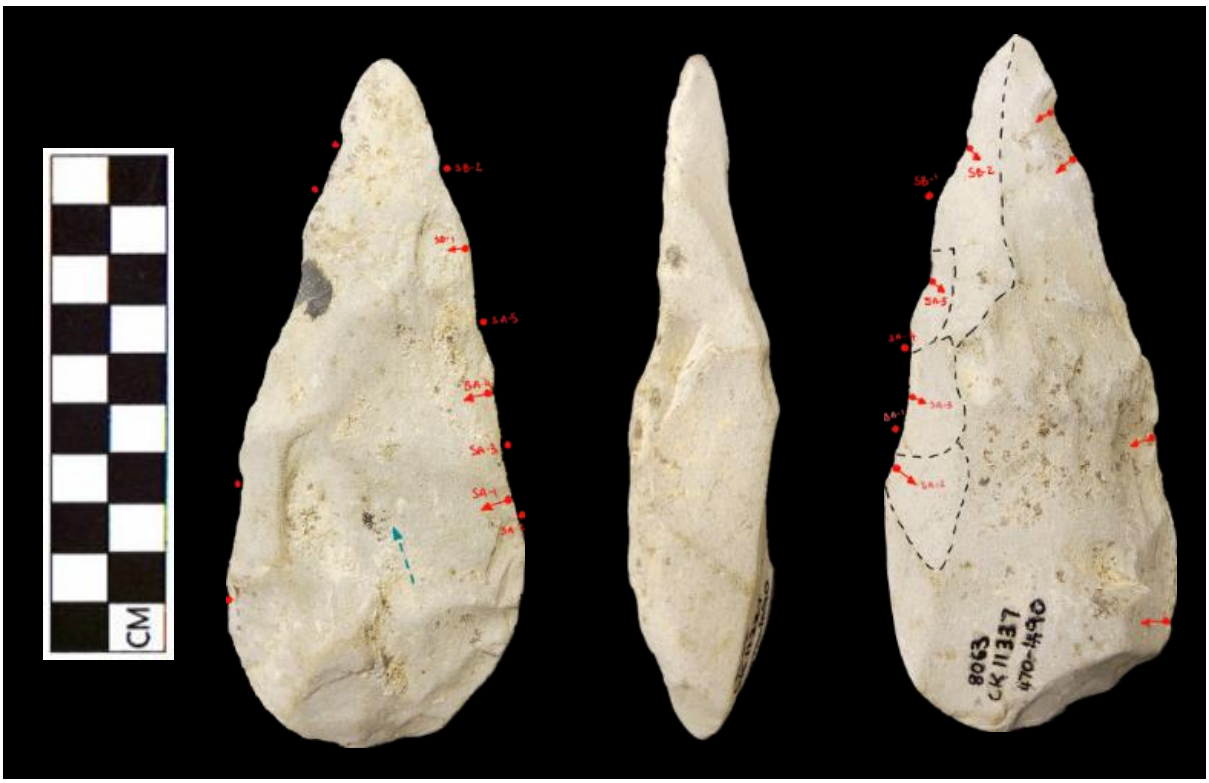


Figure 6.48: Artefact CK 11337

Figure 6.48 is a hornfels handaxe made on a flake blank with 11 shaping scars in a combination of unifacial and bifacial alternating sequences. The left lateral edge has four scars in a unifacial sequence that do not touch except, with two of them lying close to the tip. The opposite lateral edge has two sequences of bifacial alternation and is one of the few pieces in the assemblage where the order of removal is evident. Two flakes (SB) were first removed towards the tip going from the ventral to dorsal surfaces. SA begins at the bottom of the medial section and consists of five scars and three flips moving towards the tip. SA-5 covers part of SB-2 which separates the two sequences.



Figure 6.49: Artefact CK 11590

Figure 6.49 is a large LCT made on an andesite flake with 16 shaping flake scars. The transverse distal end has a notch scar and a possible removal which travels down the dorsal face, which would exclude it from the technological cleaver definitions as laid out in chapter 3. The scars could have been removed to create a denticulated working edge or could be a result of post-depositional damage or use wear. The actual shaping is focused along each lateral and around the base in a bifacial pattern while the scars at the tip are focused on one side. The technological classification of this piece is debatable, but I have chosen to include it in the cleaver category because of the shaping patterns around the lateral edges and base.

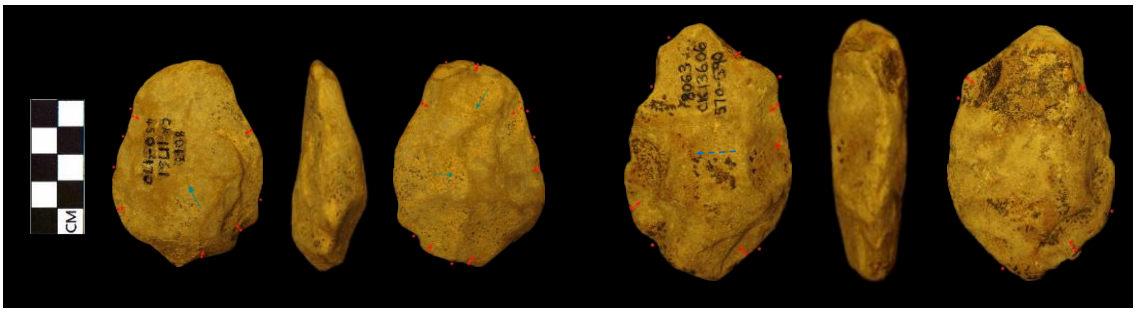


Figure 6.50: Artefacts CK 11761 (left) and CK 13606 (right)

Figure 6.50 is of two pieces, CK 11761 and CK 13606. They will be discussed together because they have similar traits and are both small andesite handaxes. CK 11761 has 14 and CK 13606 has 10 bifacial alternating flake scars all around the edge between the ventral and dorsal sides. Both are made on flake blanks, and they are heavily rolled. There is no cortical surface obvious on the dorsal surface of CK 11761, while there appears to be some cortex on CK 13606, despite the poor condition.

6.5 The core reduction strategies and LCT production

There is a limit to what can be said about the assemblage because of the sample bias, however there are a few patterns that have emerged. In the core assemblages, there is a shift in the reduction strategies from predominantly multifacial cores in the Basal Early Acheulean layer to bifacial strategies in the Organised Core Technology layer.

Cores also decrease in size between the layers, but this could be due either to factors such as high energy events or the selection choices of knappers. Despite the size difference, there are still boulder cores in each layer that have been exploited for LCT flake blanks. It is the only site in this study that has LCT cores from the in situ excavations.

LCTs blanks do not change really between the layers, as large flake blanks were produced and shaped in both. For pieces that have identifiable edge strategies, these were exploited bifacially and alternatingly along the lateral edges. The flake blanks were relatively thick and so the edges were not very acute. They were also quite wide, and so despite their thickness, the LCTs Refinement Index has an average of 0.47 and 0.5 in the Basal Early Acheulean and Organised Core Technology layers, respectively.

Sterkfontein, Rietputs 15, and EF-HR (chapter 7 and de la Torre and Mora 2018b) all display two production chains for the LCTs and cores. However, at Canteen Kopje, many examples of cores have been argued to represent LCT production. The evidence for this includes the large size of the cores, along with the large flake scars. The flake scar sizes and shapes correlate to the general sizes and blanks of the LCTs. The weathered nature of the assemblage means it could be hard to refit the full core reduction, but there is a clear production of large, predominantly side struck flakes, which are the most common LCT blank type. LCT cores are rare in Acheulean assemblages, but examples occur at Wonderboom in South Africa (Lotter *et al.* 2022), and at Gesher Benot Ya'aqov in Israel (Sharon 2010), however these are both younger than the Canteen Kopje assemblages.

6.6 Technological trends at Canteen Kopje

Overall, there is a pattern of structured core reduction in both layers, but there is a progression from the Basal Early Acheulean to the Organised Core Technology layer of longer reduction and control of single sequences, and consistent core edge management.

Chapter 7: Results: EF-HR

7.1 General observations

The first feature of the assemblage I noted is that it is incredibly fresh. There is minimal evidence of weathering on the analysed pieces and the full ranges of artefact sizes are represented (de la Torre and Wehr 2018). This allows one to determine the order of removals easily, especially on the LCTs, and on some cores. The main T2 trench was subject to multiple instances of fluvial action linked to lake level changes (de la Torre *et al.* 2018), but these did not seem to intensely affect the freshness of material.

There are 128 cores and 102 LCTs studied. The total core assemblage in de la Torre and Mora (2018b) was 130, but two specimens were not found during analysis, hence only 128 are presented here. There are also two extra LCTs included in this analysis from the 100 presented in the same paper, but these two extras were not found in situ like the rest of the assemblage. As will be seen throughout the chapter, not all pieces were included in each analysis as certain pieces may be missing some information, either from weathering or damage, and these have been excluded to remain as conservative as possible with the interpretations.

7.2 Raw material

There are four raw material types in the early Acheulean of EF-HR: basalt, trachyte, phonolite, and quartzite, and a reference collection based on McHenry and de la Torre (2018) was used to classify the raw material of each piece. River cobble blanks were commonly selected, except for quartzite which was collected from the Nairbor Soit hill. In total the core assemblage is just over 54kg, with the highest proportion of basalt pieces, making up just over 29kg. Trachyte is least represented with just under 6.5kg quartzite and phonolite making up roughly 7.2kg and 11.5kg, respectively (Figure 7.1).

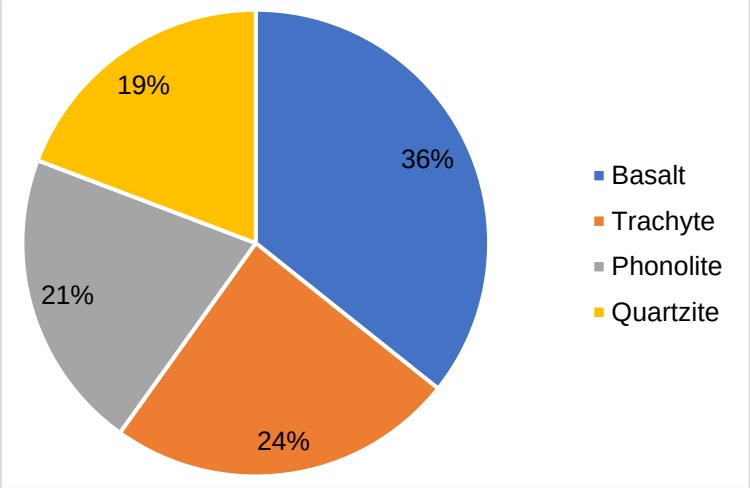


Figure 7.1: The raw material type in the core and LCT assemblage

7.3 Cores

Basalt dominates the core assemblage (39%) (Figure 7.2) and trachyte dominates the LCT assemblage (50%). Conversely, trachyte is the least used raw material in core technology (13%). Quartzite is similarly represented in each group, 20% for cores, and 17% for LCTs. Basalt (28%) is the second most common material used in making LCTs, with phonolite only representing 5%. For cores, phonolite makes up 28% of the assemblage.

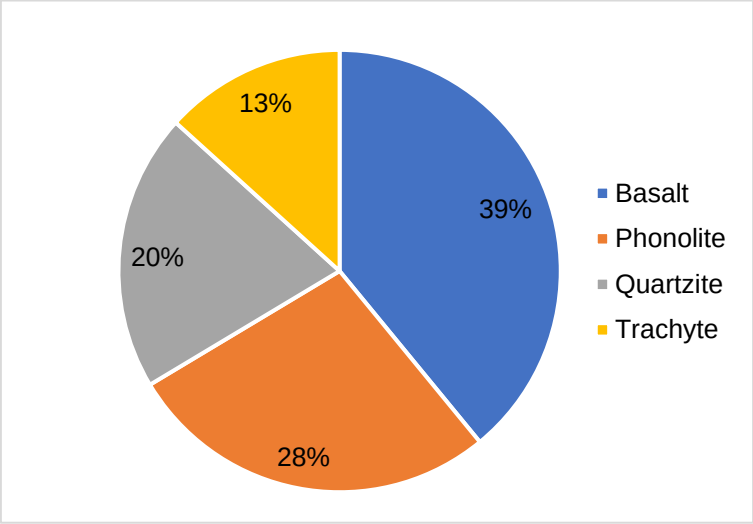


Figure 7.2: Raw material in the cores

Figure 7.3 presents the frequency of the various idealised schemes. The categories discoid, polyhedral and UAUT have one example each (descriptions of these specific pieces below), while the majority show a BAP (17.2%, n=22) core edge management, followed by BALP

(14.8%, n=19), multifacial and UAU1 (12.5%, n=16 for both). Apart from the multifacial group, these dominant schemes do not contain examples with heavy exploitation of the blank. Multifacial cores have at least three surface exploitations and suggest a more extensive exploitation. It will be important to assess these trends with regard to the presence of cortical surfaces, which is presented later in this chapter.

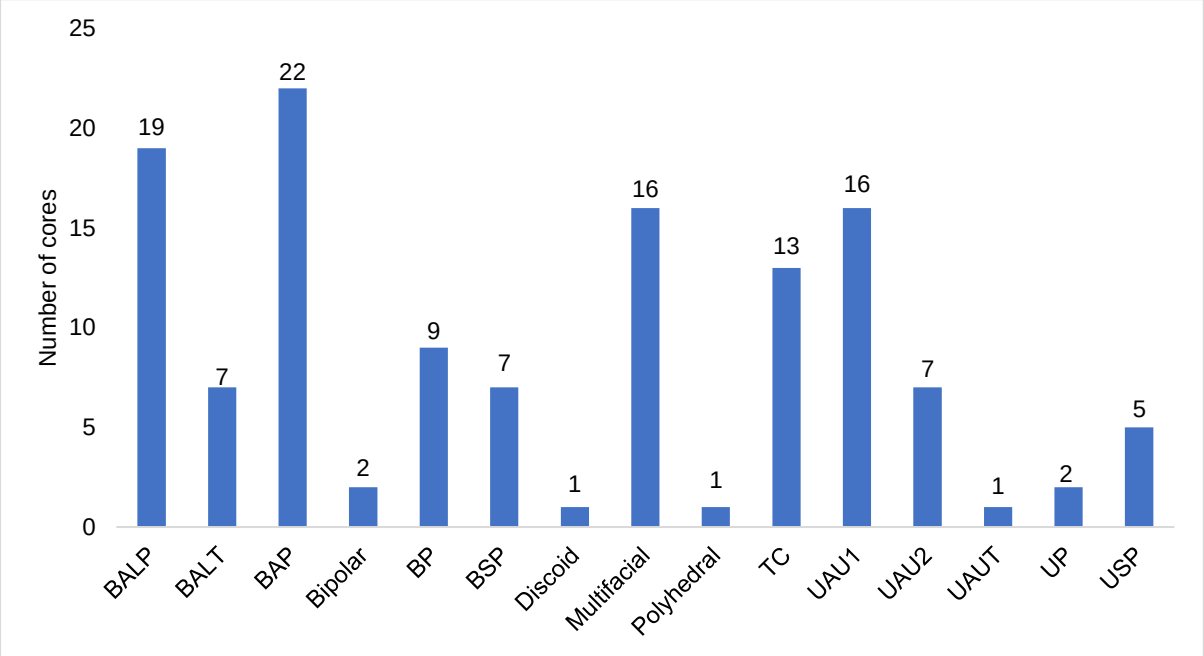


Figure 7.3: Idealised schemes of core reduction strategies

BSP, BALT and UAU2 have an equal representation (5.5%, n=7), followed closely by UP and bipolar cores (1.6%, n=2 for both). Despite the equal amount of these strategy types, there are more bifacially exploited pieces (50.8%, n=65) than unifacial (24.2%, n=31). UAU1 cores are the most numerous unifacial cores, followed by UAU2, indicating that within this group, knappers most exploited naturally abrupt edges unidirectionally, and would rotate the core lightly where possible. Only one example of a UAUT confirms that these abrupt edges were not rotated extensively.

Core strategies with exploitation of multiple surfaces (BALT, BP, discoid, multifacial, polyhedral, UAU2, UAUT, and UP) make up 39.8% (n=51) of the assemblage, while the singular surface cores (BALP, BAP, BSP, UAU1, and USP) make up 53,9% (n=69). This does not include TC and bipolar cores, as these technological categories do not distinguish how many surfaces were exploited during the reduction. Regardless of the core edge management strategies applied, knappers more frequently exploited a single surface of a core blank.

65 cores display a bifacial edge management, while 31 are unifacial, but this does not include the multifacial, TC or polyhedral cores (n=30). There are more than double bifacially exploited cores, represented across six categories, while there are only five categories of unifacial cores (Figure 7.3). Per bifacial category, there are 10.8 cores on average, while there are 6.1 cores per unifacial category. In general, knappers were applying more bifacial core strategies, as well as producing more bifacial cores. The bifacial flake scar average was 7.2, almost three more scars than unifacial cores, which averaged 4 scars. The bifacial strategies were therefore much longer than the unifacial ones, even when considering cores with multiple surface exploitation.

The single discoid has 14 scars and the highest number of scars compared to the maximum flake scars of other groups. BALT and BP each had examples of cores with 16 scars, and multifacial cores have up to 15 scars. On average, the cores have an average of 5.9 scars. The BALT scar average is 10.9, and the BP was 11.6, indicating generally long reduction sequences in these categories, which is expected. Multifacial cores have an average of 7.5 scars, which is higher than the average in the full assemblage. The lowest averages, apart from TC with 1.6 scars, are UAU1 with 3.4 scars per core, and BSP and USP, with 3.6 and 3.8 scars, respectively. A chi-squared test of the flake scars and reduction strategies gives a p-value = 1, which means there is a strong correlation between the reduction strategy and the number of flake scars on cores. Overall, knappers did not fully exploit their core blanks, but when they did apply longer sequences, it would leave up to 16 scars.

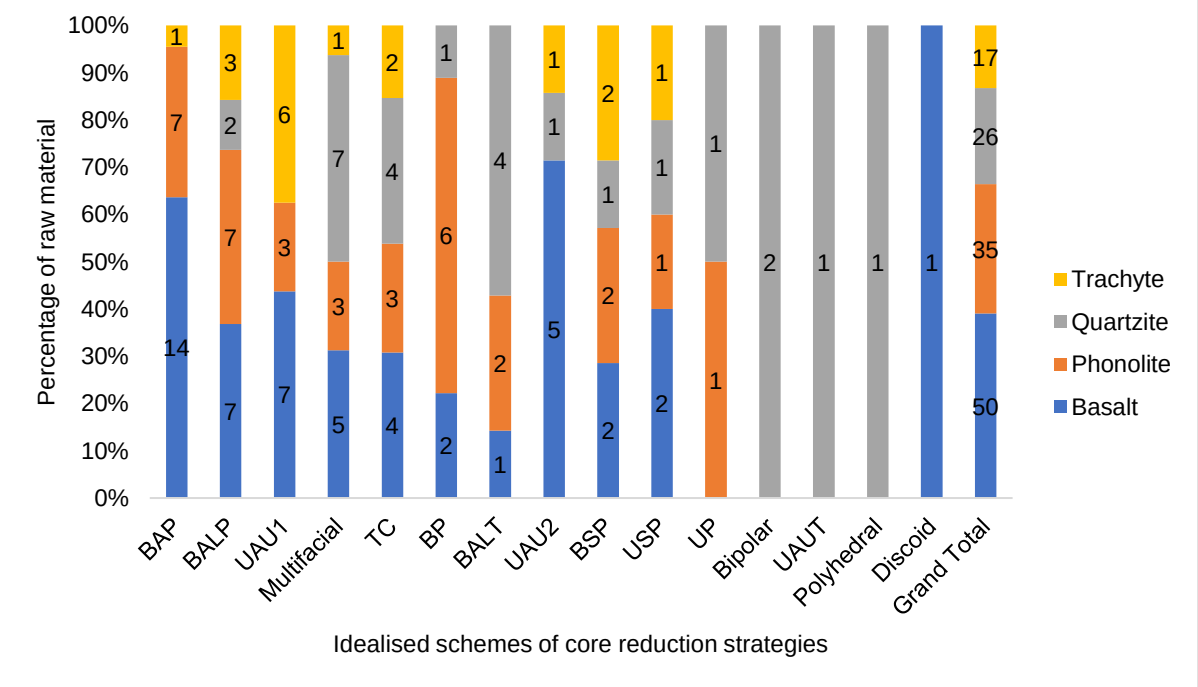


Figure 7.4: Frequency of raw material types by idealised schemes of core reduction strategies

Figure 7.4 shows the frequency of raw material types per idealised scheme category. Basalt may occur the most frequently in the assemblage, but quartzite is distributed across the most reduction schemes, with the only exceptions being discoid and BAP. The bipolar cores and the single UAUT and polyhedral cores are entirely made of quartzite. The BALT cores are predominantly made on quartzite as well, but the discoid core is entirely basalt. Apart from the individual examples mentioned, and apart from trachyte which represents the fewest pieces overall and does not dominate any category, the raw material types are somewhat evenly distributed between the categories. This indicates two things. Firstly, knappers applied various core edge management strategies across all the clasts available to them, and trachyte was more predominantly selected for LCT production.

7.3.1 Size and weight of cores

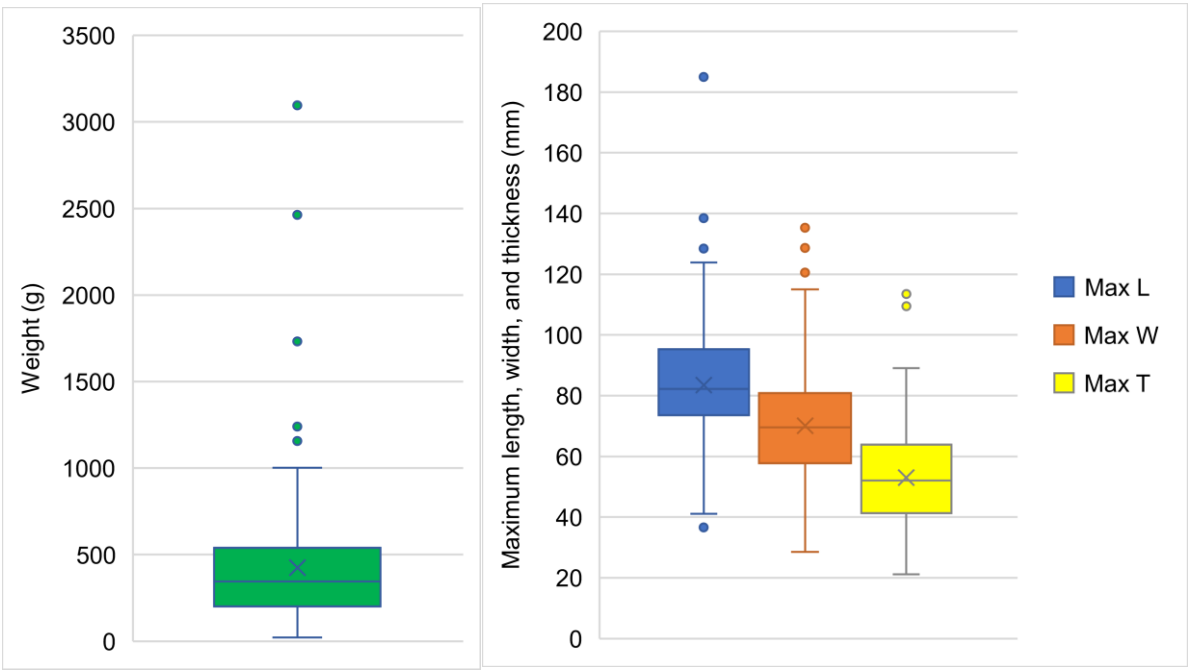


Figure 7.5: Weight (g) range (A), and the range of maximum length, width, and thickness (mm) (B)

The weight range of cores shows that they group around 400g (Figure 7.5 A), with an average maximum length of roughly 80-90mm (Figure 7.5 B). The length, width and thickness dimensions of the core group are relatively close together, with few large outliers. This indicates a trend of selecting more spherical rather than more elongated blanks. This will be explored further as more data is reviewed.

Overall, cores were not hugely varied in terms of the length to width and thickness, but there are some examples of very long cores. This means that overall knappers were using some

elongated clasts when using larger core blanks. This could have been because the natural edges on a slightly longer yet thinner piece would have been more acute and easier to knap. The majority of the raw material used in the core assemblage was soruced from the river, and so the shape of blanks is discussed below in relation to reduction startegies.

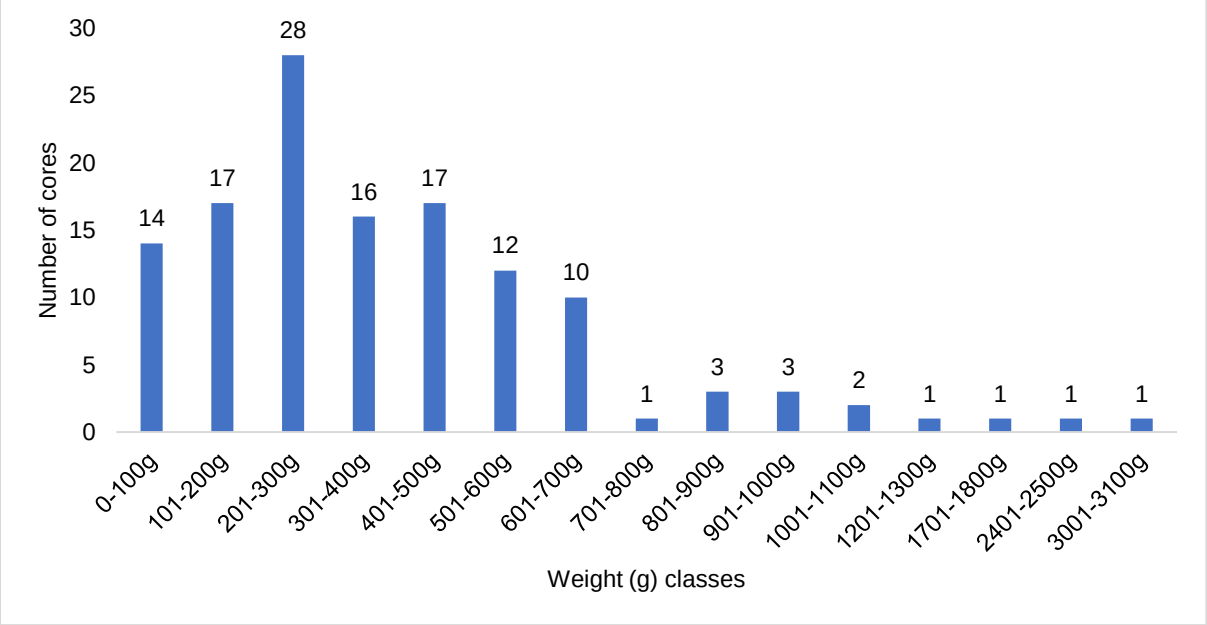


Figure 7.6: Weight classes of cores (g)

The bar graph in Figure 7.6 shows the distribution of core weights in groups of 100g. 28 cores (21.9% of the assemblage) weigh between 201-300g, with most weighing under 700g where there is a sharp drop off with only 13 cores (10.2%) in that range. There is a pattern of small cores in the assemblage and considering that blanks were collected from the river and Naibor Soit hill, it would suggest hominids were selecting within this size range.

7.3.2 Weight and flake scars

The scatter plot in Figure 7.7 details how there is a high insignificance between the weight (and size) of a core, and the number of flake scars. The R^2=0.161 indicates that core size does not determine exploitation. Considering this alongside the scar averages of longer reduction categories (such as BALT, BP and discoid) and the weight ranges shown in Figure 7.5 A, there is even more evidence that size of blank has no correlation to the extent of exploitation in the core assemblage.

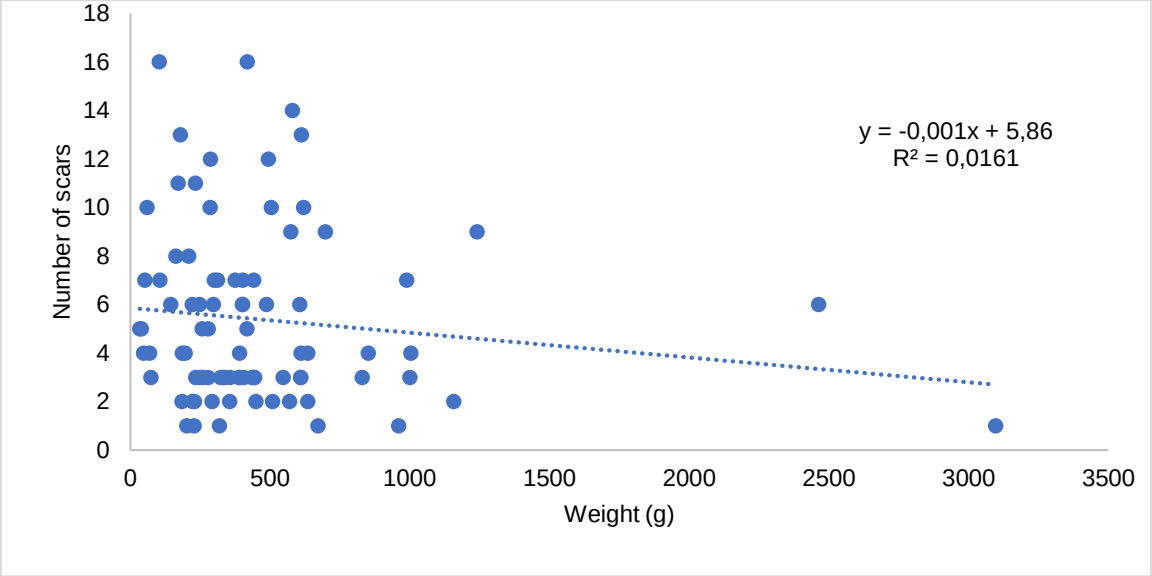


Figure 7.7: Correlation between weight (g) and number of flake scars

7.3.3 Core reduction strategies and weight

In addition to the reduction schemes, the clast sizes vary across the core assemblage. There is no set trend of certain reduction patterns being restricted to a size or weight category of raw material clast. This means that reduction sequences relied more on the morphology of core edges and platforms, either natural or archaeological.

Like the weight range of idealised schemes, the core blank weights are also quite varied. Chunks are quite small, likely as a by-product of other knapping sequences. Split cobbles and cobbles vary the most in size but have a similar median weight. Apart from the singular core made on a broken hammerstone, blocks have the highest median weight of almost 500g, and the means of each blank types have no similarity. Despite the varied range of blank weights, there is a dominant selection of clasts >600g, but there clearly is no selection of specific blank sizes for specific core reduction schemes.

The size of cores does not correlate with specific idealised schemes and edge management, as there is a large variety of weights in each category (Figure 7.8). A Kruskal-Wallis test of the equal distribution of medians gives a p-value of 0.07768, indicating no significant difference between them. The median lines are focused between 200-500g, which corresponds with the weight range presented in Figure 7.5 A. Therefore, there is a commonality in sizes, but the range in core size varies between reduction strategies.

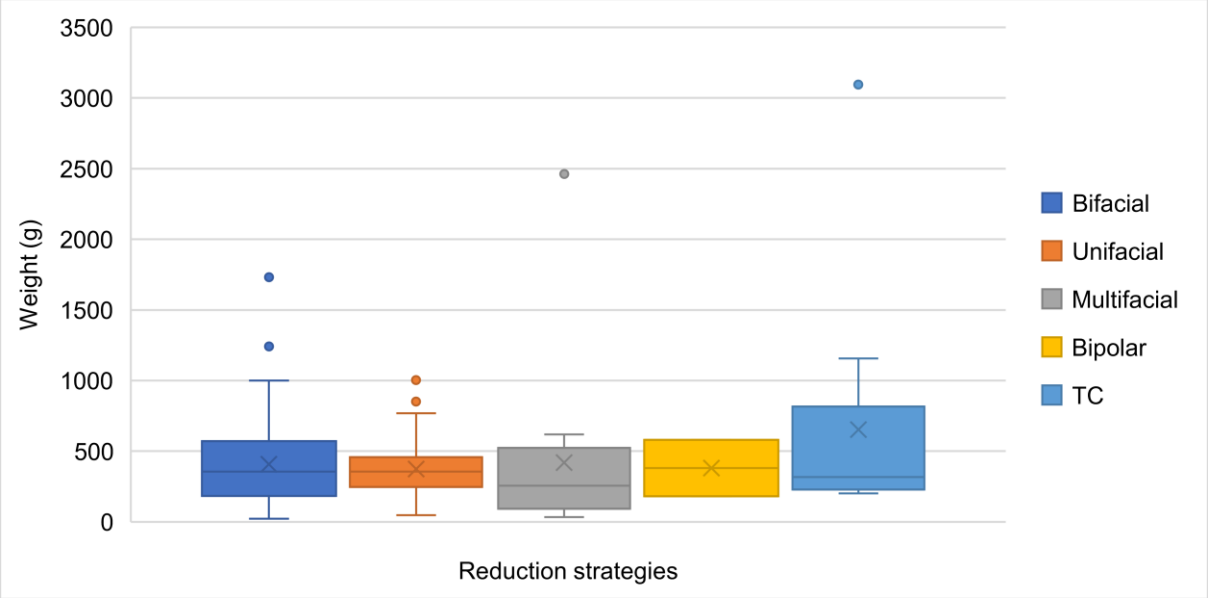


Figure 7.8: The weight ranges of idealised schemes (this graph excludes outlier points)

Interestingly, there is not much size and weight fluctuation in the multifacial cores. One could hypothesise that because this idealised scheme includes cores with no distinct continuous reduction strategy, it could be applied more liberally to many blank types. The TC category instead shows a wider range of core weight, with them being overall bigger than the multifacial cores. This could suggest that knappers were able to exploit smaller clasts more heavily when not adopting a specific core edge management.

Apart from the TC cores, the largest cores by weight fall within the BAP and UAU2 categories. As described in chapter 3, these idealised schemes appear on abrupt angles, with no alternating bifacial edge management. This, along with the fact that clasts used for blanks tend to be more spherical in shape, indicates that knappers adhered to the natural properties of the blanks and did not flip and manipulate the placement of the core much during knapping.

BALT cores are very similar in weight and size, with little range outside of the median, roughly 200g. BALP cores have a similar range if, although they average slightly larger, but they are far less numerous in number. This means that knappers were adept at flipping and rotating smaller pieces and could extend this type of core edge management more extensively.

Three categories with almost the exact same weight range are UP, USP and BP, and they skew smaller in size (maximum weight just >200g). UP and USP are schemes with acute edge management, while BP cores are primarily made on split cobbles and angular pieces.

7.3.4 Remaining cortex

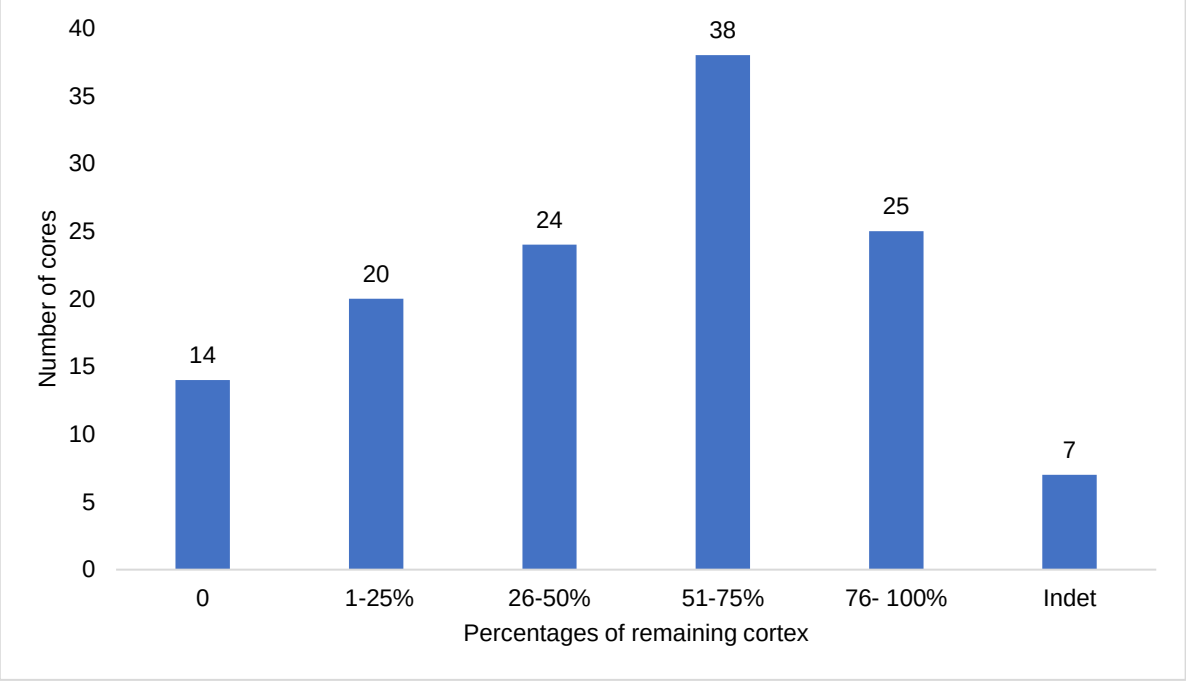


Figure 7.9: Amount of remaining cortex on cores ('Indet' stands for 'indeterminate')

Just under half of the cores in the assemblage have >50% remaining cortex (n=63, 49.2%), and 58 (45.3%) cores with <50%. For the cores with <50% remaining cortex, the categories are close in number with a slight ascension in number of cores, while the gaps between categories with >50% is wider. The weight range with the most examples is the 51-75% group. Overall, different amounts of remaining cortex are distributed across the whole assemblage, and cores are not intensively reduced (Figure 7.9). A t-test comparing the data of the amount of remaining cortex, and the idealised core strategies gave a result of p=1.9693. This indicates a strong correlation between the categories, and the remaining cortex could be inferred by the edge management scheme on the core.

7.3.5 Core blanks

Rounded clasts, primarily river cobbles, dominate the blank types, with a large sample of split clasts (Figure 7.10). In most cases, it was not possible to determine whether the cobbles were split anthropogenically or naturally, but the technological use of split surfaces as flaking platforms is consistent, and therefore they have been classified together. The tabular blocks refer to the quartzite slabs that erode out of the Naibor Soit hill.

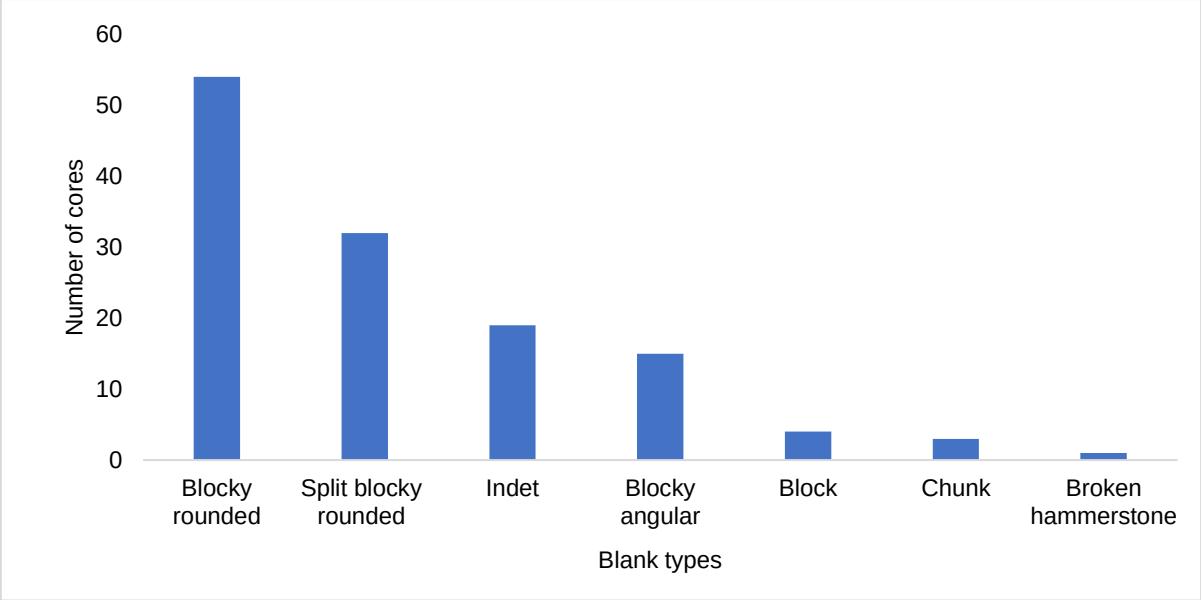


Figure 7.10: Blank types of cores

Blocky rounded blanks are the dominant blank types for all raw material types (Figure 7.11), except quartzite which generally occurs in blocks. Interestingly, there are no chunk blanks in basalt and trachyte, and very few in phonolite. Knappers were using the original clasts and not repurposing the débitage as core blanks. This could suggest that knappers were knowledgeable about the raw material properties, and how to reduce and manage certain clast shapes. The data presented in Figure 7.12 further show how blank shape affects reduction. Blocky rounded and split blocky rounded blanks are used equally for unifacial reduction while there are more blocky rounded blanks in the bifacial categories.

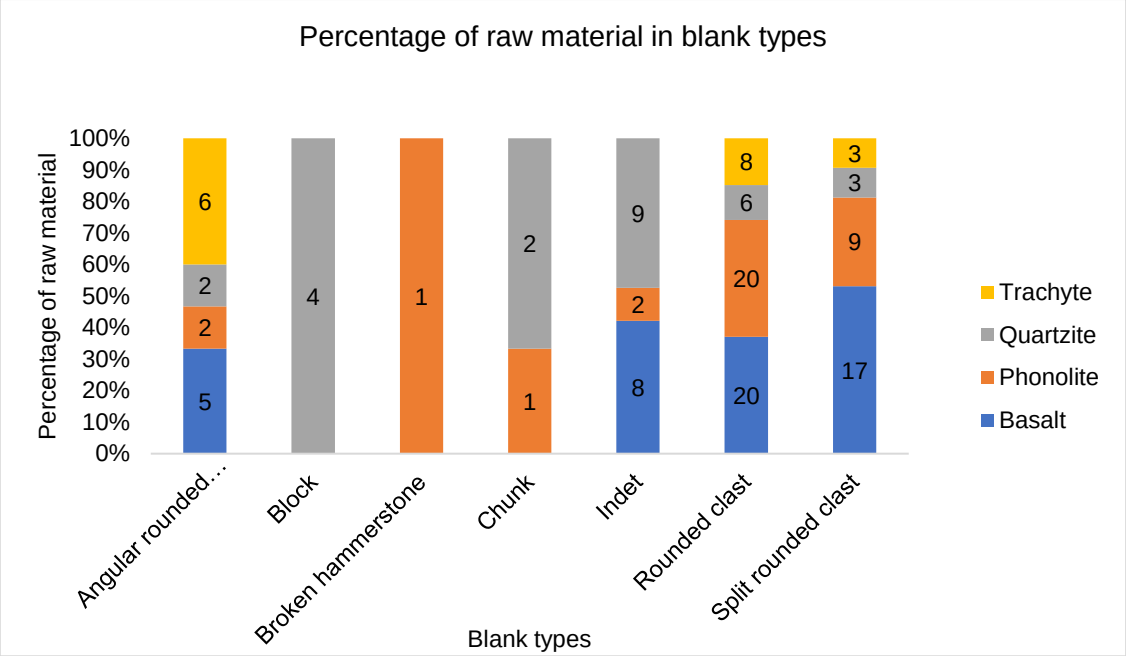


Figure 7.11: Percentage of raw materials for blank types

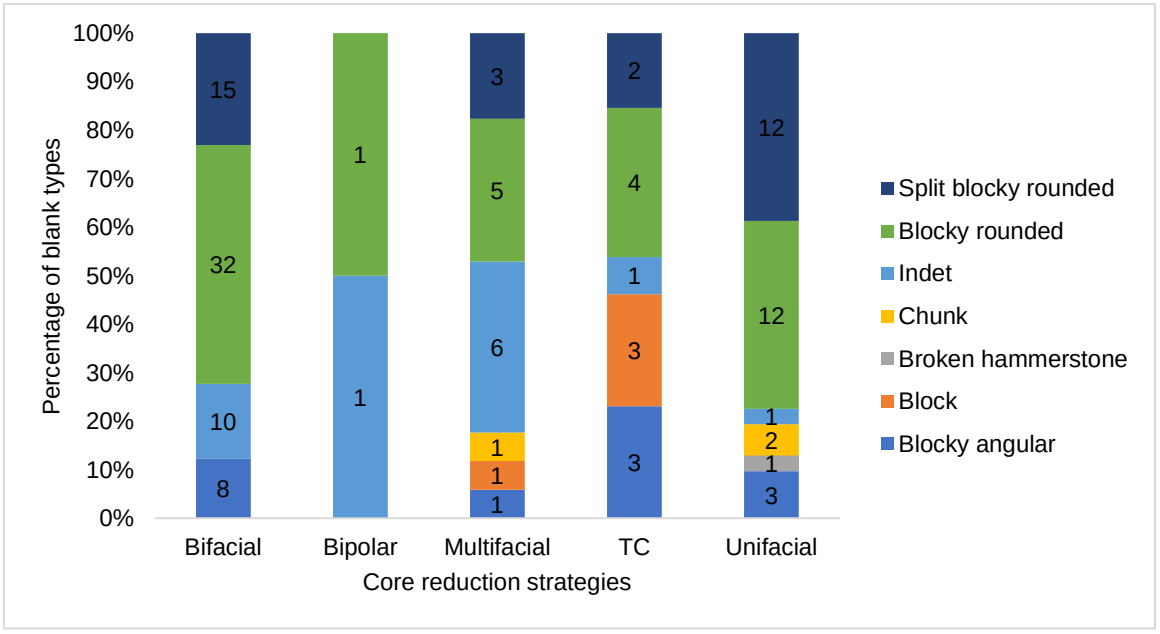


Figure 7.12: Percentages of blank types in the core reduction strategies

7.3.6 Largest flake scars

Largest flake scars (LFS) have been used as examples to explain the skill and success of knappers. Figure 7.13 shows how 41% of cores in the assemblage have feather terminations on the LFS, indicating they successfully extracted sharp-edged flakes most of the time. 30% of cores have indeterminate LFS which could be due to the intensity of reduction. Step

fractures are next most common (26%), which means they did encounter mistakes around a quarter of the time. Figure 7.14 shows the dispersals of LFS types across reduction strategies. There is no clear pattern of specific strategies that result in feather flake scars, but rather the various terminations appear across the graph. This could mean that hominids made knapping mistakes similarly while working with different core strategies.

So even though the knappers were successful at obtaining sharp edges on flakes, they were not consistent. There are few examples of core with core rejuvenation planes indicating knappers did not often need to rejuvenate cores, likely due to the proximity of raw material sources.

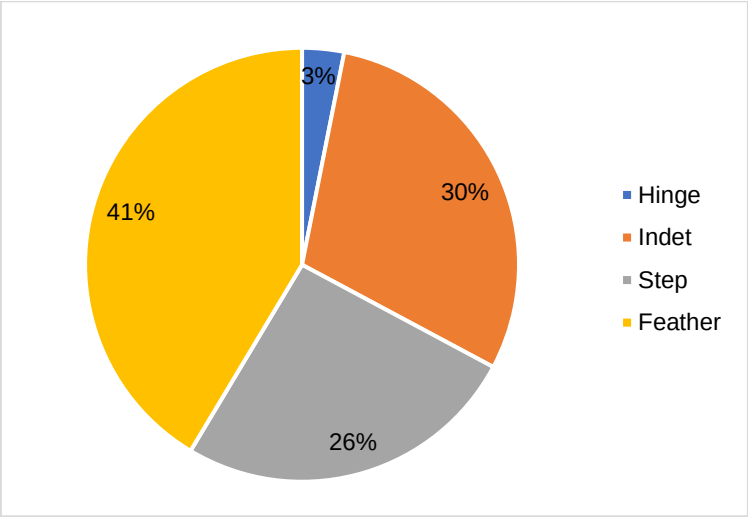


Figure 7.13: Largest flake scar types

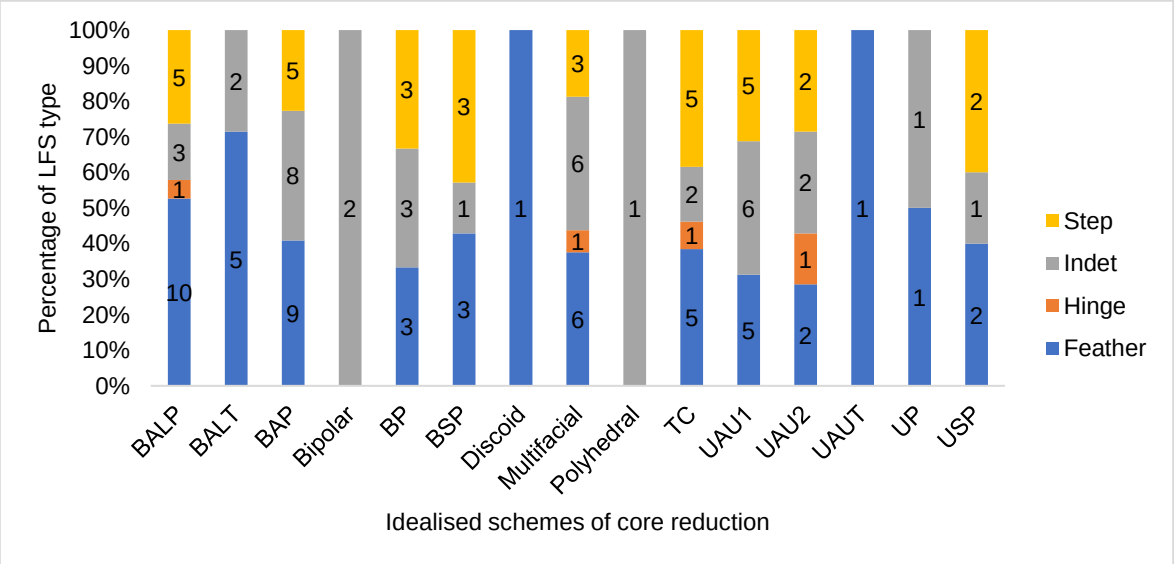


Figure 7.14: Distribution of the largest flake scar by idealised scheme

Feather terminations are the most common LFS type for all the raw materials, meaning knappers were able to produce sharp flakes on all cores (Figure 7.15). Basalt dominates all categories and there are almost as many step fractures as feather terminations in basalt, which is closer in number than the same types between other raw materials. There is no clear indication as to why basalt has so many step fractures, but again this could be a result of the general dominance of the raw material.

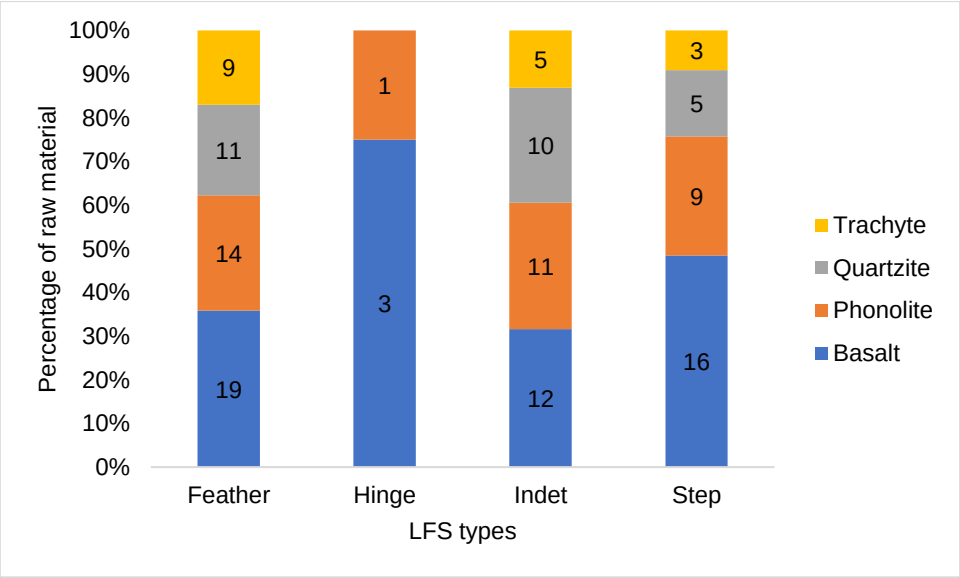


Figure 7.15: Percentage of raw material in the largest flake scar types

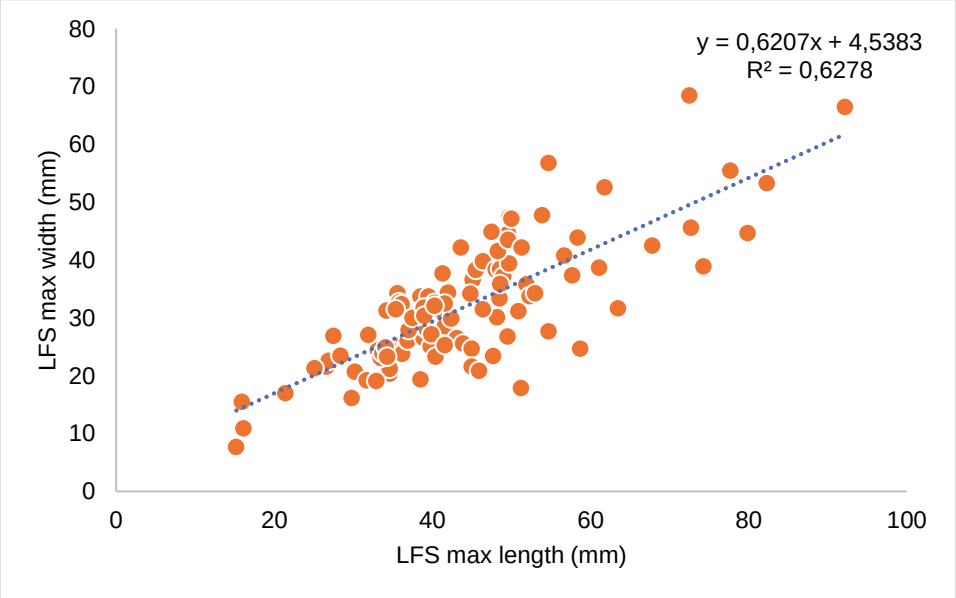


Figure 7.16: Correlation between the maximum length (mm) and maximum width (mm) of the largest flake scars

Largest flake scar sizes are relatively consistent (R-value of 0,6278) (Figure 7.16), with maximum length and width both increasing in tandem, and with both primarily within the 30-

50mm range. Knappers were able to adapt to different blank sizes. The flake sizes, however, do not correspond to any pattern with regards to their terminations, as indicated by a t-test of equal means which gave a p-value of 1.9712.

7.3.7 Diacritical analyses of cores

As discussed, the data presented above relies on the quantification of measurements and categories assigned to the cores. However, specific details about the technological features of specific pieces are limited when studying the categories alone. Detailed descriptions of cores can offer information about the flexibility of knappers during the manufacture process which can be understood in the context of the general patterns presented above. Hence diacritical analyses of a sample of cores and LCTs are presented.

BAP cores

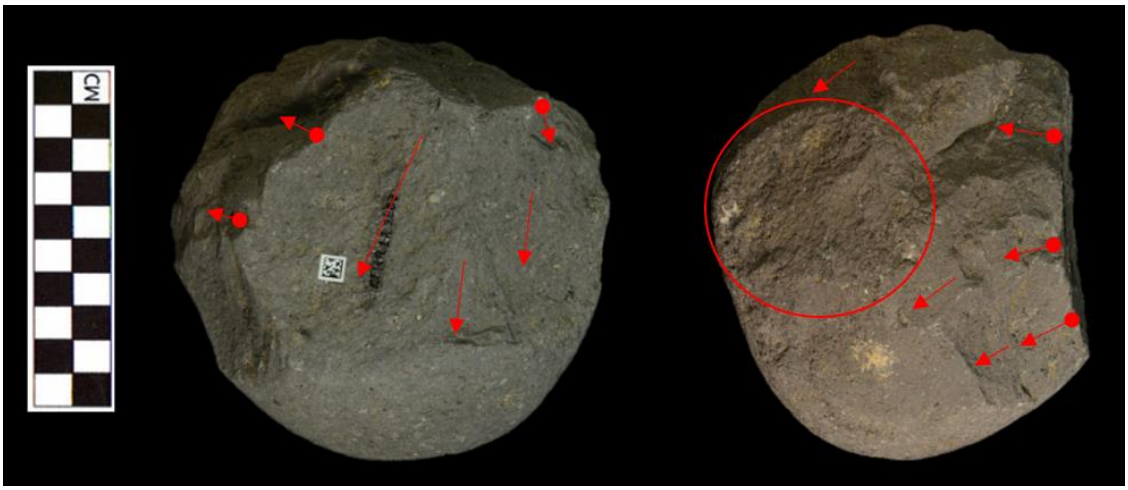


Figure 7.17: Artefact L2 1887

Figure 7.17 is a BAP core made on a large basalt cobble with nine scars. A large portion was removed to create a flat platform from which to remove multiple removals along one side. The opposite side of the platform is obtuse in angle and was likely the reason for the core being abandoned. There is some evidence of battering on the cortical surface opposite the platform noted by the red circle. This battering suggests that this could have been a recycled hammerstone.

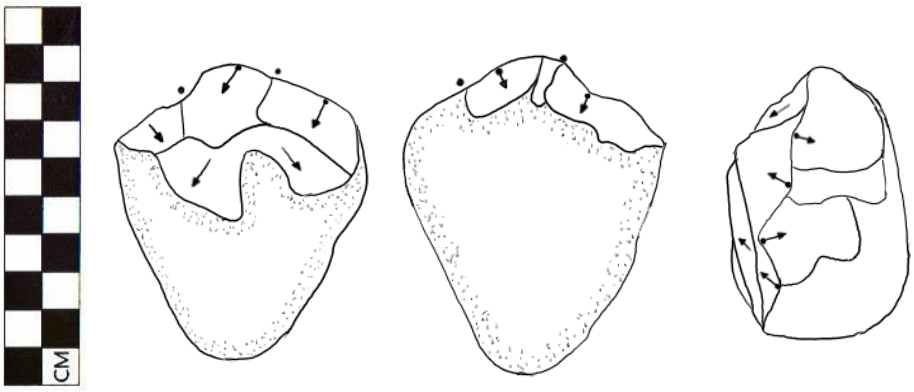


Figure 7.18: Artefact L2 792

Figure 7.18 is a BAP core with seven flake scars made on a basalt river cobble. The blank is triangular in shape and the bifacial sequence is focused on one side of the blank. This could also be labelled a BALP core based on the scars seen on the top profile view which appear to be alternating (right image in Figure 7.33). However, it seems the piece was only flipped once between the surfaces.



Figure 7.19: Artefact L2 477

Figure 7.19 is a BAP core made on a phonolite cobble with six flake scars. The blank is elongated, and scars occur along the entire vertical axis. The proximal end (following the orientation of the image) is removed and used a platform. The largest scar in the centre of the image on the right is one of the final two removals, as evidenced by the impact point, and by the fact that it cuts into the scars on either side. The angle of the platform to the opposite side of the core is obtuse and was most likely the reason for the core being abandoned.

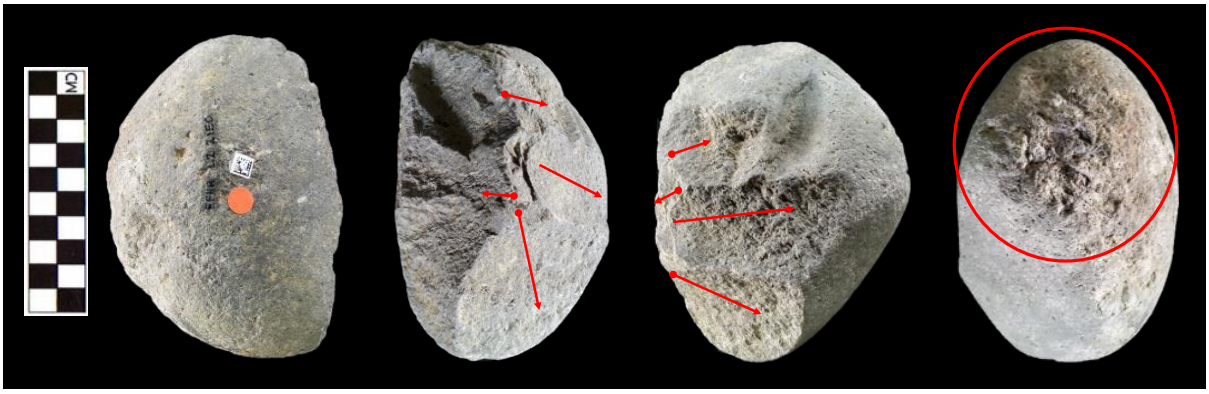


Figure 7.20: Artefact L2 2150

Figure 7.20 is a BAP core made on a basalt cobble. It is likely a recycled hammerstone with evidence of deep pitted battering on one side opposite the 11 flake scars. The bifacial reduction demonstrates a clear single sequence and rotation of the core. The largest flake scar appears at the beginning of the sequence with all scars ending in feather terminations, and only one of the flake scars has a step fracture. The scars get smaller as the sequence progresses, until the core was abandoned. The blank widens towards the end of the sequence. meaning it was harder for scars to travel further into the central volume, resulting in the smaller scars. Because the knapper was able to remove large flakes from an unprepared core blank, it indicates a comprehension of the flaking properties of this raw material to produce large flakes.

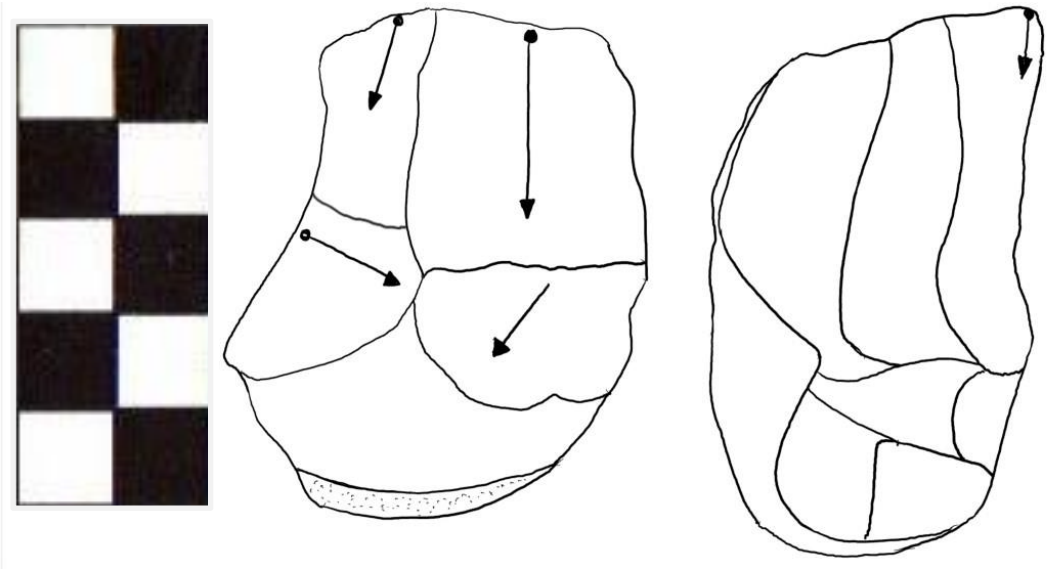


Figure 7.21: Artefact L2 1348

Figure 7.21 is a BAP core on a phonolite rounded clast blank with 4 scars. The blank is a small cobble which was split. The scars are not all unidirectional with some small flakes at a right

angle to the BAP sequence. It appears these scars came before the BAP sequence as they have been partially obscured by the later removals.

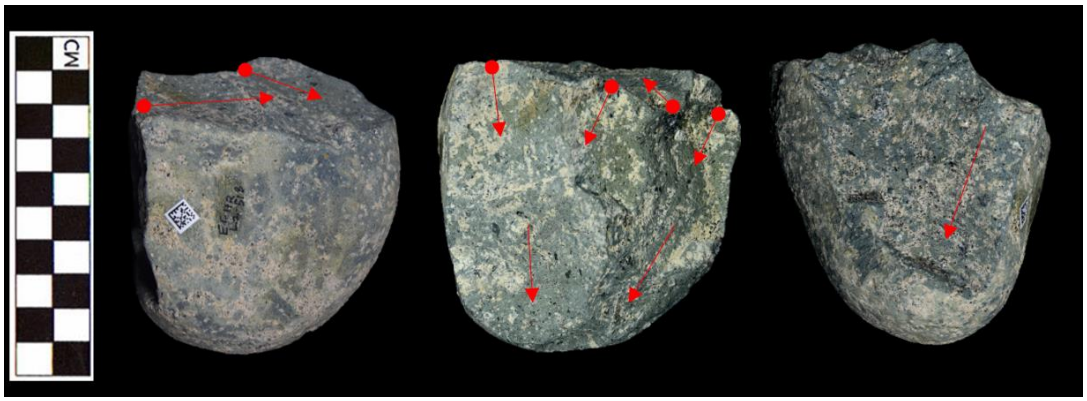


Figure 7.22: Artefact L2 518

Figure 7.22 is a core made on a phonolite cobble blank and has six flake scars that fit within the BAP schematic, though it does have some evidence of alternation on the edge working. Most of the flake scars are focused on one surface, though there is evidence of multiple layers of removals on each. The central volume remains, and the final core is quite bulky.

BALP cores

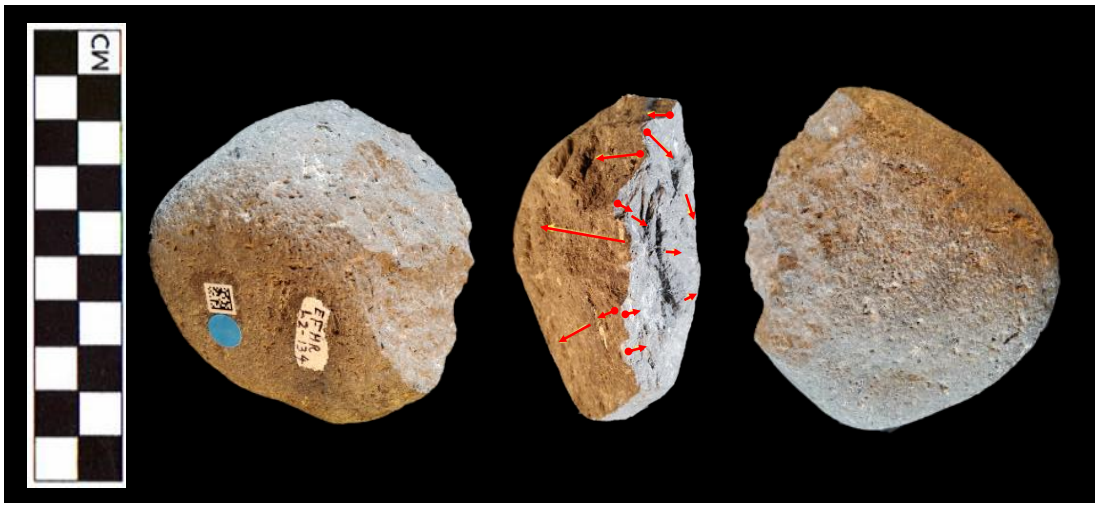


Figure 7.23: Artefact L2 134

Figure 7.23 is a core made on a trachyte cobble blank and has a reduction sequence that fits within the BALP category. There are 10 flake scars which are focused on one working edge and two surfaces and follow a single rotation. There is evidence of layered removals, and an

inconsistent application of bifacial flipping between each removal. The knapper was able to adapt the strategies during reduction to utilise apparent platforms.

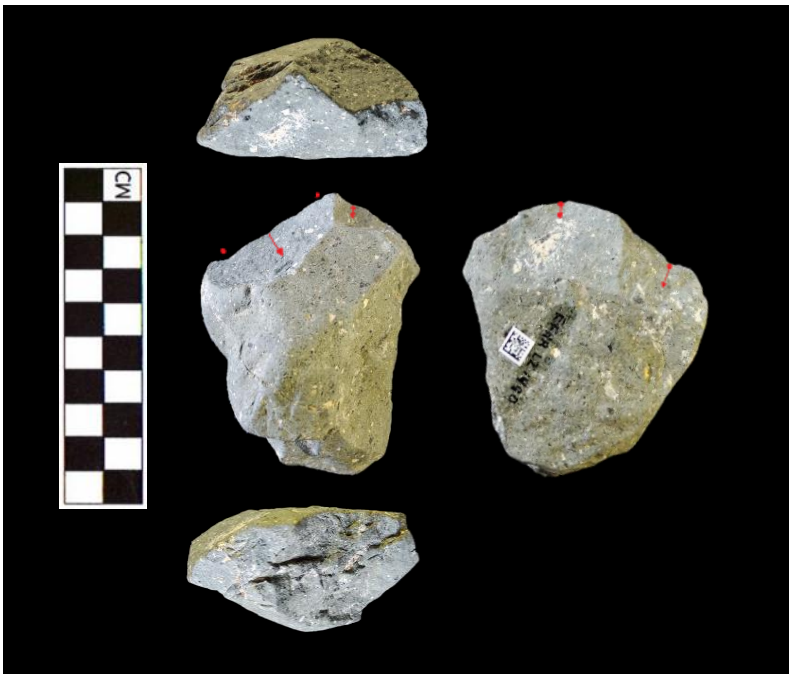


Figure 7.24: Artefact L2 1990

Figure 7.24 is a BALP core made on a phonolite blank. There is a UAU1 component to the core, adjacent to the BALP edge. The idelaised schematic shows how the two edges sit next to each other, and how the core was rotated in the same direction for both sequences. Therefore, it could possibly be a single sequence that began as a bifacial alternation on an acute edge, and moved to a more abrupt edge so the edge management changed.



Figure 7.25: Artefact L2 646

Figure 7.25 is an alternating bifacial core (BALP) along one side of a basalt split cobble blank. Similarl to the core above (L2 792), the river cobble blank is triangular, and the bifacial sequence is limited to the wide end. Many of the flake scars end with step fractures which do not penetrate the central volume of the piece. It might have been abandoned because of the successive step fractures.

BALT cores

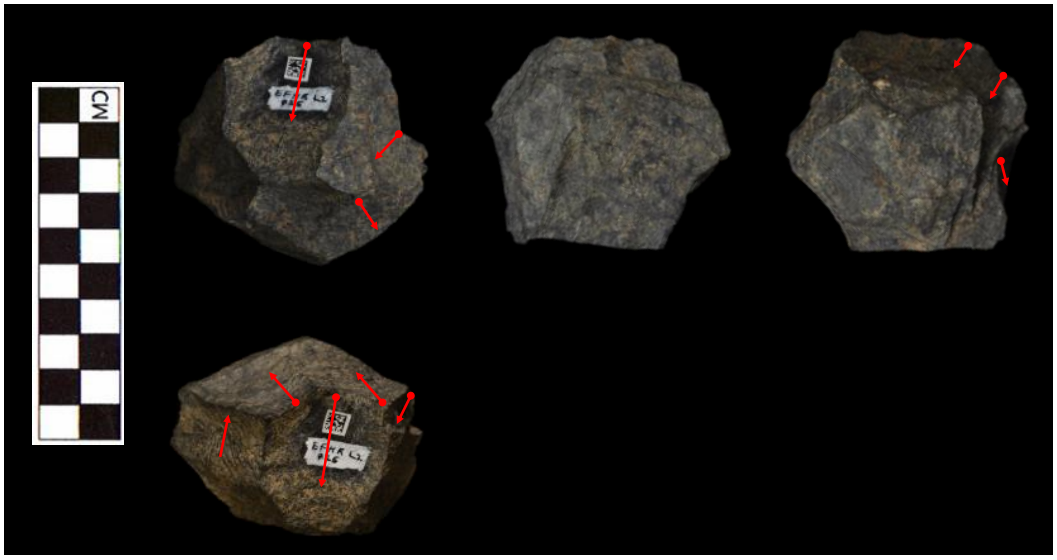


Figure 7.26: Artefact L2 725

Figure 7.26 is a core made on high quality basalt. The source of this specific basalt is, however, currently unknown. The core is fully exhausted with a combination of two reduction strategies with the dominant category being BALT along with a BP exploitation. Creation of these strategies appears to have been sequential on the core, as the BP exploitation strategy is followed by an alternating continuous edge working with removals going towards the centre in a uniform and even pattern resulting in the final discoid. However, there is little success at reducing the central volume on both sides of the core, with some cortex remaining on one of the surfaces. The surface with no cortex remaining has clearer volumetric exploitation and is parallel to the profile edge. Overall, this core fits into a general hierarchal knapping strategy whereby the interaction between the surfaces indicates a long and continuous reduction sequence.

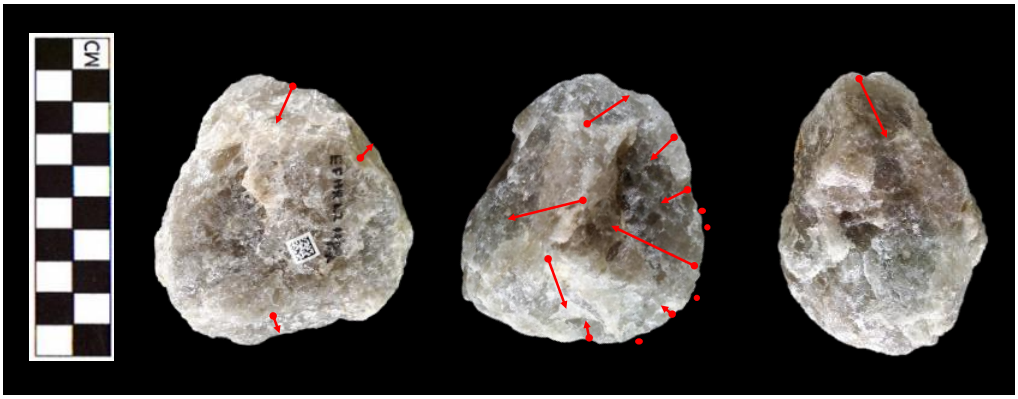


Figure 7.27: Artefact L2 1987

Figure 7.27 is a BALT core made on a quartzite cobble made up of two alternating sequences and a total of 16 scars. There is also evidence of battering, suggesting this was at some point used as a hammerstone. The two sequences do not touch but follow the same core rotation and direction of removals and could form part of one singular sequence. The idealised schematic is provided as the scars are hard to distinguish on photos of the quartzite material.

BP core

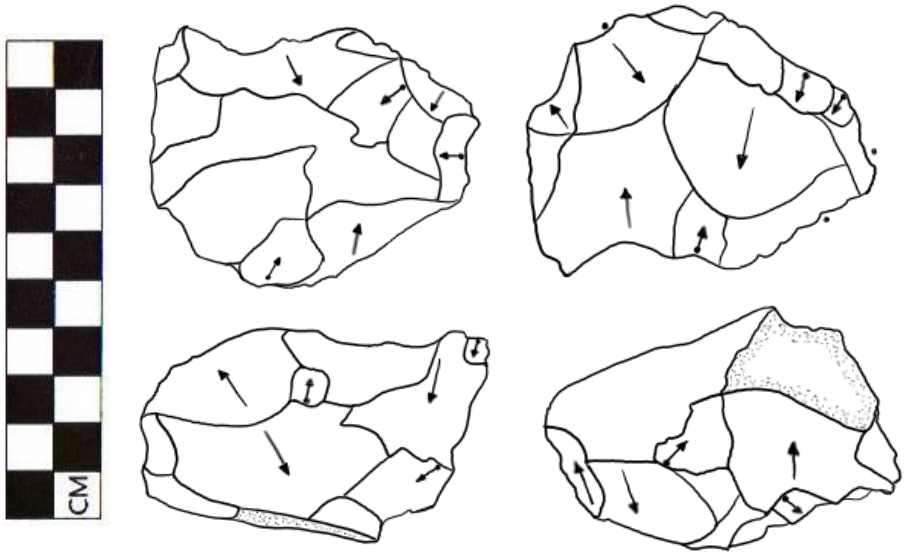


Figure 7.28: Artefact L1 123

Figure 7.28 is a BP core made on a phonolite blank. The piece has been too heavily reduced to definitively categorise the blank type. The piece has 13 scars in an asymmetrical volume exploitation between the two surfaces. The core edge management is bifacially structured and continuous but not alternating. There are multiple scars which obscure and overlap previous removals, and the central volume has been successfully removed on one surface. It could be

argued that based on the edge management this core is a discoid per the schemes in de la Torre and Mora (2018b), but it is not completely reduced on both sides.

Multifacial cores

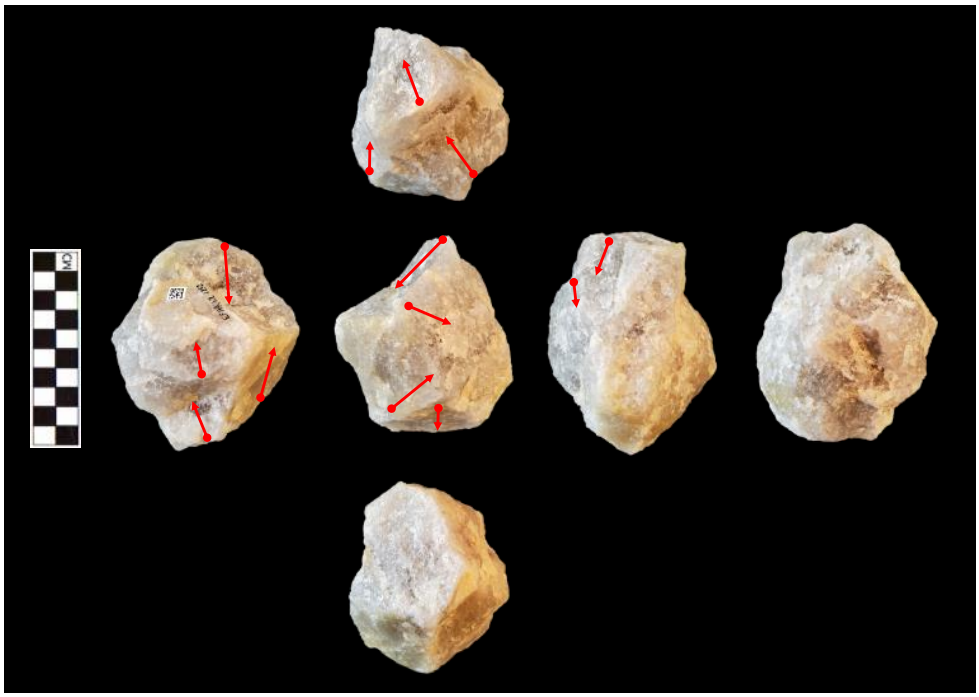


Figure 7.29: Artefact L2 1252

Figure 7.29 is a quartzite multifacial core with nine scars. The blank is indeterminate as there is little cortex remaining. There are multiple removals across the surface with some layered removals. Large removals create visible platforms for another removal on some of the edges. The exploitation focused on all available surfaces and the volume was not excessively reduced.

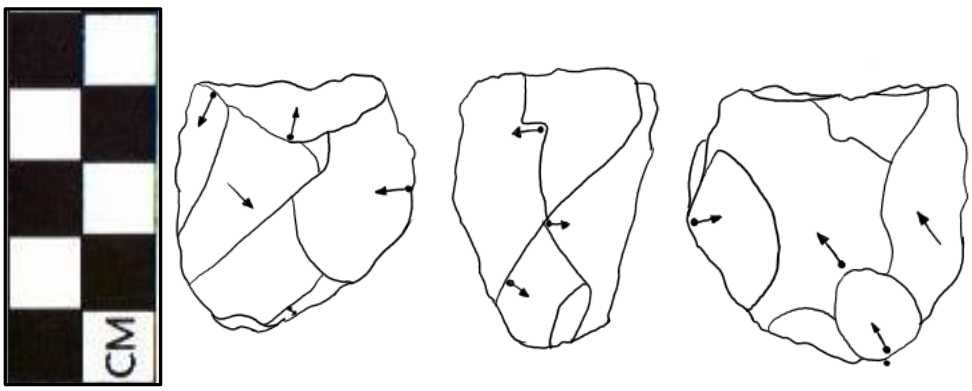


Figure 7.30: Artefact L2 1568

Figure 7.30 is a small multifacial core made on a quartzite split clast with 9 scars. The profile view has a short alternating sequence with 3 scars, but the entire surface area is exploited with scars going in multiple directions. It is which scar is the LFS is because of the many removals, but the scars mostly appear to end in feather terminations. This is therefore an example of an intensely reduced core.

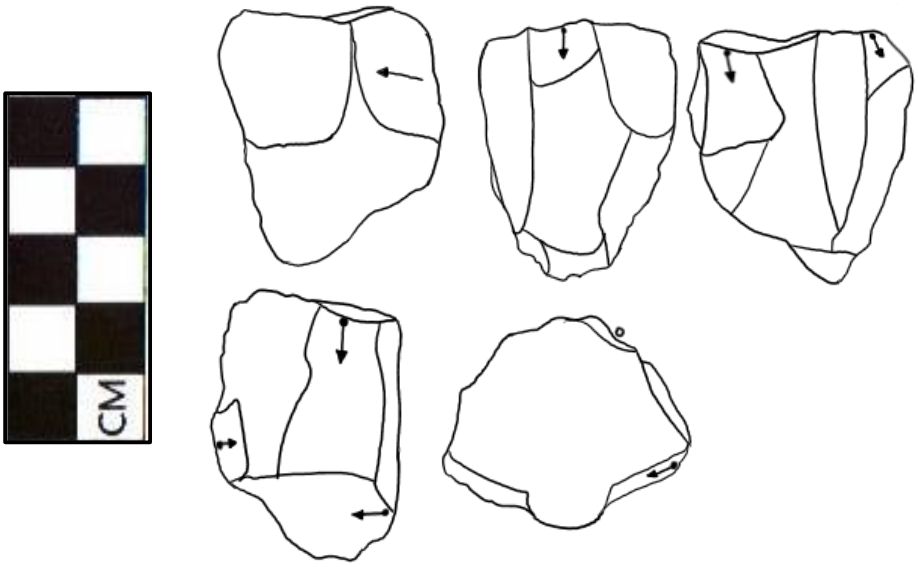


Figure 7.31: Artefact L2 533

Figure 7.31 is a small multifacial core made on a phonolite chunk blank with five scars. There appears to have been more removals, but these are not confirmed. The piece is more weathered than the standard freshness of the assemblage, and it appears that some small impact points have been eroded away. Overall, the piece appears intensely reduced but the weathering makes assessment difficult.

UAUT core

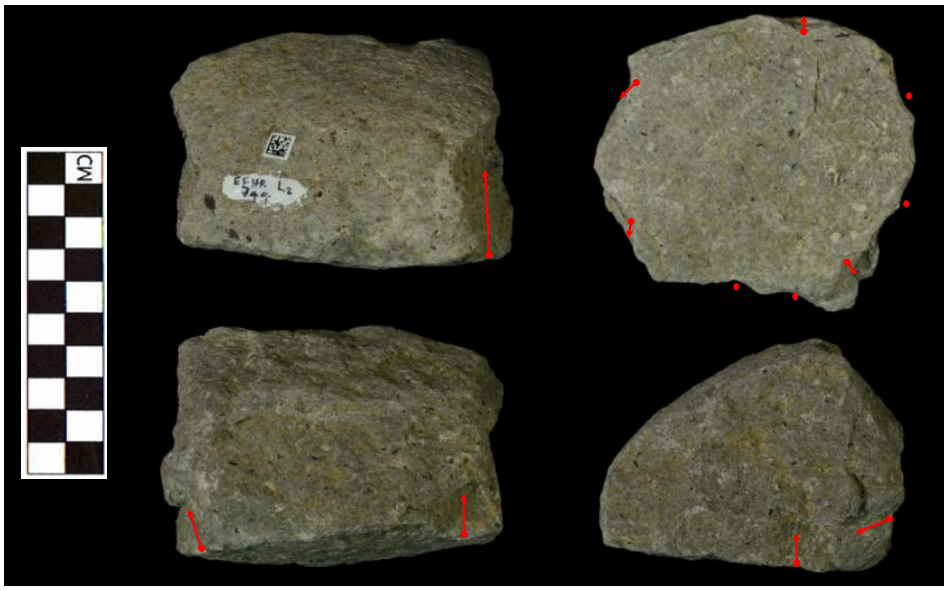


Figure 7.32: Artefact L2 744

Figure 7.32 is a single platform core made on a split trachyte cobble and falls within the UAUT category. Battering is evident on the remaining cortical surface, which could have split the blank. The battering activity appears to have also continued after the UAUT reduction, showing that hominids used and recycled pieces. There are six flake scars which extend around ¾ of the piece, covering one transversal and two sagittal surfaces. The LFS terminates in a step fracture.

USP core



Figure 7.33: Artefact L2 516

Figure 7.33 is a USP core made on a triangular shaped phonolite cobble, with the flake scars located on the wider end of the blank. There is one flake scar on the opposite side of the edge,

but this was abandoned for a dominant unifacial sequence. As with many other pieces, the sequence ends when the edge of the platform becomes too abrupt. The drawn image is a representation of how I believe the flakes to be removed, as they cannot be seen well in the photo.

7.4 Large cutting tools

7.4.1 Raw material

The raw material distribution for all cores and LCTs was discussed previously, however, trachyte was used for half of the LCTs (Figure 7.34). Basalt is most used in core reduction, but just over a quarter of LCTs are made on the raw material. There is clearly a preference for trachyte for LCT production, and a general use of basalt throughout the assemblage. Quartzite is used, proportionally, in a similar amount to the cores (17% in LCTs, and 20% for cores). Phonolite is least commonly used for LCTs, and the second most used for cores, further suggesting it was selected for core production. All these raw material types were found in proximity to the site, but knappers had a good understanding of raw material properties to use certain types of raw material differently.

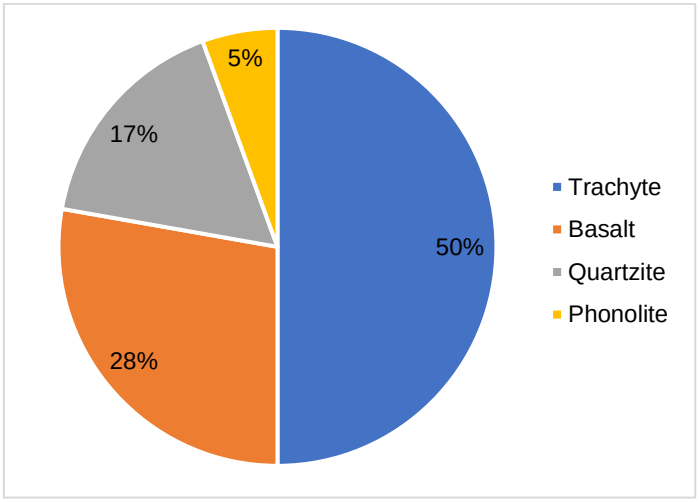


Figure 7.34: Raw material distribution in LCTs

7.4.2 Size and weight dimensions

The weights of the LCTs group around 450-650g, as shown in Figure 7.35 A. There are no pieces weighing less than 200g, with some going up to roughly 1100g. The length of LCTs ranges between just <100g to <200mm, while the ranges for width and thickness are close across the assemblage (Figure 7.35 B). This suggests that as LCTs increase in length, they

do not relatively grow in width and thickness. When considering the LCT blanks (described below in Figure 7.41), a majority are made on large flakes, suggesting knappers were able to produce large flakes at multiple sizes, however, as no distinct LCT cores are found in the deposit, it would be hard to describe the size range of LCT core blanks, and we must infer their skills through the LCTs themselves.

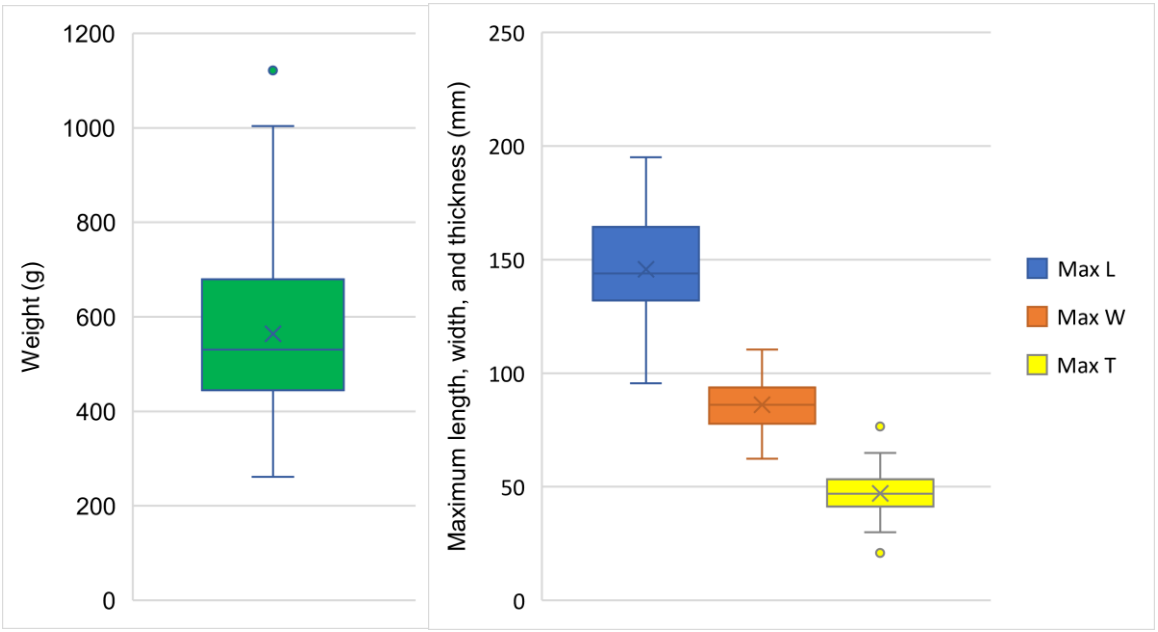


Figure 7.35: Weight range (g) (A), and maximum length, width, and thickness (mm) of LCTs (B)

Figure 7.36 is a scatter plot of the correlation between artefact weight and size in the LCTs. The maximum length of the LCTs correlate somewhat to the weight increase, as shown by the R-value of 0.6194, suggesting pieces get longer as they get heavier. Conversely, both the widths and thicknesses of the LCT collection show no correlation between these measures. Therefore, one can conclude that overall LCTs become longer as they get bigger, but not much wider or thicker. Figure 7.37 furthermore demonstrates this pattern as there is little significance between the increase of length to width and thickness, with R-values of 0.2254 and 0.0495, respectively.

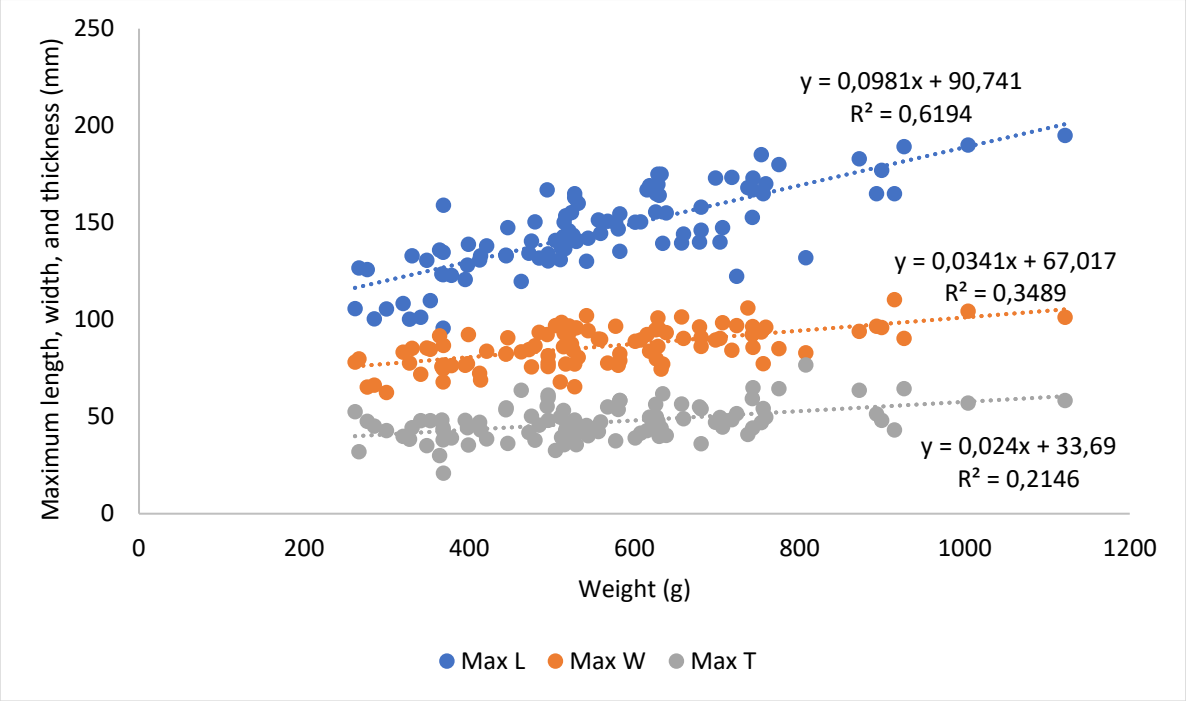


Figure 7.36: Correlation between weight (g) and maximum length, width, and thickness (mm) of LCTs

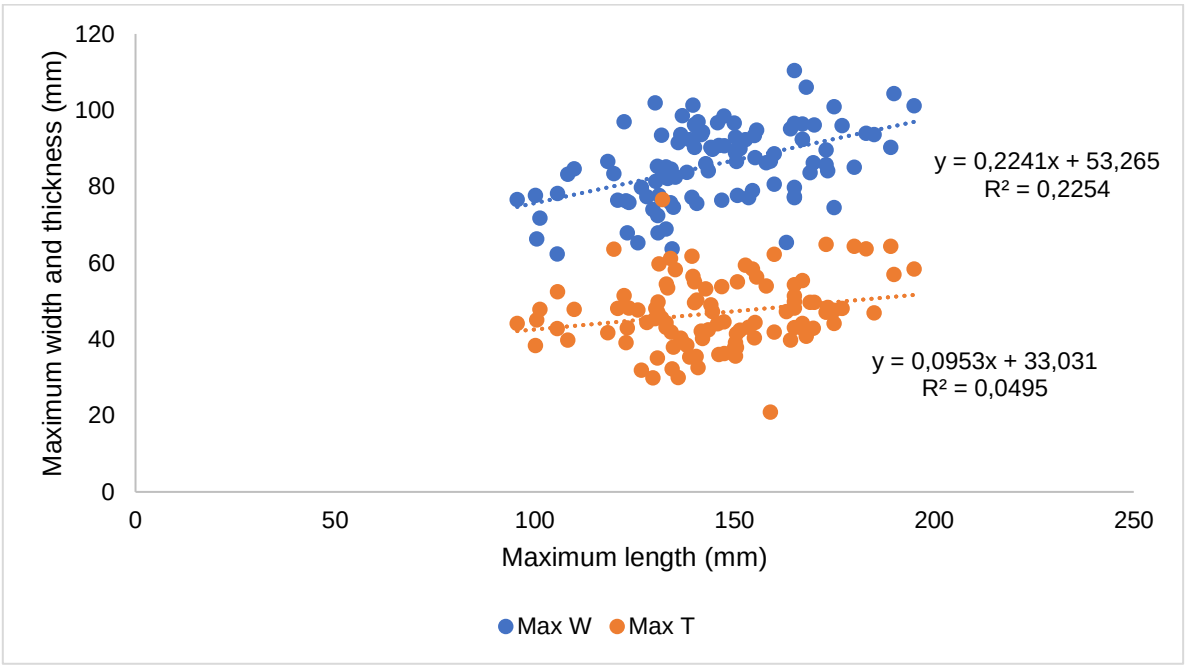


Figure 7.37: Correlation of maximum length (mm) and maximum width and thickness of LCTs (mm)

7.4.3 Refinement Index

The mean Refinement Index for the LCTs in the assemblage is 0.55. This means that the thickness of the pieces is roughly just over half the maximum width on average. This again corresponds with the preceding data that LCTs were generally long and thin. This will be

compared with the other sites in the discussion chapter to determine how variable it is between sites.

7.4.4 Shaping strategies and edge management

In chapter 3, there was a description of the various shaping strategy categories used in this thesis to describe LCT manufacture. The primary strategy applied at EF-HR is bifacial alternating, which makes up 49% (n=48) of the total LCT assemblage, while unifacial pieces make up 22.4% (n=22). Interestingly, bifacial working with no alternation only makes up 16.3% of the total, which is less than half of the alternating pieces (Figure 7.38). This suggests that knappers more commonly applied alternating shaping strategies to LCT production.

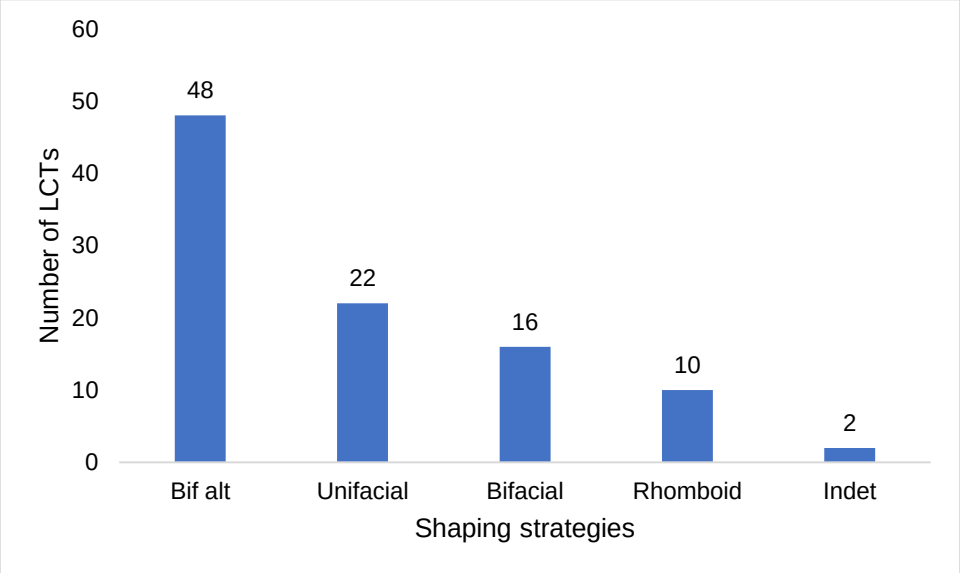


Figure 7.38: Shaping strategies of LCTs ('Bif alt' stands for bifacial alternating, and 'indet' stands for indeterminate)

In de la Torre and Mora (2018b) they described the overall assemblage as predominantly unifacial, which seemingly contradicts the above assessment. However, as will be expanded upon in the diacritical analyses, a lot of pieces have most of their flake scars on a single surface, thus their designation is unifacial. The examples of specific LCTs detailed below show the complexity of LCT edge shaping, and how general classification can sometimes obscure details. Therefore, despite most LCTs having biface alternating edge management, knappers did not focus on the surfaces equally. If the edge management and surface exploitation are considered separately, then it can be argued that a piece has a unifacial surface exploitation, but evidence of bifacial edge management. I argue that this is in line with the results as

presented by de la Torre and Mora (2018b) but gives more detail about the order or removals and variation in flaking strategies on single pieces.

Trachyte makes up half the LCT assemblage and is evenly spread across the various shaping strategies. Apart from the two pieces with indeterminate shaping strategies, all the groups have examples of all the raw material types (Figure 7.39). This shows a consistent use of trachyte and the other raw materials for all edge management strategies for LCT shaping.

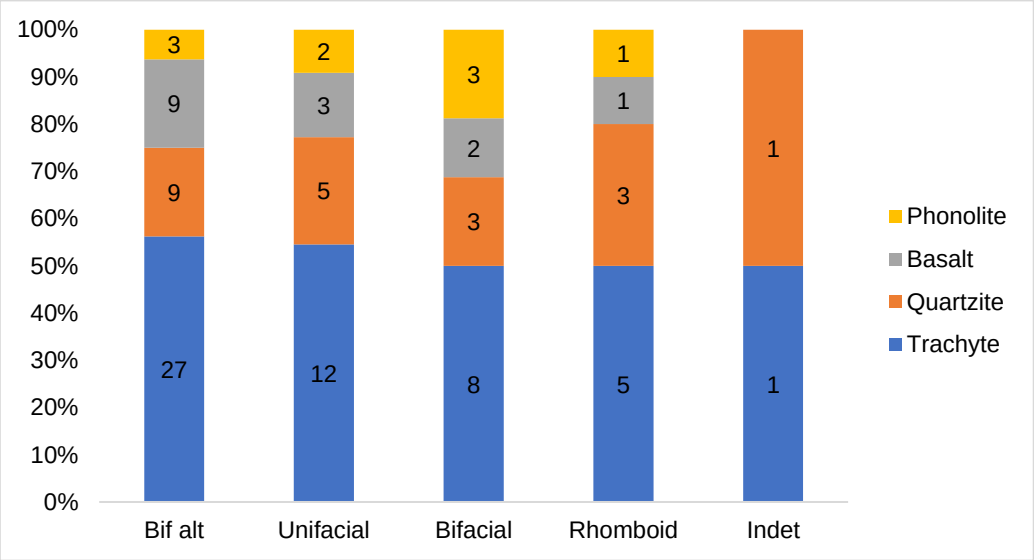


Figure 7.39: Distribution of raw material types for LCTs by shaping strategy

7.4.5 Flake scars

There is a range of 1-24 flakes on the LCTs, with the widest range in the bifacial alternating sequences (Figure 7.40). No other shaping strategies have more than 15 scars, except for one unifacial LCT with 16 scars. Bifacial strategies with no alternation also have examples of LCTs with just under 15 scars. Overall, the bifacial strategies have more flake scars, and the unifacial less.

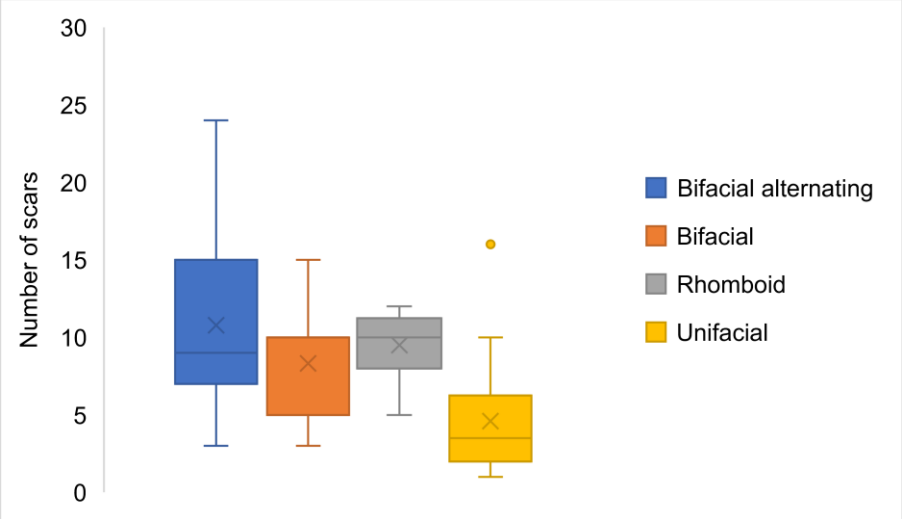


Figure 7.40: Range of flake scars by shaping strategy for LCTs

7.4.6 Blanks

LCT blank types are dominated by flakes (Figure 7.41). Flake blanks make up 77.5%, including the two split flake blanks. Cobbles are used but very rarely, only making up 8.8% of the assemblage. Overall, there is a clear use of large flakes for LCT production, indicating a consistent manufacture of large flakes. The flake blanks also have the widest range of flake scar numbers, but the median, mean, and most of the flake scars are similar to the LCTs also made on cobble blanks (Figure 7.42). This could suggest that there is a similar amount of shaping on both flake and cobble blanks. LCTs with block blank types have lower scar counts, suggesting the blank shape did not require extensive edge shaping.

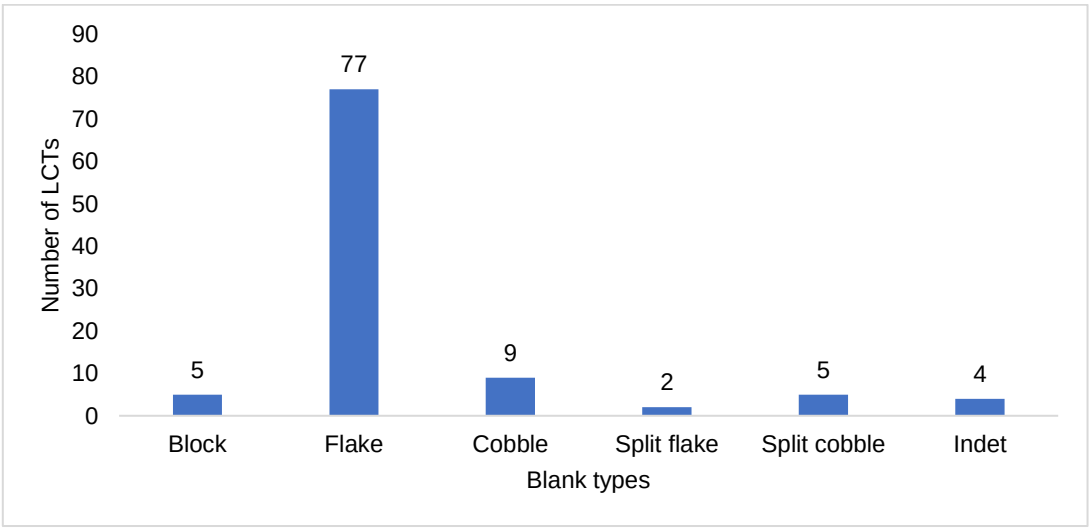


Figure 7.41: Blank types of LCTs

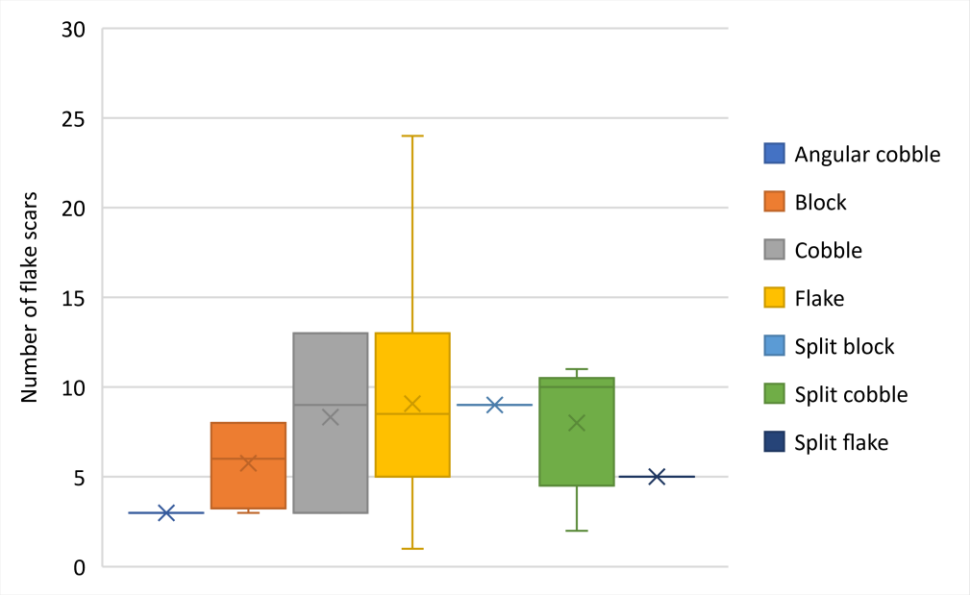


Figure 7.42: Range of flake scars per blank type for LCTs

7.4.7 Scars and flips

A critical t-test of the number of flake scars and times a piece was flipped gives a result of p=1.9728. This means here is a significant relationship between the means of each group and that LCTs with higher scar counts were flipped multiple times. Like with the other sites, this p-value will be elaborated on in the discussion when the results from all the LCT assemblages are compared.

7.4.8 Diacritical analyses of LCTs

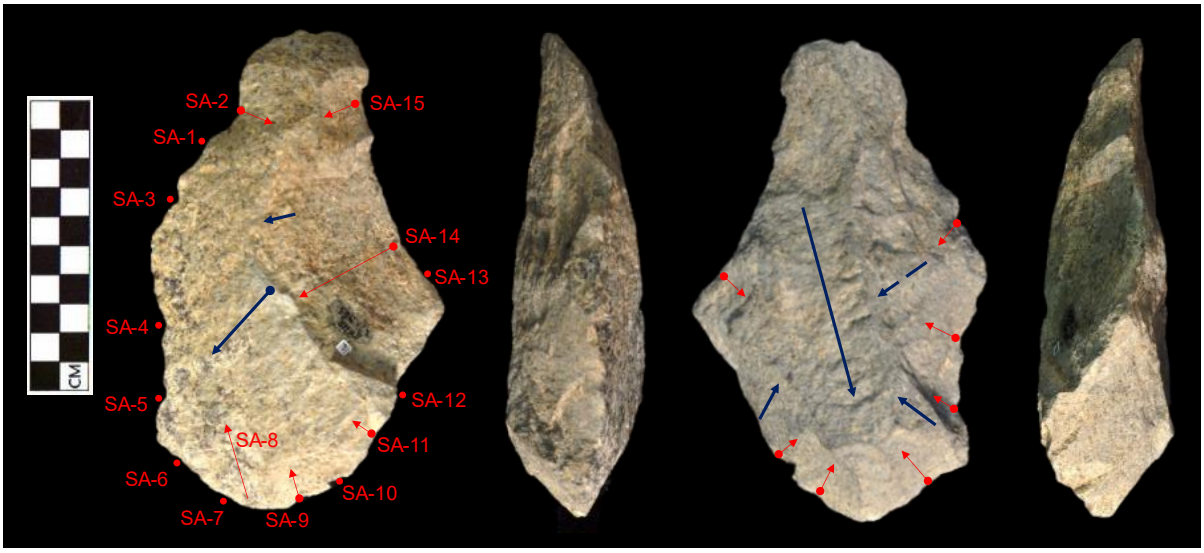


Figure 7.43: Artefact L2 355

Figure 7.43 is a trachyte bifacial LCT made with a single continuous alternating sequence that goes from the left proximal end of the ventral surface, around the distal end, and up to the proximal end of the right side. There are 15 scars in the shaping sequence and four identifiable debitage scars. The tip appears to have some damage, but it is not clear if it is use wear.

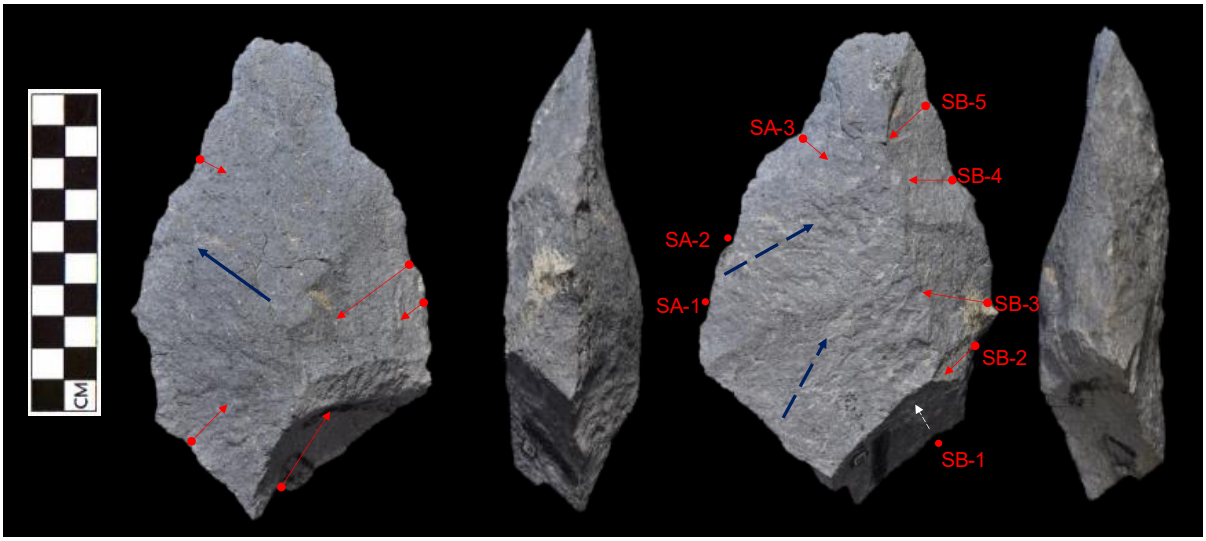


Figure 7.44: Artefact L2 36

Figure 7.44 is a basalt handaxe made on a flake blank and shaped using the 'rhomboid' pattern of two unifacial sequences on opposing edges and surfaces. There are two scars on each edge that are bifacial to their respective sequences, but the unifacial sequences dominate. Both sequences appear to go from the distal to proximal end. Three scars specifically reduce the width of the tip, created a more elongated working end.

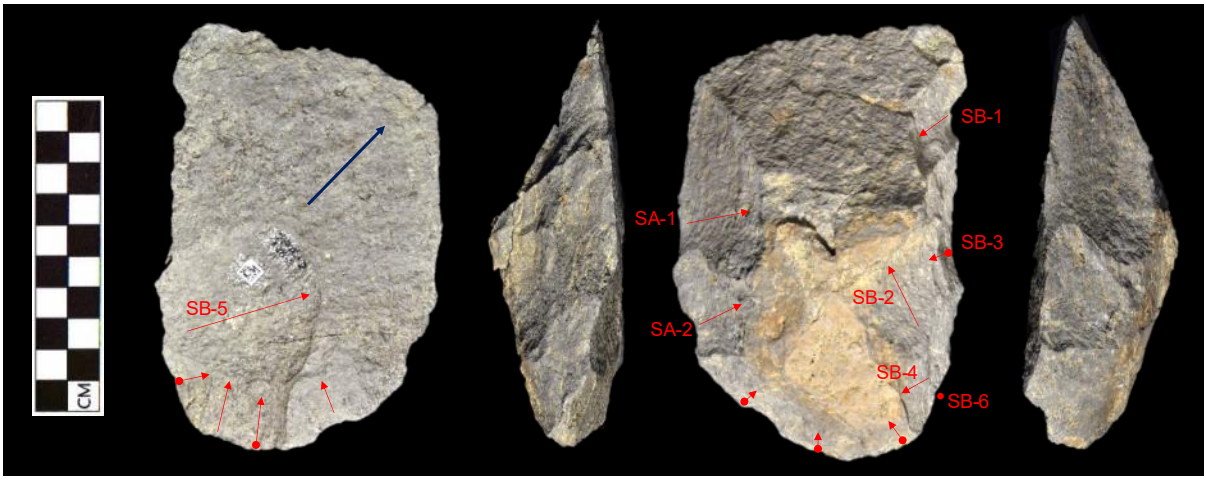


Figure 7.45: Artefact L2 1667

Figure 7.45 is a trachyte cleaver that has been shaped along the medial and distal sections of the piece, with a dominantly bifacial alternating sequence. There are 11 shaping scars, but

the order of removals is not fully evident, and the only identifiable débitage scar is the flake blank. Most of the scars shape the dorsal surface, with a few consecutive scars on the distal end of the ventral face which removed the bulb of percussion, and the tip of the piece has some damage.

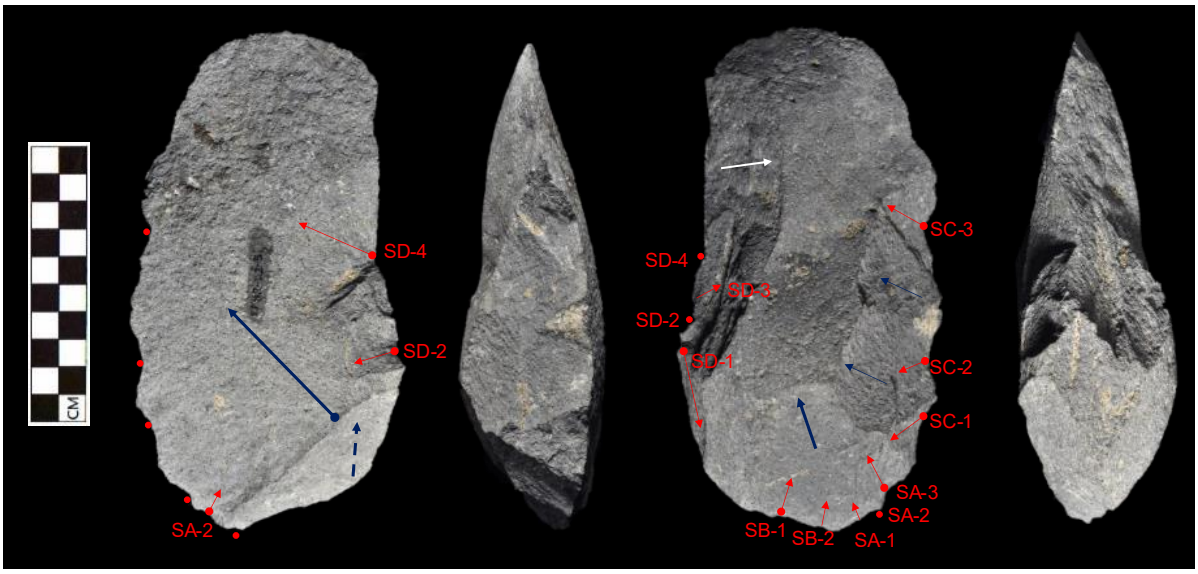


Figure 7.46: Artefact L2 5

Figure 7.46 is an example of a basalt end-struck flake blank with a dominant unifacial shaping on the dorsal face. The right side of the dorsal face has been worked unifacially to produce a notched knife edge but was started with alternating edge management at the base and on the opposite edge. The tip is untouched, which could classify this piece as a cleaver, but the laterally worked edge could make it a knife as well. There are debitage scars on the dorsal surface going in the same direction as the shaping scars, suggesting the core management was like that shaping process, prior to the blank production.

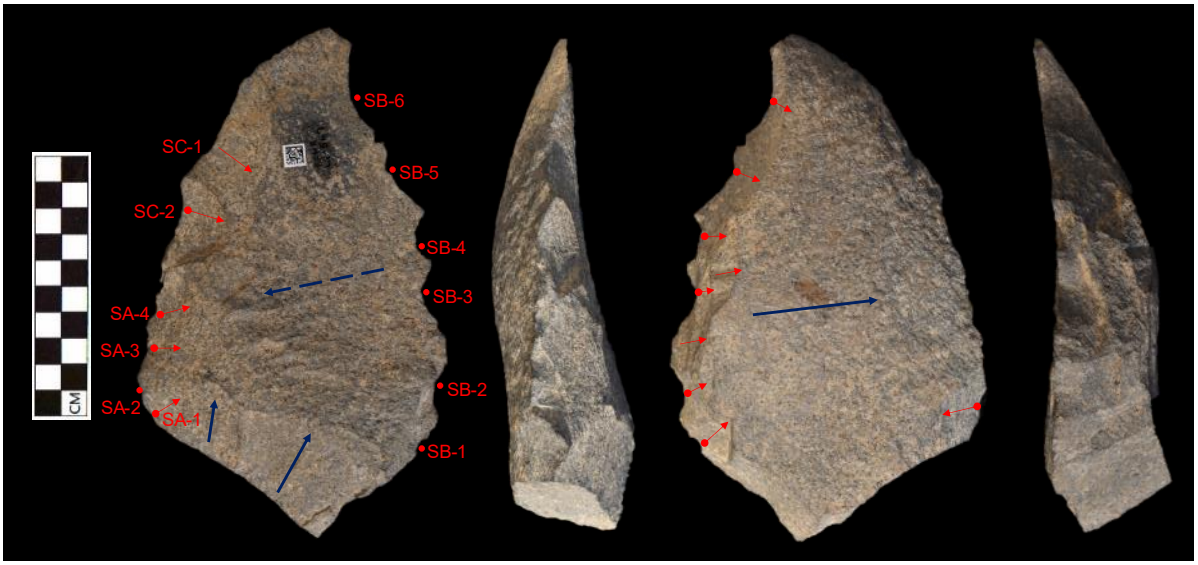


Figure 7.47: Artefact L2 549

Figure 7.47 is an LCT that fits within the 'rhomboid' shaping strategy, whereby two separate unifacial sequences on opposite edges and surfaces create an overall bifacial final product. This particular piece is classified as a knife, because one side has been shaped as a denticulate, while the opposite side has been thinned, possibly for handling.

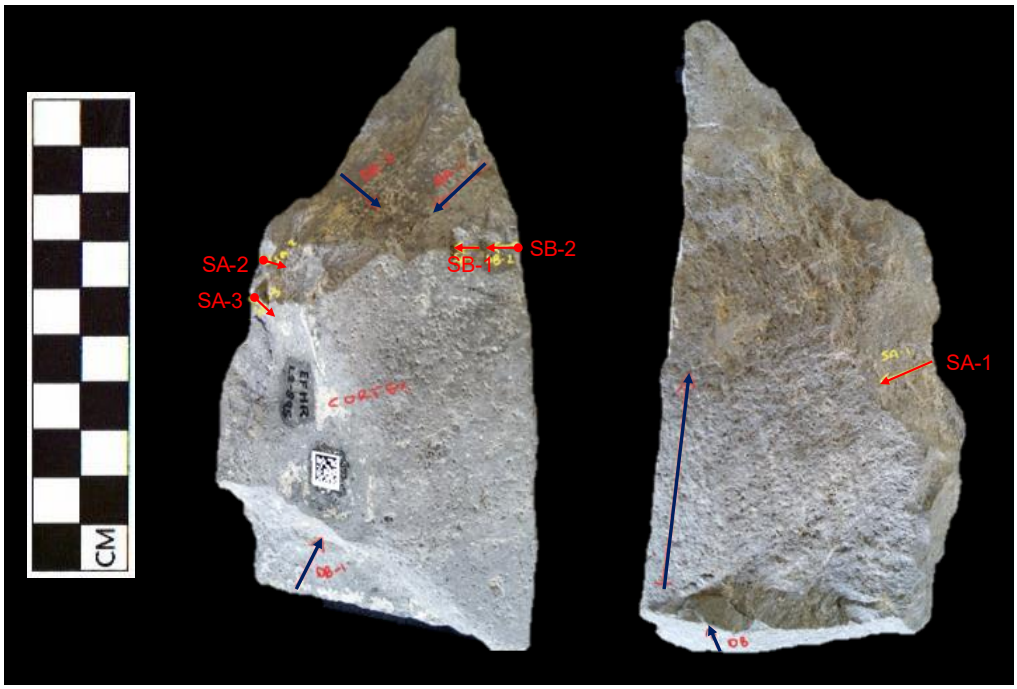


Figure 7.48: Artefact L2 895

Figure 7.48 is a unifacial tool made on a split flake blank. There were some attempts at thinning the bulky side, but these scars are small and end in step fractures (SA sequence). There is one obvious shaping scar on the thin edge of the ventral surface, which creates a notch. The

scars around the tip of the piece have no impact points and therefore come from the debitage sequence before the creation of the flake blank.

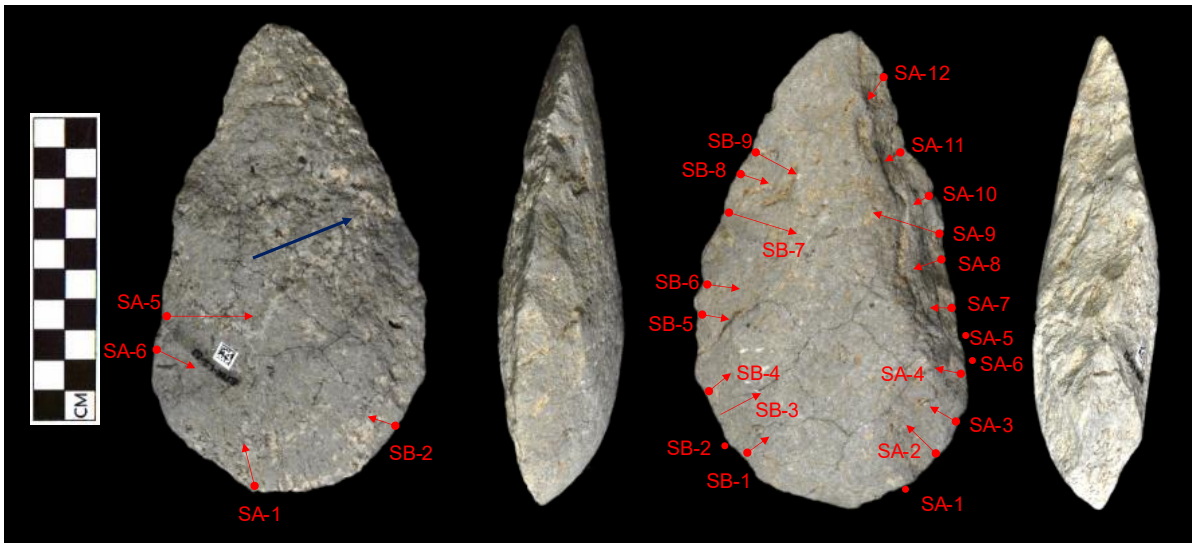


Figure 7.49: Artefact L2 53

Figure 7.49 is a handaxe and one of the few pieces with evidence of some rolling, but the order of removals is still observable. It is a predominantly unifacial handaxe made on a flake blank. The platform of the blank has been removed through the sequence B (SB), on the left side of the dorsal surface. Sequence A (SA) is partly alternating towards the distal end, maybe to thin out the bulkier section. Both sequences go from the distal to proximal ends.

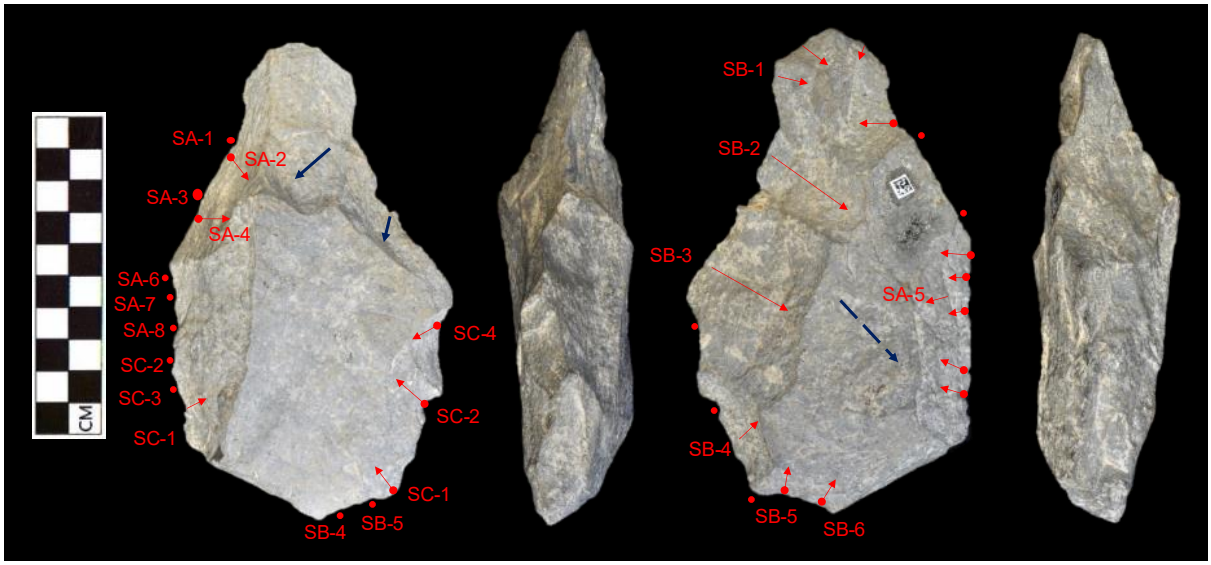


Figure 7.50: Artefact L2 665

Figure 7.50 is a handaxe made on a trachyte flake blank, with three separate shaping sequences on either side, which exploit almost the entire edge between the ventral and dorsal surfaces. Sequence A (SA) is on the left side of the dorsal side and uses a bifacial alternating strategy to thin most of the edge, except for the distal end. Sequence B on the opposite distal side is unifacial. Sequence C is bifacial to SB but the scars do not touch, so they have been separated, though they could be from the same sequence, which would be a bifacial. SA appears to go from the tip to the base, which differs to the more common order of base to tip (as seen in L2 53 (Figure 7.49), for example).

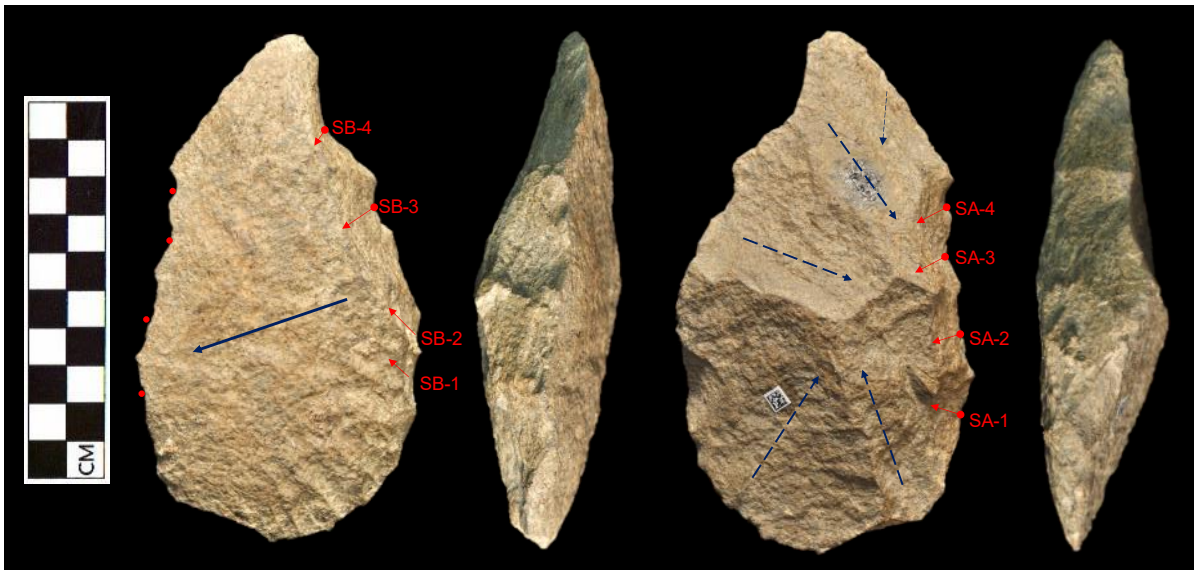


Figure 7.51: Artefact L2 790

Figure 7.51 is a knife made on a trachyte flake blank and fits within the 'rhomboid' shaping strategy. Both sequences are unifacial and have four scars going towards the tip. The tip is notched, which was created by SB-4. There are five debitage scars on the dorsal side, indicating the cobble this flake came from was heavily worked prior to the blank being produced.

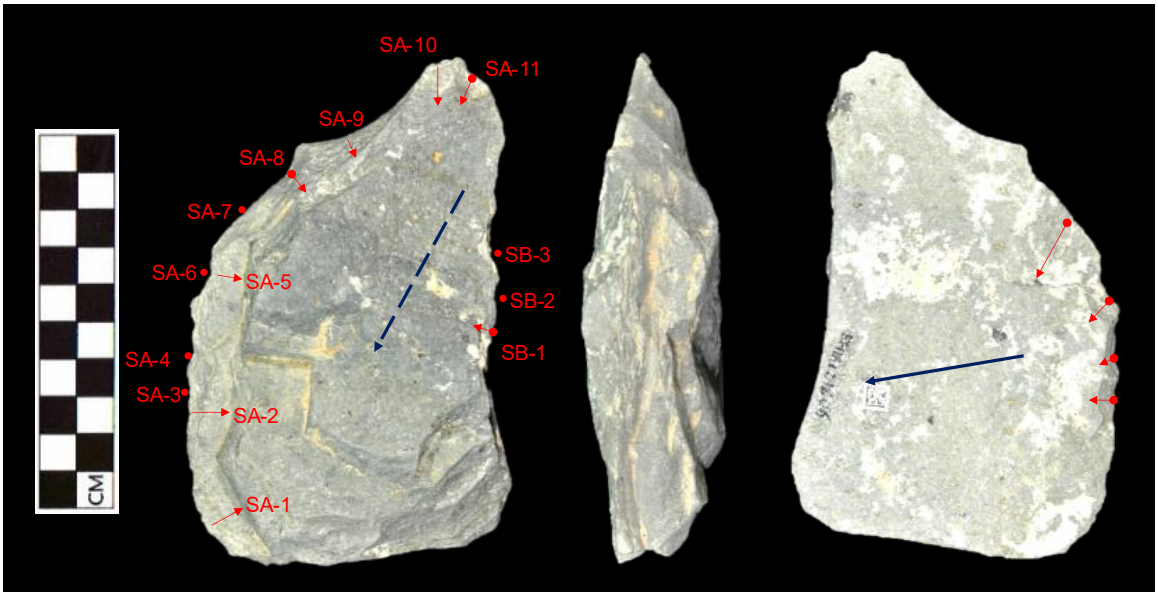


Figure 7.52: Artefact L2 1806

Figure 7.52 is a basalt knife made on a large flake and is shaped predominantly using a bifacial alternating sequence on the left dorsal side. Sequence A has 11 scars and was flipped four times, starting at the distal end, and ending at the tip. Sequence B on the opposite edge only has three scars and was flipped once. It appears SB was an attempt to thin the bulk, as the scars are shallow and end in step fractures.

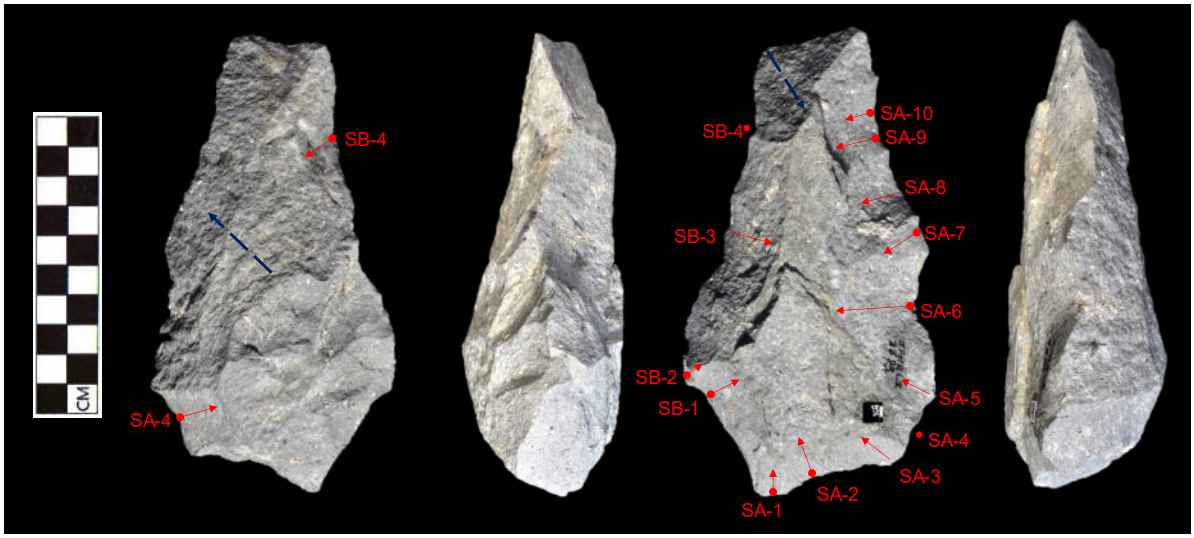


Figure 7.53: Artefact L2 1673

Figure 7.53 is a trachyte primarily unifacial handaxe. The blank is not obvious, but it was likely made on a large flake that has been partially removed by damage as seen on the lower side of the 'ventral' surface. There are two shaping sequences on either side which go up towards the tip. SA starts at the base in a unifacial strategy, with one scar (SA-4) indicating a bifacial

flip out of ten, which end at the tip. SB is a unifacial sequence on the dorsal side, with one scar (SB-4) on the opposite face just below the proximal section.

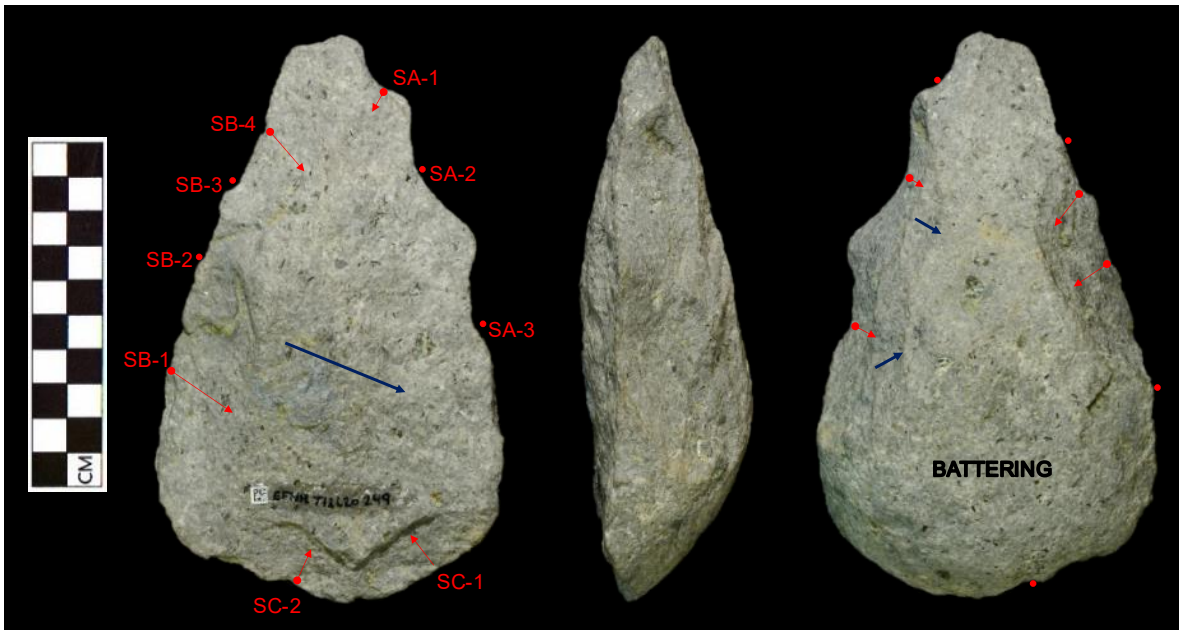


Figure 7.54: Artefact T12 L20 249

Figure 7.54 is a trachyte handaxe made on a cobble, with evidence of battering on the distal end of the dorsal surface, suggesting the cobble was used as a hammerstone. There are three distinct sequences (SA, SB and SC), which combine both bifacial alternating and unifacial shaping strategies. SA is fully visible form the profile, and site perpendicular to both surfaces. It is primarily unifacial, travelling from the dorsal to ventral sides. There is one exception (SA-1) which sits bifacially to the rest of the sequence. SC is also unifacial, while SB is alternating, with four removal and two flips.

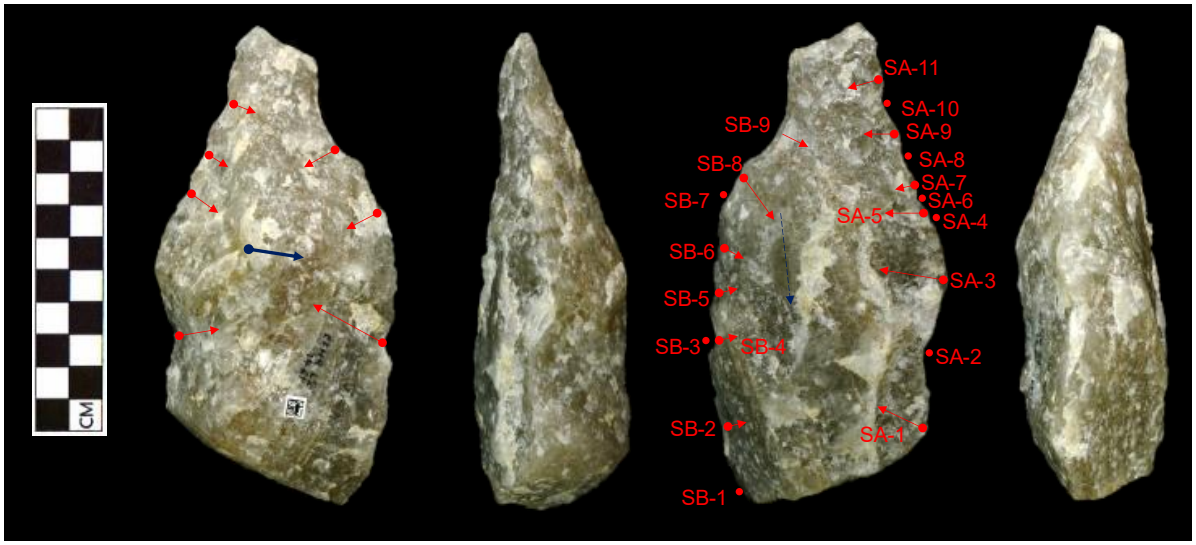


Figure 7.55: Artefact L2 1461

Figure 7.55 is a handaxe made on a tabular quartzite piece and shaped along either edge with two separate bifacial alternating sequences. SA is on the right side of the 'ventral' surface, has eight scars and was flipped 4 times. SB has 10 scars and was flipped nine times. Both sequences go from the base upwards, with the last removals successfully thinning the tip, and SA-8 creating a shallow notch.

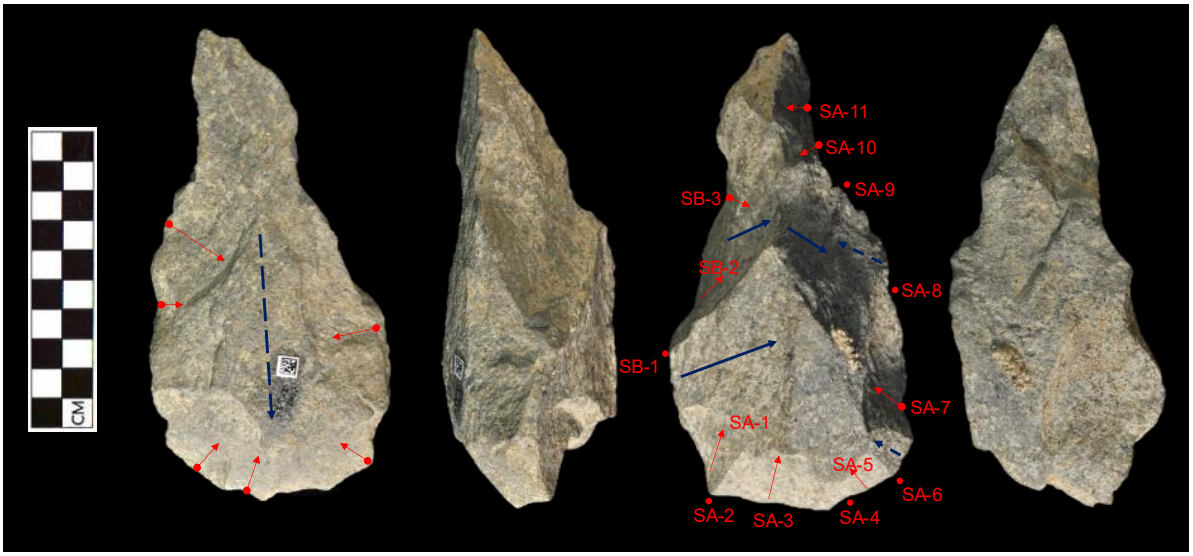


Figure 7.56: Artefact L2 572

Figure 7.56 is a phonolite pick, likely made on a large flake blank. The piece is shaped quite a bit, and the flatter surface, which is partially removed, has been classified as a ventral surface. There are two distinct shaping sequences, with SA starting on the distal left side of the dorsal surface and moves across the base and up the right side to just below the tip. SB

only consists of three flake scars, and thin the medial and part of the proximal edge opposite SA. Like the handaxe above, L2 1461, the tip is thinned out with shallow notches.

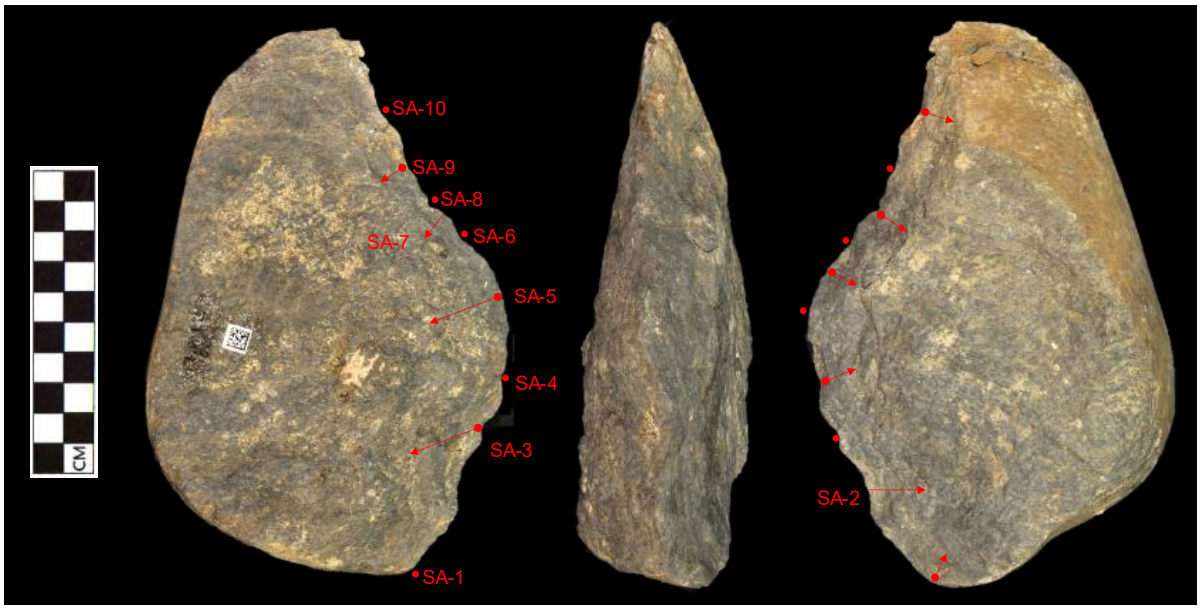


Figure 7.57: Artefact L2 590

Figure 7.57 is a knife made on a trachyte flake blank with multiple bifacial alternating scars. The flake scars are organised in a single sequence that begins at the base and end at the tip. There are a total of 10 scars and the piece was flipped eight times. The lateral edge opposite the bifacial sequence is cortical and could indicate that the core from which the flake blank was removed was not heavily reduced.

7.5 Technological trends at EF-HR

Apart from the raw material differences in the two assemblages, the main difference concerning technological behaviours is that bifacial shaping in LCTs is predominantly alternating, while it is not in the cores. The edge angles on cores were primarily abrupt, while the LCT flake blanks were acute. It could be argued that when the cores and LCTs are compared, bifacial alternating techniques are applied more regularly to acute angles, while bifacial strategies of managing the two surfaces separately is more suited to wider angles.

Cores shapes are more variable, as there was a range of different river cobble blanks selected for reduction, which were generally smaller than the large clasts needed for LCT flake blank production. Therefore, size was more imperative when knappers were selecting LCT core

blanks, while the shape of core blanks was more important. However, this is a hypothesis as there are no specific examples of LCT cores in the excavated assemblage.

Overall, the data presented here agrees with the conclusions mentioned in de la Torre and Mora (2018b), who argue that the cores and LCTs represent different production processes. Not only is there a difference in selection of blanks for both groups, but the edge management strategies applied to LCT shaping and core reduction are predominantly different, even though the same techniques appear in both.

Chapter 8: Comparison between sites

In the first section of this chapter, the various attributes and analyses of core reduction strategies presented in each chapter on the sites will be discussed and compared. Secondly, the patterns of LCT edge shaping will be discussed, and the various core edge management techniques of cores will be compared.

8.1 Cores

Table 8.1: Means of core dimensions, weight and number of scars ('Max' stands for maximum)

Site	No. of cores	Weight mean (g)	Max length mean (mm)	Max width mean (mm)	Max thickness mean (mm)	Cortex	Number of scars
Sterkfontein M5W	264	422.1	87.2	73.6	56.4	2.1	6.4
Rietputs 15 ACP	88	180.6	69.2	55.8	37.3	2.4	5.2
Rietputs 15 Pit 5							
Canteen Kopje Basal Early Acheulean layer	39	6351.2	226.3	164.2	118.1	2.4	5.8
Canteen Kopje Organised Core Technology layer	40	2740.3	152.2	109.9	79.6	2.6	5.9
EF-HR	128	428.1	83.5	70.1	53	2.3	5.88

8.1.1 Raw material and blank types

Raw material is different at the sites, in rock type, shape and size. This has effects on the core reduction strategies and the final products, even if technological strategies are similar between sites (McNabb and Kuman 2015). The proximity of raw material sources can indicate how varied an assemblage is, and how intense reduction generally is, and if there are any clear

selection patterns by hominids (Jones 1994; Blumenschine *et al.* 2012). The shapes, properties and qualities of material at the different sites reflect in the technology. At Sterkfontein the quartzite is generally fine grained, and the vein quartz is more brittle. The quartzite was selected throughout the Oldowan and Acheulean at Sterkfontein, but it became more prominent in the early Acheulean, especially for heavy-duty tool production. When compared to the quartzite from Olduvai there is a closer match between the quartz from Sterkfontein (Figure 8.1). The two artefacts presented in Figure 8.1 are examples of the standard raw material types of quartzite (following Hay 1976) and vein quartz (Sherwood 2021) used in Olduvai Gorge and the Cradle of Humankind, respectively.

The quartzite at EF-HR is quite unique (see discussion in chapter 2) and is selected less than the other rock types and shapes for reduction. It is sometimes mistakenly called quartz, because it is highly metamorphosed (Hay 1976; Arroyo and de la Torre 2016). The shape of quartz from Sterkfontein is often blocks, chunks, or indeterminate types, and TC and multifacial reduction strategies dominate the cores. At EF-HR the quartzite is tabular in shape and the blanks are mainly blocks, chunks and indeterminate types as well. Multifacial, TC, and bipolar cores have multiple quartzite examples.



Figure 8.1: Examples of quartzite (LCT) from Olduvai Gorge (left), and vein quartz (core) from Sterkfontein Caves in the Cradle of Humankind (right)

At Sterkfontein, fine-grained quartzite was selected for LCT production as well as core reduction, and long and structured sequences were primarily made on quartzite (Sherwood 2021). The quartzite is blocky in shape, often with abrupt and rounded edges. At EF-HR, rounded and split river cobble clasts of basalt and phonolite were primarily selected for core reduction, while larger raw material blanks, mainly trachyte, were selected for LCT production. There were no LCT cores recovered in the OGAP excavations, and the flake blanks were

>10cm. which means that trachyte clasts were likely quite large. Unfortunately, the shape of the clasts is unknown as they are not on site. Rounded and complete cobbles were more likely to be used for bifacial reduction strategies, while unifacial cores had an equal representation of rounded and split rounded clasts. Blocks were used only for test cores and multifacial strategies, which could suggest that the spherical clasts and clasts with rounded edges were more suitable to bifacial reduction strategies. Trachyte clast blanks used in the core reduction were angular with rounded edges and were often split.

At Canteen Kopje, andesite cobbles and boulders were most used in the analysed samples. Despite the large range in core sizes, similar edge management techniques were applied in each layer. In the Basal Early Acheulean layer, large boulders were used more for TC, multifacial, and abrupt edge management strategies, and in the OC layer, split clasts correlated with bifacial strategies, while spherical clasts were more unifacially worked. Between these sites, the same strategies are applied, but at different rates because of the raw material shapes, specifically the edge shapes. Overall, blank shape and angles are more important than size for the reduction strategy applied, rather than the specific raw material types. However, there is selection of certain types for core and LCT flaking.

8.1.2 Flake scars

The number of flake scars and the core reduction schemes from each assemblage were analysed using chi-squared analyses and presented in their respective results chapters. This was done to test the hypothesis that there are expected flake scars number for each reduction strategy. Only Rietputs 15 ACP had a p-value of 0.05 indicating an association between the categories, while the other core assemblages all had p>0.05 (Sterkfontein p=0.24; Canteen Kopje Basal layer p=1; Canteen Kopje Organised core layer p=0.93; and EF-HR p=1). Overall, there is no general expectation of flake scars and reduction strategy across the sites.

8.1.3 Organised core reduction strategies

At Sterkfontein and EF-HR there are examples of cores with intensive volume reduction, and hierarchal exploitation of surfaces. This includes pieces with BHC, BALT, and discoid edges management, but most cores at each site are partially exploited. The Northern Cape sites have a more pronounced trend of organised core reduction.

Long reduction sequences which demonstrate a structured control of the core edge management are rare in all the assemblages. These are categories such as BALT, BHC, and discoid. In each of these cases a core was intensely reduced through multiple rotations of the

blanks. In some cases, the piece was also continuously flipped during reduction. Knappers were able to maintain long reduction sequences to exhaust the surface volume of a core.

The changes in core reduction in the Acheulean have been linked instead to the emergence of hierarchal surface management, leading to the development of prepared core technology (White *et al.* 2011; Leader 2014; Leader *et al.* 2018). In the case of this thesis, these reduction strategies are identified at Canteen Kopje and Rietputs 15, especially through the work of Leader (2009; 2014) and Leader *et al.* (2018). The hypothesis of progressive change in the early Acheulean was discussed in chapter 2, section 2.3.3, as evident through the shift from 'simple' to 'organised' core reduction.

In each layer at Canteen Kopje there are cores with asymmetrical volume reduction, and a surface used for preferential flake removal. Interestingly, there is a wide size range in these cores, and in the overall shape of the blank, and angles of the edge between surfaces is of more importance to the reduction strategies. These strategies were also used to produce flakes < and >10cm, so come cores also belong in the LCT production. The edge management of the organised cores included in the study sample have been placed within different bifacial categories, including BHC, BALT, and BALP. The edges management strategies range between alternating and traditional bifacial, but there is a continuous rotation of the piece between at least two faces of the core.

8.1.4 Cores with multiple idealised schemes

Multifacial cores can provide information on the general trends at a site. This core reduction strategy is dominant at Sterkfontein and in the Basal Early Acheulean layer sample at Canteen Kopje. One of the hypotheses we can address from the predominant application of multifacial techniques is the relative age of the deposit. The Basal Early Acheulean layer is stratigraphically older than the Organised Core layer at Canteen Kopje, while the absolute date for Sterkfontein M5W is not known. However, an analysis of the core reduction strategies suggests the latter could be an older deposit within the early Acheulean, as is the case for the Basal Early Acheulean layer in Pit 6 at Canteen Kopje (see section 2.3.3).

These layers also both have the highest proportion of cores with multiple idealised schemes. At Sterkfontein, there are 20 examples of such cores -17 have a dominant multifacial scheme, and three have a non-dominant multifacial scheme. In most cases, the structured exploitation appears on a single surface and/or platform, with the multifacial scheme either opposite or encompassing most of the surface area around it. Sterkfontein core technology is more expedient in that knappers are exploiting blanks with natural platforms and abandoning

knapping sequences. Hominids were flexible and adaptive during the knapping process, as they could variably manage differently shaped natural platforms on a single core.

8.1.5 Reduction intensity

Figure 8.2 presents the combined data of remaining cortex from all the sites. All the assemblages have a large number of cores with remaining cortex between 51-75%, but the pattern differs slightly for Sterkfontein and the Basal Early Acheulean layer at Canteen Kopje. At Sterkfontein, most cores are in the category 1-25%, and overall, 53% of cores have <50% remaining cortex. At Canteen Kopje, within the cores that could be categorised based on cortex, there was an exact split between cores with both < and >50% cortex. There were also two examples of cores with no remaining cortex.

At EF-HR, Rietputs 15 ACP, and the Organised Core Technology layer at Canteen Kopje Pit 6, more than half the assemblage has >50% cortex remaining. The divisions are close, with the widest range in the Canteen Kopje layer, where >50% remaining cortex makes up 57.5%, versus <50% in 42.5% of the assemblage. In all these sites, and the Basal Early Acheulean layer, the dominant category is the 51-75% range. This range is the second most prominent at Sterkfontein. Overall, it seems that assemblages which could be the oldest in this study have a slightly higher reduction intensity, but the majority of core reduction types nevertheless have >50% cortex.

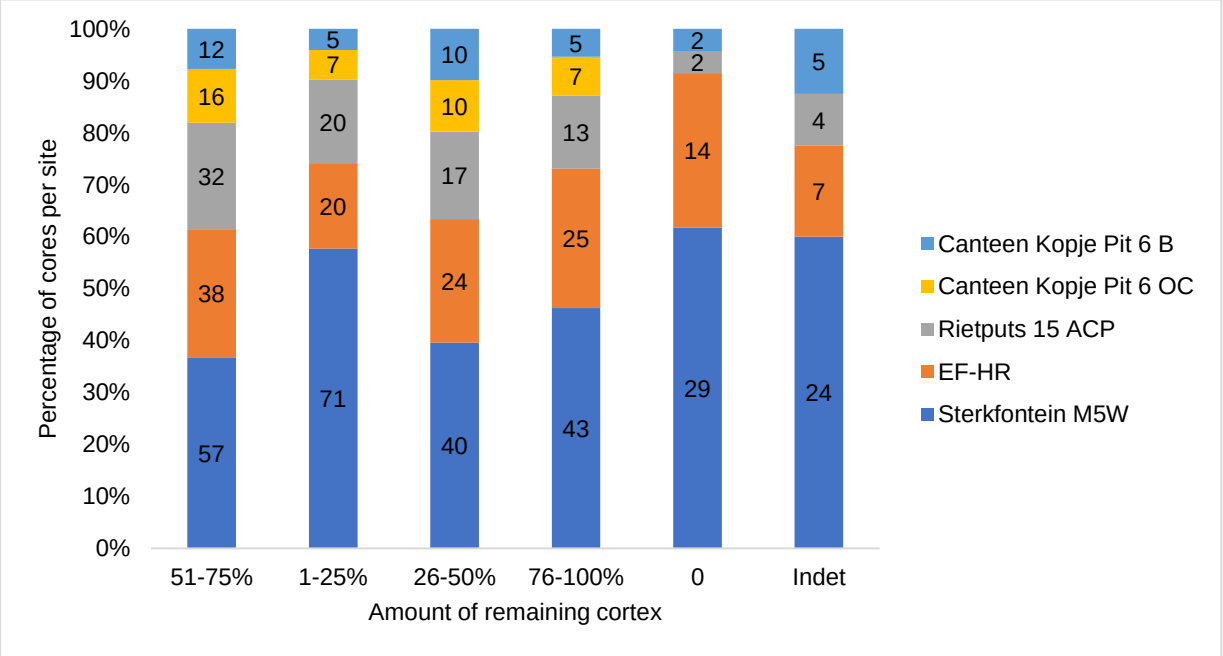


Figure 8.2: The amounts of remaining cortex in the core assemblages of all the studied sites

The number of flake scars on a core can be indicative of the level of reduction which occurred at a site (Clarkson 2013; Shipton and Clarkson 2015). The average highest scar count is 16.2 across the sites, with Sterkfontein having a core with 21 removals. The Basal Early Acheulean layer at Canteen Kopje has the lowest maximum scar count of 14, while the Organised Core Technology layer has 15. EF-HR is the closest to the average with a maximum of 16 flake scars.

There is no clear trend of the correlation of weight to number of flake scars on cores between the sites. The most significant correlation is seen at ACP in Rietputs 15, but that R^2=0.944, is still low. The change from the Basal Early Acheulean to the Organised Core Technology layers is minor, but there is a slight increase in significance in the Organised Core Technology layer. This means that over time, there was a slight increase of core reduction intensity. However, the data used in the various graphs indicate that core size (using weight as a proxy), does not influence the extent of reduction measured by the number of flake scars.

8.1.6 Bipolar reduction

The specific traits of the bipolar reduction at each site were limited and not heavily investigated in this thesis. However, it was the most common core reduction strategy applied in the ACP assemblage from Rietputs 15. The blanks are generally quite small at the site, and the bipolar reduction was used to split many pieces. At other sites, like Sterkfontein, bipolar reduction is sometimes mixed with freehand percussion on individual cores. This may be linked to the opportunistic core reduction seen in the assemblage. It could also be due to the fact that recycled hammerstones are sometimes used as cores, seen at EF-HR. Overall, these actions appear to have been used to create artefacts with platforms for further reduction or through percussive activities, rather than specific bipolar tool types. A deeper investigation into the practice is needed to understand better, which is not offered in this thesis.

8.1.7 Principal component and correspondence analysis

The PCA tests used in this thesis summarised the various data collected by indices that could distribute the data in relation to each other (see chapter 3, section 3.2.6). Figure 8.3 is a PCA graph showing the main variations between each sites. PC1 accounts for 95% of the variation and that the two Canteen Kopje assemblage differ to the other assemblages by size, especially concerning the mass and width. While PC2 correspond more with length and thickness, Therefore, the overall size of the core from both Canteen Kopje assemblages separate it from the other assemblages, which are more similar in their size ranges.

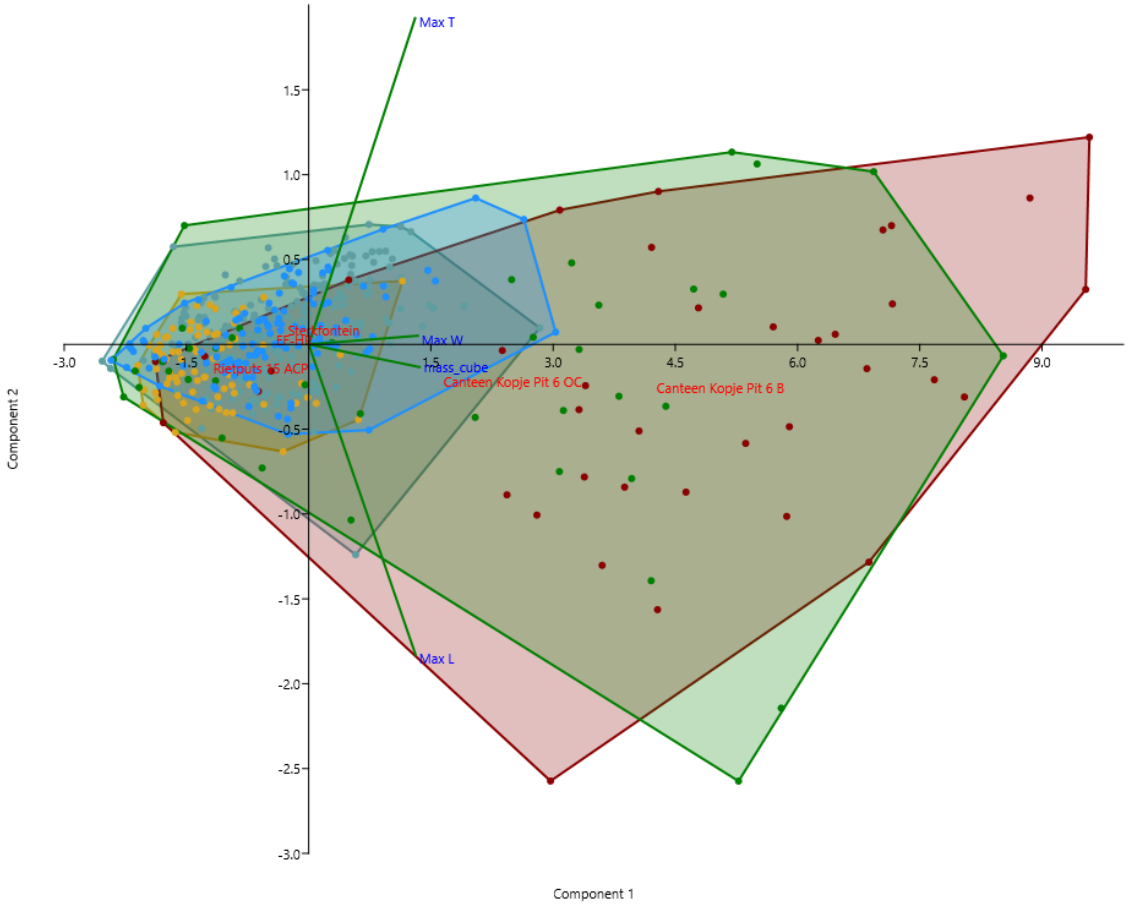


Figure 8.3: PCA of the core data from all sites

It could be argued that the large size of the cores at Canteen Kopje indicate that the raw material sources were closer to the site that the sources for the other assemblages. Hominids would not have been able to transport the boulder cores far and were likely more selective of a smaller range of blank sizes when having to transport them for some distance. Sterkfontein, Rietputs 15, and EF-HR all contain river cobble blanks but lie further from a river source than Canteen Kopje. This could account for the difference in general core size.

If the Canteen Kopje assemblages are removed from the PCA, a clearer image of the other assemblages emerges (Figure 8.4). PC1 represents a majority of the variation between the maximum core thickness and the blank types, and the size metrics are closely plotted to thickness. The general size and weight of cores is similar with each assemblage, suggesting knappers at these sites possibly selected raw material within certain size classes. If this were the case, it would relate to the distance of raw material sources, and the movements of hominids on the landscape. As discussed, the larger size of cores at Canteen Kopje was partly

due to the proximity of raw material, and along with the transport of smaller clasts over somewhat further distances will be explored in chapter 9.

PC2 relates to the amount of remaining cortex and the number of scars and idealised scheme of core reduction. The number of scars and scheme plot very closely, meaning they correlate strongly, but the amount of remaining cortex does not indicate either. Cores with more extensive reduction sequences in terms of removals do not necessarily determine the level of exploitation. This means that the 'organised' strategies of core edge management and volume control are not always exhaustive and could relate to the argument that blank and edge shape were more indicative of the reduction strategy.

All the assemblages plot broadly over the graph, but Rietputs 15 ACP aligns more closely to blank type, and the presence of hammerstones. Sterkfontein and EF-HR fall into a similar area of distribution, but Sterkfontein relates the most to scar counts and reduction scheme. EF-HR has the widest distribution along PC1, but all three assemblages plot similarly along PC2. The bulk distribution of EF-HR is with raw material, remaining cortex and blank shape, and has the widest range of artefact size. Percussion technique is central in the graph and relates closely to hammerstones. This is a logical connection, but the location of 'technique' suggests it is variable between the assemblages. Therefore, while each site has a dominance of freehand over bipolar percussion, there is no set pattern of either. Raw material types plot closely with remaining cortex and blank shape, which could support the argument of overall blank shape being closely related to reduction intensity. However, raw material types are not indicative of reduction strategy.

The data used in this correspondence analysis graph reflects the association of different core reduction strategies to the various sites. The strategies were simplified into bifacial alternating, bifacial, unifacial, discoid, multifacial, polyhedral, test cores, and split cobbles. Figure 8.5 shows how Sterkfontein M5W, and the Basal layer at Canteen Kopje Pit 6 are more closely associated to multifacial, test, and discoid core reduction strategies. The Organised core layer at Canteen Kopje Pit 6 and EF-HR have a closer association to bifacial cores, and somewhat to bifacial alternate cores. In general, bifacial alternate cores do not associate as closely to any assemblage as the previously mentioned strategies, while bipolar cores have very little association to any assemblage.

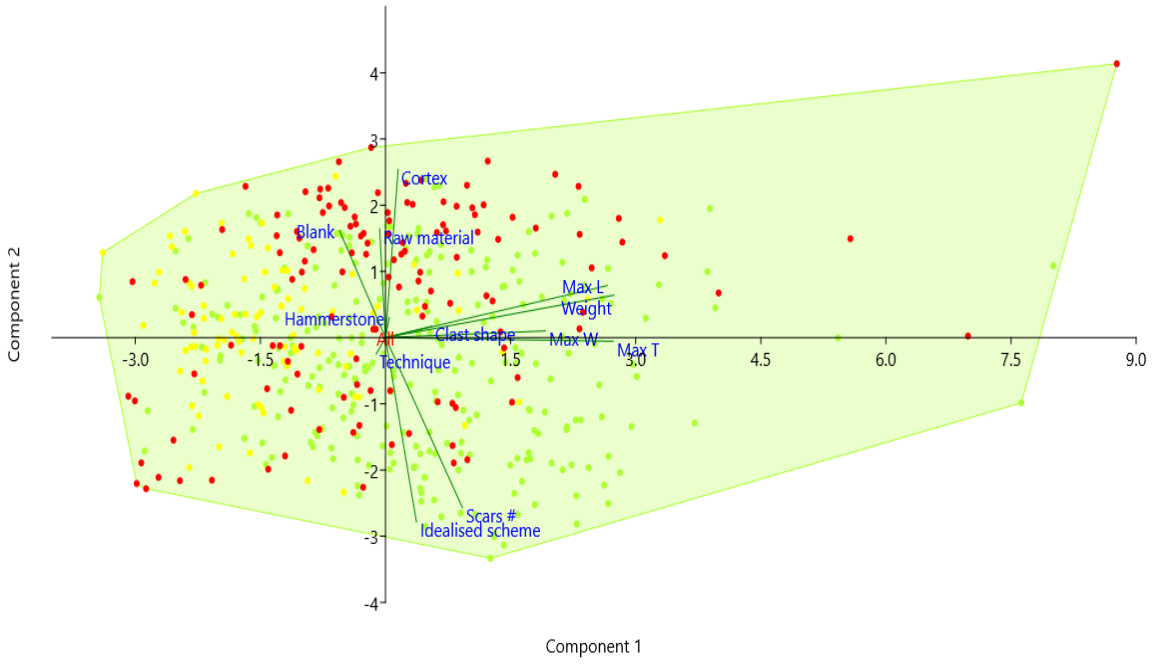


Figure 8.4: PCA of core assemblages from Sterkfontein (green), Rietputs 15 ACP (yellow), and EF-HR red).

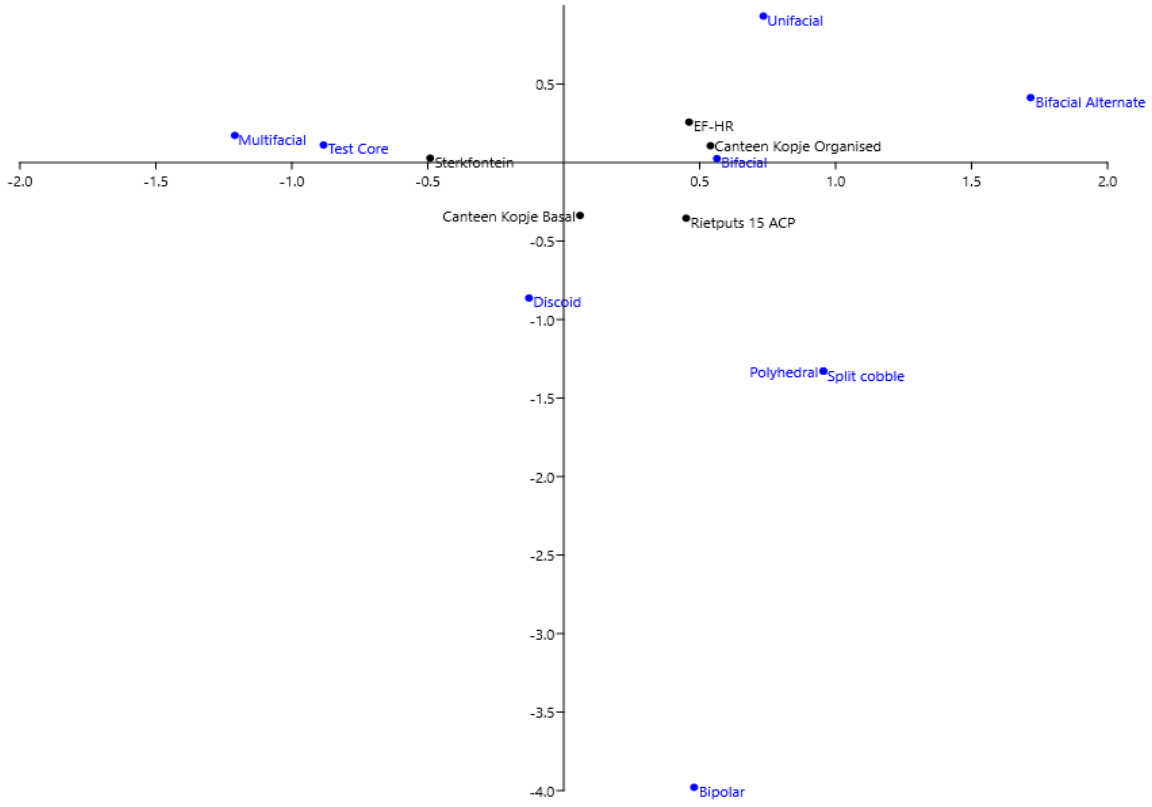


Figure 8.5: Correspondence analysis of core reduction strategies

It is interesting that EF-HR and the Organised core layer at Canteen Kopje Pit 6 have similar associations of core reduction strategies, while the core sizes are so vastly different. This reinforces that edge management strategies were not deterministic of core size, and that core edges were more important. Discoid technology as well as multifacial and test cores are closely associated to the older assemblage from Basal layer at Canteen Kopje Pit 6, and Sterkfontein M5W. As suggested in section 2.3.3, Kuman and Gibbon (2018) hypothesise that the early Acheulean material from Sterkfontein and the ACP at Rietputs 15 are older because of the presence of 'simple' reduction strategies. If the technological behaviours of these two assemblages are similar, then these deposits could be of a similar age, which could prove the hypothesis correct. However, this would need to be backed up with data from more sites and assemblages to confirm.

There is also an interesting trend of the differences between extensive discoidal reduction, and bifacial reduction (following the definitions of de la Torre and Mora 2018b), which could reflect progressive changes in core reduction strategies through the earliest phase of the Acheulean technocomplex, if again the hypothesis is correct. This would also need to be tested with other datasets to come to a meaningful conclusion for the entirety of the early Acheulean in East and South Africa.

8.2 Large cutting tools

The presence of LCTs, and specifically handaxes, defines the Acheulean, and the importance of their numerical representation has been debated among archaeologists (Leakey 1971; de la Torre 2016). In this thesis, the edge management and shaping of LCTs were analysed, to compare to the reduction strategies of cores in the same assemblages. The shaping strategies used in LCT production were laid out in Figures 3.16 and 3.17 and were based on understanding how the piece was flipped and rotated during the shaping process.

Table 8.2: Means of LCT dimensions, critical t-test p-value of number of scars and flips in shaping sequences, and the Refinement Index ('Max' stands for 'maximum')

Site	No. of LCTs	Weight mean (g)	Max length mean (mm)	Max width mean (mm)	Max thickness mean (mm)	Refinement Index Th/W	Scars and flips p-value
Sterkfontein M5W	16	452.88	119.77	77.83	50.18	0.64	2.0639

Rietputs 15 ACP	18	362.36	109.57	74.97	39.99	0.55	2.0469
Rietputs 15 Pit 5	62	483.57	125.89	80.57	42.34	0.53	1.983
Canteen Kopje Basal Early Acheulean layer	60	546.03	134.96	82.39	39.4	0.49	
Canteen Kopje Organised Core Technology layer	33	472.22	128.67	79.46	38.27	0.49	
EF-HR	102	554.61	145.26	85.82	46.88	0.55	1.9728

8.2.1 Raw material

There was a preference for a certain raw material for LCT production at each site, which I argue denotes selective behaviour on the parts of the knappers. Even at sites with multiple raw material options, a single type tended to dominate. At EF-HR, trachyte was used for 50% of the LCT assemblage, but far less in the core assemblage. At Rietputs 15, Ventersdorp lava dominates both LCT assemblages (ACP and Pit 5), but it makes up >80% in the slightly older ACP collection, while quartzite is used for LCT production at Sterkfontein.

Similar to sites like Melka Wakena in Ethiopia, selection of raw material is varied, but fine-grained ignimbrite was chosen for LCT production (Gossa 2020; Hovers *et al.* 2021). This trend, seen across the sites studied here, and at other Acheulean assemblages, suggests hominids were active in testing various raw materials in each context to select those best for the various reduction strategies. If this pattern continues throughout the earliest phase of the Acheulean, one could argue that the emergence of the technocomplex is categorised but specific selective behaviours, alongside technological features such as the production of flakes >10cm.

8.2.2 LCT blanks

At all the sites the most common blank types for LCT production were flakes, followed by indeterminate types, and then cobbles. At EF-HR, Pit 5 at Rietputs 15, and Canteen Kopje (both layers), flake blanks were used for shaping strategies but most commonly for bifacial

alternating. At Sterkfontein and the ACP in Rietputs 15 flake blanks were most common but many cobble blanks were also used for shaping. The cobble sized clasts correspond to some of the highest p-values for flipping blanks while shaping them while the acute edge angles of flake blanks were effectively exploited and appear to have required fewer shaping scars to achieve a desired final product.

8.2.3 Shaping strategies

As discussed, a distinction of LCT shaping was made between bifacial alternation, bifacial without alternation, unifacial and rhomboidal (following de la Torre and Mora 2018b) (see descriptions in chapter 3). Core edge management strategies and LCT shaping strategies cannot be directly compared as they are different technological products, but it would be of interest to determine whether there are similar strategies applied to the edge of all the studies artefacts. I am interested in identifying similar patterns across the studied sites, and edge management strategies are a feature that can be explored.

Bifacial alternating and bifacial shaping strategies were most prominent in each assemblage. Unifacial sequences were common at EF-HR, and the overall assemblage had many predominantly unifacial LCTs. Rhomboid-shaped LCTs were also mainly made on flake blanks, again because there was little need to thin the edges. Unifacial scars were also mainly made on flake blanks as well, which further suggests that the shape of the edge on flake blanks was more consequential to the shaping strategies than raw material or blank size.

At Rietputs 15 Pit 5, there is a fairly even split of flakes and cobble blanks used for LCTs. The cobbles from the site are generally flat and/ or faceted, meaning that the natural angles were more acute. Therefore, the edges of the two blank types were exploited similarly. At Sterkfontein, rhomboid and unifacial shaping was exclusively done on flake blanks, while the blockier cobble blanks were bifacially worked. The bifacial strategies likely helped to manage the more abrupt edges better, while the flake blank edges were already sharp and acute.

At Canteen Kopje, flake blanks occur in the sampled assemblages of both layers. As some pieces were difficult to assess, not all pieces were recorded for scars. For the LCTs recorded in the Basal Early Acheulean layer, there was an equal amount of rhomboid and bifacial alternating shaping, but an increase to all bifacial exploitation in the Organised Core Technology layer. However, these flakes were quite big and thick which could mean the angles were not acute enough to shape using only unifacial strategies.

8.2.4 Refinement Index

The assemblages with the most refinement in LCT production are from the two layers in Pit 6 Canteen Kopje. Both assemblages have a Refinement Index of 0.49, while all the other sites

have an index over 0.5. Sterkfontein M5W LCTs have the highest Refinement Index at 0.64. The ACP assemblage from Rietputs 15, and EF-HR have the same index of 0.55, while the Pit 5 material from Rietputs 15 is 0.53 (Table 8.2). From this data alone, it is evident that Sterkfontein has the least thin LCTs, but this does not consider the influence of raw material and blank shape.

At Canteen Kopje, there is a consistent production of large flakes from boulder cores in both the Basal Early Acheulean and Organised Core Technology layers. Flakes are generally thinner than other blank types such as cobbles or blocks, which would influence the final shape of the LCT (Kuman *et al.* 2016). At Sterkfontein, there are few examples of large flakes being produced relative to the overall assemblage size, nor boulders on the landscape that could be used to produce flakes >10cm (see Sherwood 2021 for data on the raw materials in the Cradle of Humankind). These Refinement Indices are typical for the average indices for Africa. In Kuman *et al.* (2016) (Appendix 4) the data from major sites in the continent are given, with an average index of 0.55 for the early Acheulean. In general, LCTs were not intensely thinned on the continent and these sites have similar refinement level.

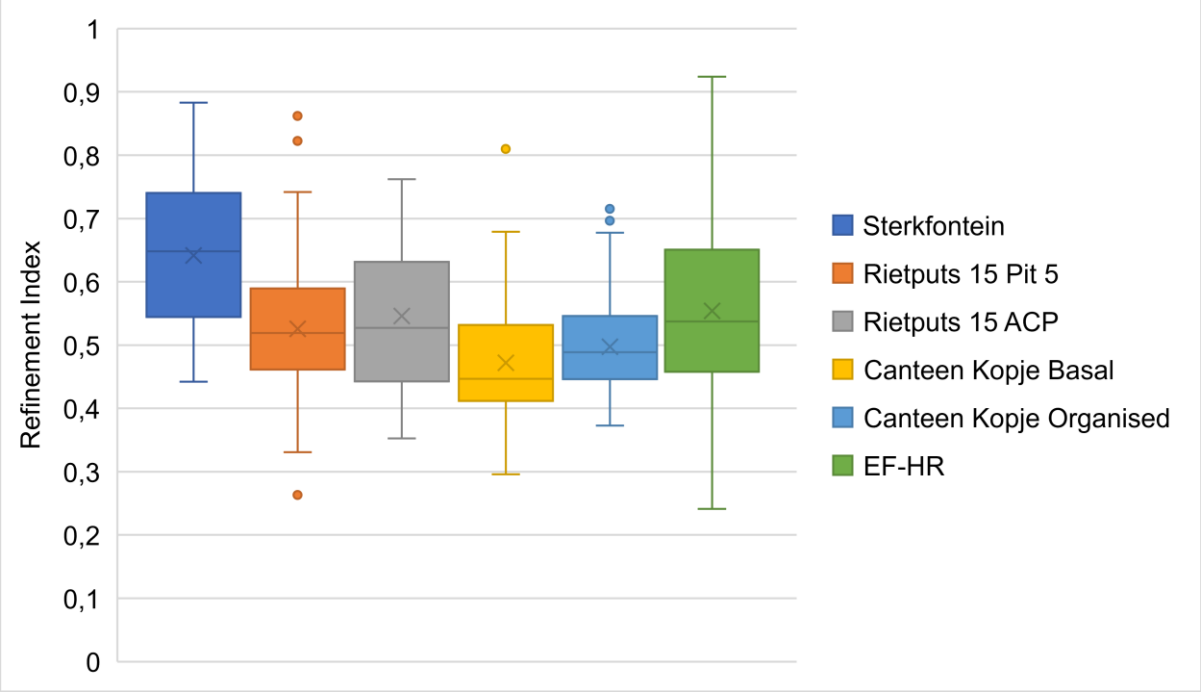


Figure 8.6: Boxplot of the Refinement Indices of LCTs across the sites.

Figure 8.6 is a box and whisker plot of the range of Refinement Indices of all analysed LCTs in each assemblage. Sterkfontein has the highest average Refinement Index of all the sites, but a smaller range than that of EF-HR. Interestingly, the highest and lowest refinement index

of any individual LCT is found both at EF-HR, which has the same average index as the ACP at Rietputs 15, which has the second smallest range, This wide index range at EF-HR could be due to the size of the assemblage, but the two assemblages from Canteen Kopje (despite not being fully analysed here) have high numbers of LCTs and the lowest refinement Indices of all sites. Overall, this indicates variability in LCT size and shape within single sites, even when similar blanks are used, such as at EF-HR and Canteen Kopje which both have dominant flake blanks.

8.2.5 Shaping scars and flipping

As mentioned in chapter 3, when possible, the number of times an LCT was flipped during the shaping process was recorded. The resulting p-values are obtained from critical t-tests of the means between the two attributes. The data from Canteen Kopje is biased because of the level of weathering on pieces does obscure some of the details needed to identify flipping.

Between the sites analysed in this thesis. there is some difference in the amount of flipping observed during LCT shaping (Table 8.2). The assemblages from Sterkfontein M5W, Canteen Kopje, and Rietputs 15 have high p-values >2, suggesting there is a strong correlation between the number of flake scars and the number of times a piece was flipped. EF-HR and Pit 5 from Rietputs 15 have a similar p-value, and knappers could have manipulated the LCT blanks in similar ways.

If Sterkfontein and Rietputs 15 ACP are indeed older early Acheulean collections, and if Pit 5 and EF-HR are slightly younger at 1.3 Ma and >1.33 Ma, respectively, then perhaps hominids were flipping LCT more during the earliest part of the early Acheulean. But the high rate for the Organised Core Technology assemblage at Canteen Kopje contradicts this, however, it is a sampled amount of LCTs so the data could be skewed. It would also be useful in the future to do a study of the various sections of the LCTs. At EF-HR there were many scars shaping the tips of handaxes, with less of a focus on thinning the overall bulk. It would be interesting to see if this trend is particular to the site. The hypothesis put forward by Kuman and Gibbon (2018) cannot be proved with this LCT data, but future work on more early Acheulean assemblages could provide a more definitive answer.

8.2.6 Principal component and correspondence analysis

A PCA was run on the analytical features measured on the LCTs to determine how the assemblages compare to each other (Figure 8.7). The two assemblages from Canteen Kopje were not included in this particular test as the freshness of the material meant that the number

of scars, edge management sequence, and flip count could not be recorded[5]. Overall, the two assemblages from Rietputs 15 plot closer together along PC1 and are separated out by their raw material and maximum thickness. EF-HR and Sterkfontein plot similarly along PC1, while EF-HR is more widely spread along PC2, tough this appears to be related to the size of each assemblage.

PC1 has the widest spread with maximum thickness, length and width creating the most variability between the sites. The number of scars and the number of flips have plot almost exactly on top of each other and could be confused as a single line and account for the top end of PC2. They are therefore most closely related across all the assemblages, meaning that the number of shaping scars in LCT production is heavily influenced by the strategy adopted by the knappers. The length, width and mass of the pieces are closely related to the LCT types, while the thickness and raw material align closely on the opposite end of PC1.

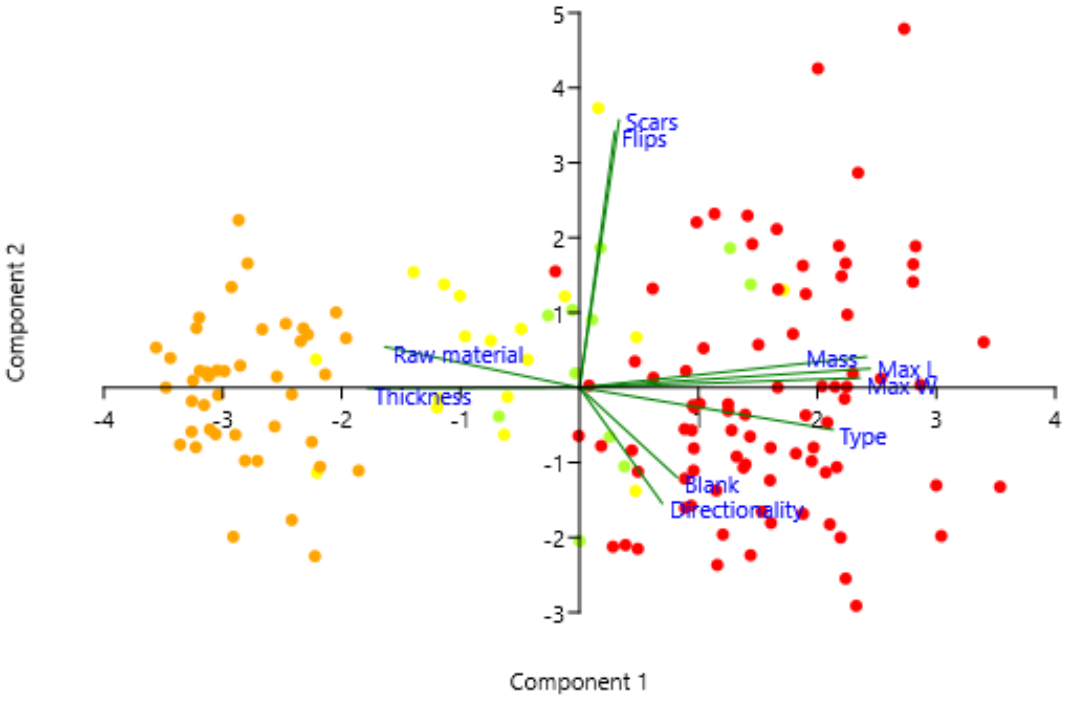


Figure 8.7: Principal component analysis of LCTs from Sterkfontein (green), Rietputs 15 ACP (yellow) and Pits 5 (orange), and EF-HR (red)

A correspondence analysis (Figure 8.8) of the assemblages and LCT shaping strategies reveals that bifacial alternating and rhomboid shaping corresponded closest to Sterkfontein then EF-HR. Bifacial shaping was closest to Rietputs 15 ACP then Pit 5 and unifacial shaping

[5] See Appendix 5 for a PCA including the data from Canteen Kopje. Through consultation with Dr Matt Caruana it was advised to not include this in the primary data due to the bias from the sample assemblage.

corresponds the least with any of the assemblages. The Canteen Kopje assemblages were not included in the test as the level of weathering was too much to accurately record all flake scars on all the analysed pieces.

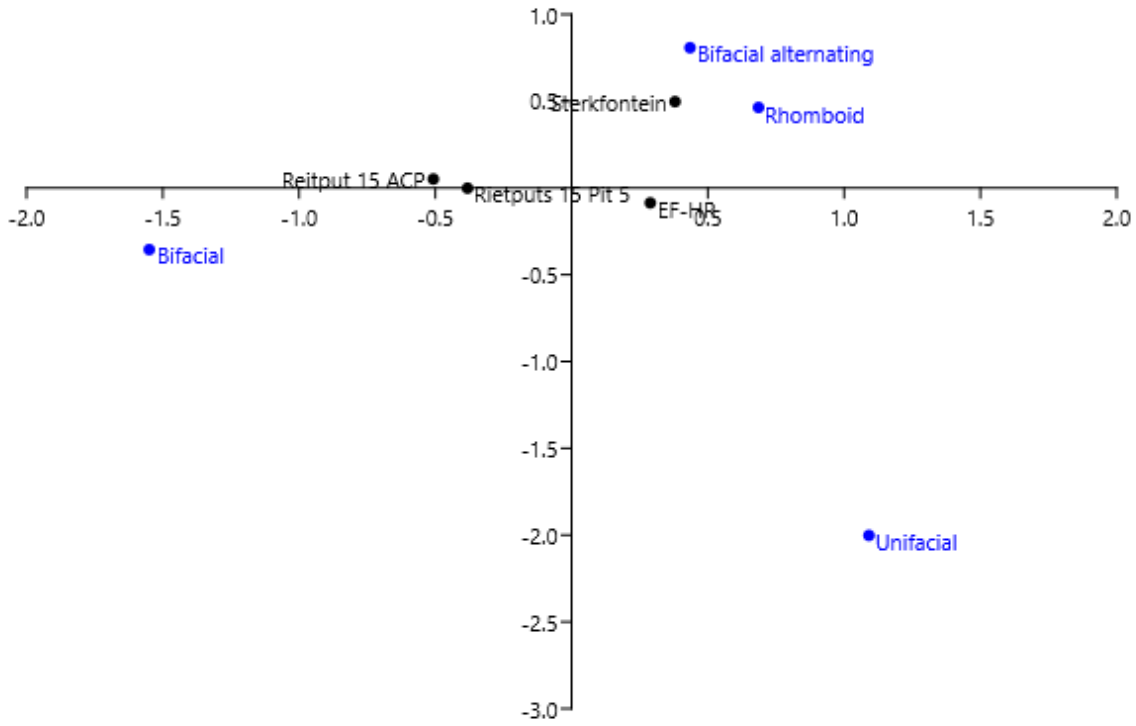


Figure 8.8: Correspondence analysis of LCT edge shaping strategies from Sterkfontein, Rietputs ACP and Pits 5, and EF-HR.

8.3 Summary

The full conclusions of the thesis will be presented in the next chapter, but from the comparative discussion of the data from the sites there are two main points we can infer. Firstly, blank shape, especially edge shape, is much more relevant to the reduction and shaping strategies applied to both cores and LCTs. Secondly, there is a homogenous trend between the sites of separate production strategies for cores and LCTs as they are technologically different conceptual groups. Similar edge strategies are applied for each, but blank types and raw material choices are different to more varied types seen in core assemblages.

Chapter 9: Discussion and conclusion

9.1 Discussion

In this section, the data presented in this thesis will be discussed and compared. The results will then be contextualised within a larger context for the earliest phase of the Acheulean technocomplex in Africa through discussion of some case studies of other sites from both East and South Africa. Lastly, my overall interpretations of the data will be summarised, along with an assessment of the approach used in this thesis.

9.1.1 Idealised schemes of core reduction strategies

One of the arguments I made earlier in this thesis is the need for more consensus among researchers in technological analysis in order to develop a better understanding of a technocomplex (Conard *et al.* 2004), and in particular, a clearer understanding of how early Acheulean assemblages in South Africa compare with those in East Africa. One of the aims of this research was to apply the same methodology across a number of sites to determine whether this creates cohesive datasets that can be compared. In doing so, one could potentially elicit complex and nuanced details about specific technological behaviours in different regions and site contexts. This could then contribute to addressing questions about the cohesive nature of the Acheulean as a whole, a subject that is of interest for archaeologists (de la Torre 2016; Texier 2018; Shipton 2020; Ashton and Davis 2021). Therefore, the methodology applied should be adaptable to different regions in order to provide detailed comparative information.

The schemes applied (following de la Torre and Mora 2018a) are useful to understand specific reduction trends because they focus on both edge management and volume reduction, whereas other methodologies such as that discussed by Diez-Martín *et al.* (2019) do not consider volume reduction as much. The categories are set up to classify cores by multiple factors: the edge management strategy, the angle of the worked edge, the number of surfaces exploited, and the intensity of the volume reduction. The system assumes that similar strategies of bifacial (BP, BAP, BSP, BALP, BALT, discoid), unifacial (UAU1, UAU2, UAUT, USP, and UABI) and multifacial schemes can produce different levels of core reduction intensity. The reduction intensity is identified by the amounts of cortex on a surface, the remaining central bulk, and the number of surfaces/faces of a core that are exploited. Although these schemes create multiple technological core types, the details they provide give the researchers clear understanding of the specific exploitation trends because they also compartmentalise the general patterns. For the analysis of core volume at each site, the

categories have been grouped in each chapter as bifacial, unifacial, multifacial, bipolar and test cores. This was done because an original graph presenting the data for each individual category showed a wide variety of weight differences, with no discernible pattern (see Appendix 4 for the original graphs). However, when the categories were grouped, a more cohesive pattern emerged. Therefore, the grouped schemes are most useful for providing detailed descriptions of artefacts and developing a comprehensive qualitative analysis of reduction strategies.

Another useful feature of the schemes is the data about reduction intensity that one can acquire. Along with analysis of the overall scar count relative to volume data presented in each chapter, the specific pattern in each group is evident. Bifacial cores are more common at all the studied sites, sometimes being more than twice the amount of unifacial cores, but within the bifacial category there is some diversity in specific edge management. At EF-HR, the abrupt bifacial cores are mainly shaped on one face (BAP cores), while at Sterkfontein the dominant bifacial core types have acute edges (BSP cores). Both are schemes where one surface is exploited to create a platform for removals on the adjacent surface.

9.1.2 Technological behaviours identified in the core assemblages

Sterkfontein

Multifacial core flaking strategies were most common at Sterkfontein M5W. However, the knappers could produce structured and continuous sequences using unifacial and bifacial edge management, but there were few bifacial alternating strategies. Generally, the cores were only partially exploited before being abandoned. The hominids were adaptable to the context and raw material features and were able to produce a range of technological behaviours. There are multiple examples of cores with combined reduction strategies, which are multifacial cores with specific unifacial or bifacial edge management on different surfaces. This combination of edge management strategies is noted by Prof de la Torre at other sites in East Africa (*pers. comm.*).

Rietputs 15 ACP

The cores from the ACP were not heavily reduced and had evidence of only partial exploitation of the blank surfaces. Bipolar cores dominate the ACP assemblage, but bifacial reduction is most common in the freehand cores. Leader (2009) and Kuman and Gibbon (2018) had argued that the ACP collection has no clear pattern of organised core reduction. While the cores from Pit 5 (ca. 1.3 Ma) were unavailable for this study and cannot be compared in detail, Leader *et al.* (2018) provide data to show that 56% of the cores follow simple flaking patterns,

but organised cores comprise a substantial 17% of the types. These strategies focus on either exploiting or creating a large flaking surface, with 86% of the examples having asymmetrical properties.

Canteen Kopje Pit 6

There is a limit to what can be said about the assemblages because of the sample bias in my study and the weathering of pieces. However, the core assemblages show a shift in the reduction strategies from predominantly multifacial cores in the Basal Early Acheulean layer to bifacial strategies in the overlying Organised Core Technology layer. The size of cores decreases in the Organised Core Technology layer, but this could be due either to high energy events or the selection choices of knappers, which are questions to explore in the future. Despite the overall size differences, there are still boulder cores in each layer, and it is suggested that these could be LCT flake cores. Canteen Kopje is the only site in this study that has potential LCT cores from the in situ excavations, creating an avenue for research beyond this thesis.

EF-HR

Core shapes are variable, as there was a range of different river cobbles used as blanks for reduction, but they tended to be bulky with abrupt angles. A large majority of cores were flaked using abrupt bifacial sequences, following the shape of the natural edges. This means that the shape of core blanks was an important factor in edge management. The clasts were likely brought into the site from local riverbeds, and were mainly under 600g in weight, suggesting they were choosing smaller clast sizes to carry. Larger clast sizes were exploited for LCT flake blanks, but these cores are not found in the site. Therefore, the distinct trends in core and LCT production chains is confirmed by the differences in raw material use.

Comparison of the core assemblages

When comparing Sterkfontein and EF-HR assemblages, there are a few important features to note. The full range of the same reduction strategies is produced at each site, but there are higher frequencies of ‘multifacial’ cores at Sterkfontein. At EF-HR there are more bifacially worked cores than unifacial, and there is a similar trend at Sterkfontein. However, the bifacially reduced cores from EF-HR vary between alternating reduction and the exploitation of the two surfaces separately. At Sterkfontein, there are more bifacial cores where each surface is exploited separately, rather than alternatingly.

A key difference between EF-HR and Sterkfontein is the cobble blank shape. At EF-HR the cobbles are very rounded, while they are blockier with rounded edges at Sterkfontein (Kuman 1996; Field 1999). Thus, each technological trend shows an adherence to the natural shape

of the blanks. It is thus reasonable to argue that there are technological similarities between the core assemblages at each site, supporting the hypothesis that the Sterkfontein M5W assemblage belongs in the earliest phase of the Acheulean technocomplex when compared to the EF-HR type series.

In the assemblages from Canteen Kopje and Rietputs 15, there are similar trends to the above sites in core reduction. Bifacial alternating cores with a partial exploitation (BALP cores) are most common in the Organised Core Technology layer at Canteen Kopje, which indicates that knappers exploited two surfaces by routinely flipping the core, using the previous removal as a platform. This sequence was used on only one partial section of BALP cores. In the Basal Early Acheulean layer at Canteen Kopje, multifacial cores dominate, and edges were exploited more opportunistically.

The ACP core assemblage from Rietputs 15 has an equal presence of the three idealised schemes in the bifacial group (BAP, BSP, and BALP), which is also the dominant group. Therefore, knappers were using these reduction strategies interchangeably and were capable of different edge management. Split clasts were used more for unifacial reduction and were generally small, and whole cobble-sized clasts with rounded edges were bifacially reduced. The difference in application is linked to the shape of the blanks because the raw materials from each site are different in shape and quality. To conclude, the blockier clasts with rounded edges at Sterkfontein were exploited bifacially, while spherical clasts from EF-HR were often split to create abrupt edges for unifacial reduction. The large boulder cores from Canteen Kopje were also exploited bifacially, but often the blank edges were more acute in angle. This resulted in a more acute knapping edge. Therefore, the shapes of core blanks rather than their size influenced the edge management strategies.

Organised core strategies

The appearance of complex knapping strategies is well documented in the ESA (Delagnes and Roche 2005; Mesfin and Texier 2022) and they appear in the form of recurrent and often bifacial reduction sequences. These trends are visible at the sites studied in this thesis, such as with the BALT cores displaying asymmetrical surfaces at Sterkfontein, Rietputs 15 ACP and the Canteen Kopje Organised Core Technology layer. These do not comply with the criteria of Levallois as defined by Boëda (1953, 1995), but they exhibit organised core edge management, and volume reduction, akin to the work described in Leader *et al.* (2018) and Wilkins *et al.* (2010). Therefore, none of these assemblages displays a form of prepared core technology (see discussion in chapter 2, section 2.3.2), but they can be used to understand how these technological behaviours developed.

The data provided reveals that knappers were able to sometimes control the volume of a core and were able to create recurrent and bifacial reduction sequences on cores in all the assemblages. However, asymmetrical control of the pieces is not common, and it is mostly seen in my analysis of the sampled assemblage from the Canteen Kopje Organised Core Technology layer. Therefore, if we follow the definition of prepared core technology presented in Mesfin and Texier (2022), this assemblage is possibly the only one which could generally display the broad category of prepared / predetermined core reduction behaviours within my study, whereas this behaviour is uncommon in the other assemblages.

The presence of these organised core reduction strategies in the ESA of Africa is very much an area of interest for future research. Sites such as Nyabusosi in Uganda (Texier 1995; Mesfin and Texier 2022), Peninj in Tanzania (de la Torre *et al.* 2003), and Garba IVD at Melka Kunture in Ethiopia have some form of prepared core technology (Gallotti 2013), but these could be independent inventions not associated to the broader use of the strategy in the MSA and Middle Palaeolithic (Mesfin and Texier 2022). The fact that there is a continuation of organised core reduction at Canteen Kopje Pit 6 suggests that it was not an independent invention but was the basis of the Victoria West and other prepared core strategies seen later in the deposit.

9.1.3 LCT shaping strategies

Sterkfontein

The LCT assemblage from Sterkfontein is small, especially relative to the core assemblage. The edge shaping strategies were predominantly bifacial alternating sequences, and LCTs were generally consistent in size and primarily made on flake blanks. Fine-grained quartzite was used for the LCTs, but the blanks were likely brought to site as there is no evidence of LCT cores in the assemblage. The detailed analysis of each piece showed that knappers were focused on shaping the laterals and distal ends of the blanks, and they often retouched the tip of the piece. The small assemblage size may suggest that LCTs were removed from the site, or alternatively that there was a more common occurrence of core and flake technological behaviours.

Rietputs 15

Bifacial alternating and bifacial shaping are most prominent in each assemblage and there is a variety in the blank types and shapes. Pit 5 has a larger assemblage than the ACP, and therefore has more examples of blank shapes. The low number of LCTs in the ACP could represent either a focus on core and flake knapping, or that LCTs were removed from the area. The LCTs from Pit 5 also have a higher number of flake scars. On average, Pit 5 has

more LCTs with between 7-10 flake scars, which suggests that the shaping sequences were longer than at the ACP.

Canteen Kopje

The data provided for the LCTs from both Canteen Kopje assemblages are less than the other sites, but this is due to the level of weathering on the artefacts. Details such as shaping scars and flake sequences are not easily identifiable, and to be conservative, many have not been recorded. This means that the information about LCT edge shaping is limited, but a general overview of the pieces is possible. The LCT blanks are primarily large side struck flakes for both layers. Analysing the production processes for the LCT blanks was not the aim of this thesis, and a detailed study in the future could provide much information on those technological behaviours of knappers. In cases where the edge strategies were recorded, there was a dominance of bifacial and alternating shaping sequences along the lateral edges. The flake blanks were relatively thick and so the edges were not very acute, but the blanks are also quite wide. This means that the LCTs are not thick relative to their width and therefore have refinement indices of 0.47 and 0.5 in the Basal Early Acheulean and Organised Core Technology layers, respectively.

EF-HR

The original description of the LCT assemblage in de la Torre and Mora (2018b) is that it was primarily unifacial. The analysis presented here details the nuance of the edge shaping strategies on LCTs, and even though the pieces are primarily shaped on one surface, there are multiple instances of alternating bifacial retouch. These shaping sequences are not intrusive into the central volume and this feature could demonstrate that knappers had the ability to successfully produce large flake blanks that required little retouch for workable edges. 50% of the LCTs are made on trachyte, and over 70% overall are made on flake blanks, with a Refinement Index of 0.55. The knappers were bringing in large flake blanks to the site, as there is no evidence of LCT cores.

Comparing the LCT shaping strategies

As mentioned in the introduction, in this thesis the focus of analysis for LCTs is on the edge shaping strategies. This was done to compare edge management of the artefacts, even though cores are waste products and LCTs are a shaped, conceptual tool type. The results show that there is a similarity in the way the angles of blanks were flaked at all the sites, meaning there are common edge management strategies between the two groups. However,

the difference between cores and LCTs is seen in the organisation of flaking scars, because for bifacial edge management, LCTs had more alternating sequences than cores.

There was also generally a difference seen in raw material selectivity for LCTs and cores, as LCTs were often made on large flake blanks which were carried to the sites like at Sterkfontein and EF-HR, while core blanks were made on rounded and/or blocky clasts. More specifically, at EF-HR hominids brought in mainly trachyte flake blanks, and large quartzite flakes were transported to Sterkfontein. At both of these sites there is no evidence for LCT cores, and the raw material was brought in from nearby riverbeds. For the two Canteen Kopje assemblages, flakes were commonly used for LCT blanks. For the two Rietputs 15 assemblages, there was more of a mix of flake and rounded clast blanks for LCTs, with a range of clasts sizes and types close to the area.

LCT cores

At both Canteen Kopje Pit 6 assemblages, multiple cores have been argued to be LCT cores (see chapter 6). This means there is no clear distinction of production chains for the LCTs and cores, as is seen at Sterkfontein, Rietputs 15, and EF-HR. The evidence for this includes the large size of the cores, and largest flake scar sizes and shapes correlate to the general sizes and blanks of the LCTs. Although the weathered nature of the assemblages makes study of the shaping sequences difficult, there is a clear production of large, predominantly side struck flakes for LCT blanks. As the production of LCT blanks was not the focus of this thesis, more work is required in the future to properly understand how the LCTs and boulder cores relate to each other.

9.2 The early Acheulean in East and South Africa

The technological behaviours described in this thesis are similar to sites like Melka Wakena in Ethiopia, where selection of raw material is varied, but fine-grained ignimbrite was preferred for LCT production (Gossa 2020; Hovers *et al.* 2021). This trend, seen across the sites analysed in this thesis and in other Acheulean assemblages, suggests hominids were active in testing various raw materials in each context to select those best for the various reduction strategies. If this pattern continues throughout the earliest phase of the Acheulean, one could argue that the emergence of the technocomplex is categorised by specific selective behaviours, alongside technological features such as the production of flakes >10cm.

There are multiple sites with deposits dating to the earliest phase of the Acheulean technocomplex across Africa, but there are many more sites in East Africa, with fewer recorded in South Africa. The sites discussed below are case studies that display interesting technological behaviours in the lithic assemblages. While they are found in different site contexts, they provide examples of sites with similar patterns that could be studied further to take comparisons forward in order to achieve a broader understanding of the early Acheulean in Africa.

Maropeng, South Africa

A site in South Africa with evidence for combined idealised schemes is Maropeng, also in the Cradle of Humankind, South Africa (Moll 2017). Maropeng is an open-air site with one of the largest assemblages in the area, with 693 artefacts, excavated from four trenches covering a total of 20m². This assemblage provides a representative sample for the site, as the known extent of the deposit is 191200m². The assemblage fits within the earliest phase of the Acheulean technocomplex >1 Ma (Pollarolo *et al*. 2010), with the majority of large cores and flakes made primarily on local quartzite blocks. Because of the richness of the deposit, the site is a useful comparative collection to the Sterkfontein material (Pollarolo *et al*. 2010; Morrissey 2015; Moll 2017), and in time further work on the specific technological behaviours in the assemblage will be done to compare the data to the results of this thesis.

Cores at Maropeng comprise 14.6% (n=101) of the assemblage), while LCTs only represent 1.7% (n=12). The excavated material was analysed by Moll (2017) using the scheme published at the time by de la Torre (2011), a scheme from which the method in de la Torre and Mora (2018b) was adapted. Multifacial and TC reduction schemes dominate the core assemblage, with low numbers of flake scars (a mean of 3-8 scars), and high percentages of remaining cortex on the cores. The 2017 study of the Maropeng material included flakes, chunks, and other debitage. While that data cannot be directly compared in this thesis, the flakes show that knappers were able to produce feather terminations on flakes, while cores would often be abandoned when mistakes such as step fractures occurred.

The core flaking strategies followed the natural shape of the blanks, and cores were often abandoned after the natural platforms were exhausted. Compared to Sterkfontein, both assemblages have cores that were exploited for the natural angles of their clasts, but Maropeng cores appear to have been more exhaustively flaked on these platforms. A feature noted in Moll (2017) is that some cores have a general multifacial reduction but one edge has been worked using a single platform flaking sequence, a technological behaviour similar to the cores with multifacial edge management described in this thesis. Following the categories

in de la Torre and Mora (2018b), these cores would also be classified as having multiple core edge strategies, which is a pattern identified at Sterkfontein.

The Maropeng LCTs are shaped both unifacially and bifacially. Only the handaxes have small retouch scars, along with more intrusive shaping scars, but the scars display multiple step fractures. Thus, volumes were unsuccessfully reduced, although it is possible these are examples of discarded pieces. The cleavers are made on large flake blanks and possess minimal shaping along the edges. The flake assemblage corresponds with an intense reduction sequence due to the multiple dorsal scars and non-cortical platforms, which contrasts with the generally simple core assemblage. The initial interpretation presented in Moll (2017) was that the flakes came from LCT production, or more exploitative core reduction strategies. However, more recent analysis of the Maropeng assemblage makes it apparent that even 'simple' core strategies could produce multiple scars on a core, resulting in flake dorsal surfaces with evidence of extensive reduction.

The Maropeng deposit represents a long-term accumulation, with evidence of differing technological traits within the lithic production. It would be interesting to consider these traits in relation to the sites studied here, especially Sterkfontein, which is close in location and tool types, as there are many similarities in the core edge management strategies between the assemblages. These similarities include the dominance of multifacial cores, and the reliance on natural blank shapes. However, the long-term accumulation of material at Maropeng could bias our interpretations, and more work is needed to conclude if the deflated horizon represents the full spectrum of artefact types.

Melka Wakena, Ethiopia

Historically, typological analysis of cores has shown minor differences in reduction strategies from the Oldowan to Acheulean (Leakey 1971; Diez-Martín *et al.* 2009), but the use and application of qualitative technological analyses can describe the emergence, diversification, and progression of Acheulean technology. Hovers *et al.* (2021) demonstrated how these progressive technological stages occurred at the site of Melka Wakena in Ethiopia, a highland site complex (>2000 masl) with Acheulean deposits spanning the earliest phase of the Acheulean between ~1.6->0.7 Ma. This site is of interest because it is an early Acheulean assemblage from a different context and region to those studied in this thesis.

Gossa (2020) analysed the material and described it as belonging in the Acheulean technocomplex, with similar technological markers as sites like SHK Annexe, Olduvai Gorge (de la Torre and Mora 2020), where there is a low representation of LCTs and LCT by-products. The assemblage from MW2-L3 at Melka Wakena, one of the oldest in the site, has no LCTs, but a sophisticated series of core reduction strategies made on a variety of raw

material cobble blanks. Younger deposits at the site have LCTs and related by products, which become increasingly refined and shaped but maintain a similar size profile. Knappers also consistently selected fine grained ignimbrite for LCT and large flake production. These traits show how LCT production emerged alongside developing core reduction strategies and became more refined over the course of the technocomplex (Gossa 2020; Hovers *et al.* 2021). Such a site would be of interest to compare and contrast with the sites analysed in this thesis because it gives a full range of technological progression during the Acheulean technocomplex.

BK, Olduvai Gorge, Tanzania

As mentioned in the introduction, there was an intention to study the material excavated by Mary Leakey from BK in Olduvai Gorge but this was hindered by the Covid-19 pandemic. The discussion presented here in in thesis comes from published data from Leakey (1971) and Diez-Martín *et al.* (2009). Diez-Martín *et al.* (2009) developed a similar approach to analyse core reduction strategies as de la Torre and Mora (2018b), the approach used in this thesis. Both approaches categorise core technology by the surface exploitation and flake directionality, but the Diez-Martín *et al.* (2009) approach focuses less on the central volume (see chapter 2).

The results from Diez-Martín *et al.* (2009) indicated that the freehand core assemblage displayed small flake production, with evidence of bifacial hierarchal and unifacial centripetal control, alongside multifacial reduction. However, bipolar core reduction dominates the assemblage, argued to represent an expedient and wasteful production of flakes for butchery activities. Compared to the other sites analysed here, at BK there is an occurrence of multifacial reduction alongside controlled / hierarchal bifacial reduction. It follows a similar trend whereby knappers were able to exploit cores using continuous strategies of sophisticated edge management. The main difference of a site like BK is the higher presence of bipolar reduction, which is a local adaptation to the Naibor Soit quartzite which was brought into the site (Diez-Martín *et al.* 2009). While this thesis examines freehand core reduction strategies, bipolar cores appear in all the assemblages and could potentially indicate site-specific behaviour (see Caruana 2015 for a discussion around local occurrences of bipolar versus freehand percussion).

Sánchez-Yustos *et al.* (2017) compared core reduction strategies at the nearby sites of SHK Annexe and BK in Olduvai Gorge to determine how they each fit into the Developed Oldowan. If we set aside the debates about the validity of the Developed Oldowan as an industry and focus on their discussions around core reduction, one can identify progressive change in core preparation and elaboration / lengthening of the flaking sequence between 1.5-1.3 Ma at SHK

and BK. BK dates to ~1.3 Ma and demonstrates small flake production and early forms of prepared core technology. SHK Annexe dates to ~1.5 Ma and displays similar technological behaviours in regards to core manipulation but larger flake scars were produced. The raw material choices between the sites were different, but both assemblages demonstrated an adaptability of knappers to their environments across time, although within a small spatial range due to the proximity of the sites. In other words, the assemblages have comparable technological behaviours but they show how hominids were able to adapt their techniques to produce different flake products, with an increase in core manipulation and preparation in the later BK assemblage. This study reinforces the argument that variability between sites and assemblages with differing dates relates heavily to raw material and site context, but the hypothesis could also apply that archaeological trends change slowly and gradually and we can therefore track relative age in technological patterns. The paper also demonstrates the necessity to adopt similar methodological approaches for comparative studies in order to identify nuanced details between sites, as is the aim of this thesis.

9.3 Conclusion

Technological and comparative analyses have become popular in ESA studies over recent years (Tostevin 2011; de la Torre 2014; Moll 2017). These kinds of studies have demonstrated similarities between different sites, but the specific details of how reduction strategies are applied have not yet been investigated between East and South Africa. The sites analysed in this thesis have been a first attempt to do this, using EF-HR in Olduvai Gorge, Tanzania, and Sterkfontein Caves in the Cradle of Humankind, and Rietputs 15 and Canteen Kopje in the Northern Cape, South Africa.

This thesis discusses the regional trends in core reduction strategies of the earliest phase of the Acheulean technocomplex through an analysis of core and LCT assemblages from four sites in eastern and southern Africa, with six assemblages. It has been shown that LCT manufacture and core reduction strategies constitute distinct processes at each site, with the exception of the potential LCT boulder cores from the two Canteen Kopje assemblages. However, hominids applied similar edge management strategies for LCTs and cores in both processes. There is much complexity in the earliest assemblages of the Acheulean, but this study shows that these variations occur because of the differences in blank shapes and site contexts, rather than because of cognitive or behavioural differences. Therefore, my conclusion with regard to core edge management is that hominids from these distant regions displayed remarkedly similar technological behaviours during the earliest phase of the Acheulean technocomplex.

In general, it is evident that ‘simple’ edge management strategies with little central volume reduction were the common core strategies in these early Acheulean assemblages, but the emergence of more structured, recurrent, and continuous sequences follows. This is documented in the Canteen Kopje Pit 6 Organised Core Technology layer, and the trend is further supported by the patterns published by Leader et al. (2018) for the ~1.3 Ma old Rietputs Pit 5 assemblage, as well as by Sánchez-Yustos et al. (2017) for two sites at Olduvai. These organised core strategies eventually led to the development of prepared core technologies (following the definition used by Mesfin and Texier 2022). These progressive changes, in conjunction with the dominance of bifacially alternating edge shaping sequences on LCTs, give some idea of how the early Acheulean emerged technologically and developed through time. It shows that this change occurred not only through the introduction of new types of tools, but also through the common edge management strategies applied in the different and distant regions.

A trend of progressive change during the early Acheulean phase is still a hypothesis that needs more work to confirm, but those sites suggested to be earlier appear to have more opportunistic multifacial reduction of cores, along with fewer LCTs. At Sterkfontein there are no absolute dates for the Member 5 West deposit, and archaeological age estimates have relied on comparing the material to other typologically similar sites. Similarly, for the earlier sites of both ACP at Rietputs 15 and the Basal Early Acheulean layer in Pit 6 at Canteen Kopje, both in the Northern Cape, multifacial and bipolar reduction were most prominent, along with fewer LCTs. While these comparisons are useful to place the assemblages in the early Acheulean phase, such comparative analysis may also provide the potential to understand progressive changes within the early Acheulean itself in the absence of firm dates, as was suggested by Kuman and Gibbon (2018) for the ACP assemblage at Rietputs 15. These sites have different contexts and raw material types, but similar strategies are applied in different frequencies between the suggested younger versus older assemblages. Larger samples and better dating in future research are needed to fully understand this transition within the earliest phase of the Acheulean technocomplex and to address progressive development in reduction strategies. However, such proportional changes are tentatively supported by this study. The two stratified assemblages at Canteen Kopje currently provide the strongest quantitative evidence for change in the core reduction strategies.

Although these patterns require fuller investigation with well-dated sites, the approach used in this study may hopefully allow assemblages such as Sterkfontein M5W to be better placed in relative time. Such comparative data as presented in this study, even with these few case study examples, can help researchers to consider the broader picture of technological behaviour in relation to human evolution. The usefulness of such a study is to understand the

early iterations of the Acheulean, a technocomplex marking a massive cognitive leap forward (Isaac 1969; Leakey 1969; de la Torre 2014; Toth and Schick 2019). I hope that the data presented here will be seen as a helpful contribution, and many more comparative studies can adopt the ideas and aims presented here (see Shipton 2018 for a discussion on the need for comparative studies to understand the bigger picture of technological change over time).

There are multiple questions that have arisen out of this thesis for future consideration. The need to include more assemblages is paramount for determining whether these trends occur in other early Acheulean sites, especially in regards to edge management strategies, volume reduction, and landscape adaptation. The presence of prepared core technology in the ESA was discussed, and more work on the connection between 'organised' and 'prepared' cores as defined in this thesis could be further explored in the literature. In general, there are many issues around the use of terminology by researchers working in different regions and time periods, and this needs to be addressed in order to properly compare datasets. These terms include 'predetermination' versus 'prepared,' and 'simple' versus 'organised' flaking strategies, as well as definitions of 'skill' shown in lithic material.

In my opinion, this thesis provides some methodological questions that can be explored further. The usefulness of applying the same technological approach to multiple sites proves instrumental in developing broader understandings of the early Acheulean between regions. However, methods used must have clear reasoning as to why they were chosen, as they can help answer different questions. The schemes of idealised core reduction from de la Torre and Mora (2018b) can provide much coherent information on surface exploitation, directionality, volume reduction and edge management, and could be used to compare these technological traits.

In conclusion, this thesis demonstrates through analysis of these specific flaking strategies a more detailed image of the technological behaviours in the early Acheulean within six assemblages. The shape of raw material blanks that are specific to each site is one of the most important features that influenced the core reduction and LCT shaping strategies, including the clear separation of manufacture processes for cores and LCTs. The variations between the sites which are independent of such influences could also indicate a slow and incremental change during the early Acheulean between >1.5 Ma and 1.3 Ma.

Reference list

Andrefsky, W. 2005. *Lithics: Macroscopic Approaches to Analysis.* Cambridge: Cambridge University Press.

Arroyo, A. & de la Torre, I. 2016. Assessing the function of pounding tools in the Early Stone Age: A microscopic approach to the analysis of percussive artefacts from Beds I and II, Olduvai Gorge (Tanzania). *Journal of Archaeological Science* 74: 23-34.

Asfaw, B., Beyene, Y., Suwa, G., Walter, R.C., White, T.D., Wolde Gabriel, G. & Yemane, T. 1992. The earliest Acheulean from Konso-Gardula. *Nature* 360: 732-735.

Asfaw, B., White, T., Lovejoy, O., Latimer, B., Simpson, S. & Suwa, G. 1999. *Australopithecus garhi*: a new species of early hominid from Ethiopia. *Science* 284(5414): 629-635.

Ashton, N. & Davis, R. 2021. Cultural mosaics, social structure, and identity: The Acheulean threshold in Europe. *Journal of Human Evolution* 156: 103-111.

Bar-Yosef, O. & Goren-Inbar, N. 1993. The lithic assemblage of Ubeidiya*. Qedem* 34: 1-266.

Beaumont, P. & McNabb, J. 2000. Canteen Koppie: the recent excavations. *The Digging Stick* 17(3): 3-7.

Beaumont, P. & Vogel, C. 2006. On a timescale for the past million years of human history in central South Africa. *South African Journal of Science* 102: 217-228.

Beshkani, A., Beuzen-Waller, T., Bonilauri, S. & Gernez, G. 2017. Large Kombewa flake production in north Oman. *Arabian Archaeology and Epigraphy* 28(2): 125-137.

Beyene, Y. 2003. The emergence and development of the Acheulean at Konso. *Anthropological Science* 111: 58.

Beyene, P.Y., Suwa, G. & Asfaw, B. 2006. The beginning of the Acheulean culture in its environment context at Konso, Ethiopia. Abstract. In: de Lumley, H. (ed) *Les Cultures a Bifaces du Pleistocene Inferieur et Moyen dans le Monde. Emergence du Sens de l'Haromie*. Nice: Edusud.

Beyene, Y., Katoh, S., WoldeGabriel, G., Kart, W.K., Sudo, M., Kondo, M., Hyodo, M., Renne, P.R., Suwa, G. & Asfaw, B. 2013. The characteristics and chronology of the earliest Acheulean at Konso, Ethiopia. *Proceedings of the National Academy of Sciences* 110(5): 1585-1591.

Beyene, Y., Asfaw, B., Sano, K. & Suwa, G. (eds). 2015. *Archaeological Collections: Background and the Early Acheulean Assemblages, vol. 2*. Tokyo: The University Museum, The University of Tokyo.

Binford, S.R. 1968. Early Upper Pleistocene adaptations in the Levant. *American Anthropologist* 70(4): 707-717.

Binford, S.R. & Binford, L.R. 1968. *New Perspectives in Archeology*. Chicago: Aldine.

Binford, L.R. & Sabloff, J. 1982. Paradigms, systematics, and archaeology. J*ournal of Anthropological Research* 38: 137-152.

Bleed, P. 2001. Trees or chains, links or branches: conceptual alternatives for consideration of stone tool production and other sequential activities. *Journal of Archaeological Method and Theory* 8(1): 101-127.

Blumenschine, R.J. 1995. Percussion marks, tooth marks, and experimental determinations of the timing of hominid and carnivore access to long bones at FLK *Zinjanthropus*, Olduvai Gorge, Tanzania. *Journal of Human Evolution* 29(1): 21-51.

Blumenschine, R.J., Stanistreet, I.G., Njau, J.K., Bamford, M.K., Masao, F.T., Albert, R.M., Stollhofen, H., Andrews, P., Prassack, K.A., McHenry, L.J., Fernández-Jalvo, Y., Camilli, E.L. & Ebert, J.I. 2012. Environments and hominid activities across the FLK Peninsula during *Zinjanthropus* times (1.84 Ma), Olduvai Gorge, Tanzania. *Journal of Human Evolution* 63: 364-383.

Boëda, E. 1953. Levalloisien et Moustérien. *Bulletin de la Société Préhistorique Française* 50: 226–235.

Boëda, E. 1991. Approches de la variabilité des systèmes de production lithique des industries de paléolithique inferieure et moyen: chronique d'une variabilité attendue. *Techniques Culture* 17–18: 31–79.

Boëda, E. 1995. Levallois: a volumetric construction, methods, a technique. In: Dibble, H.L. & Bar Yosef, O. (eds) *The Definition and Interpretation of Levallois Technology*: 41–68. Madison: Prehistory Press.

Boëda, E. & Pelegrin, J. 1980. Approche technologique du nucléus Levallois à éclat. *Etudes Préhistoriques Lyon* 15: 41–48.

Bordes, F. 1950. Principes d'une méthode d'étude des techniques de débitage et de la typologie du Paléolithique ancien et moyen. *L'Anthropologie* 54 : 19-34.

Bordes, F. 1961. *Typologie du Paléolithique Ancien et Moyen*. Bordeaux : Institut de Préhistoire de l´Université de Bordeaux.

Bordes, F. 1968. *The Old Stone Age*. New York: McGraw-Hill.

Bordes, F. & de Sonneville-Bordes, D. 1970. The significance of variability in Paleolithic assemblages. *World Archaeology* 2(1): 61-73.

Braun, D.R., Rogers, M.J., Harris, J.W.K. & Walker, S.J. 2008a. Landscape-scale variation in hominin tool use: Evidence from the Developed Oldowan. *Journal of Human Evolution* 55(6): 1053-1063.

Braun, D.R., Tactikos, J.C., Ferraro, J.V., Arnow, S.L. & Harris, J.W.K. 2008b. Oldowan reduction sequences: methodological considerations. *Journal of Archaeological Science* 35: 2153-2163.

Braun, D.R. & Hovers, E. 2009. Introduction: Current issues in Oldowan research. In: Hovers, E. & Braun, D.R. (eds) *Interdisciplinary Approaches to the Oldowan.* Dordrecht: Springer: 1-14.

Braun, D.R., Aldeias, V., Archer, W., Arrowsmith, J.R., Baraki, N., Campisano, C.J., Deino, A.L., DiMaggio, E.N., Dupont-Nivet, G., Engda, B. & Feary, D.A. 2019. Earliest known Oldowan artifacts at >2.58 Ma from Ledi-Geraru, Ethiopia, highlight early technological diversity. *Proceedings of the National Academy of Sciences* 116(24): 11712-11717.

Caruana, M.V. 2014. Analyzing percussive technology from the Earlier Stone Age. Unpublished PhD dissertation. Johannesburg: University of the Witwatersrand.

Caruana, M.V. 2017. Lithic production strategies in the Oldowan assemblages from Sterkfontein member 5 and Swartkrans member 1, Gauteng province, South Africa. *Journal of African Archaeology* 15(1): 1-19.

Caruana, M.V. & Mtshali, S.P. 2018. Assessing the durability of Oldowan stone tools in South Africa: Implications for quartz selectivity and use. *Lithic Technology* 43(4): 245-254.

Caruana, M.V. 2020. Exploring the influence of predation risks on Oldowan tool use in South Africa. *Journal of Field Archaeology* 45(8): 608-620.

Caruana, M.V. 2020. South African handaxes reloaded. *Journal of Archaeological Science: Reports* 34: 1-8.

Caruana, M.V. 2021. Pilot study comparing the effects of thinning processes on the cross-sectional morphologies of Early and Late Acheulian handaxes. *Archaeometry* 63(3): 481-499.

Caruana, M.V. 2022. Extrapolating later Acheulian handaxe reduction sequences in South Africa: A case study from the Cave of Hearths and Amanzi Springs. *Lithic Technology* 47(1): 1-12.

Caruana, M.V. & Herries, A.I. 2020. An Acheulian balancing act: A multivariate examination of size and shape in Handaxes from Amanzi Springs, eastern cape, South Africa. In: Cole, J., McNabb, J., Grove, M. & Hosfield, R. (eds) *Landscapes of Human Evolution. Contributions in Honour of John Gowlett*: 91-115. Oxford: Archaeopress.

Chavaillon, J. 1979. Essai pour une typologie du matériel de percussion. *Bulletin de la Société Préhistorique Française* 76(8): 230-233.

Chazan, M. 1997. Redefining Levallois. *Journal of Human Evolution* 33: 719–735.

Chazan, M., Hagai, R., Matmon, A., Porat, N., Goldberg, P., Yates, R., Avery, M., Sumner, A. & Horwitz, L.K. 2008. Radiometric dating of the Earlier Stone Age sequence in excavations at Wonderwerk Cave, South Africa: preliminary results. *Journal of Human Evolution* 55: 1-11.

Chazan, M., Avery, D.M., Bamford, M.K., Berna, F., Brink, J., Fernandez-Jalvo, Y., Goldberg, P., Holt, S., Matmon, A., Porat, N. & Ron, H. 2012. The Oldowan horizon in Wonderwerk Cave (South Africa): Archaeological, geological, paleontological and paleoclimatic evidence. *Journal of Human Evolution 63*(6): 859.

Clark, J.D. & Kurashina, H. 1979. Hominid occupation of the east-central highlands of Ethiopia in the Plio–Pleistocene. *Nature* 282(5734): 33-39.

Clarke, D.L.1978. *Analytical archaeology*. Columbia University Press.

Clarke, R.J. 1994. On some new interpretations of Sterkfontein stratigraphy. *South African Journal of Science* 90(4): 211-214.

Clarke, R.J. 2012. The history of research in human evolution in Africa and what lessons have been learned. In: Sanz, M. (ed) *Human Origin Sites and the World Heritage Convention in Africa*: 44-67*.* Paris: United Nations Educational, Scientific and Cultural Organization.

Clarke, R. 2013. Australopithecus from Sterkfontein Caves, South Africa. In: Reed, K., Fleagle, J. & Leakey, R. (eds) *The paleobiology of Australopithecus*: 105-123. Springer, Dordrecht.

Clarke, R.J. & Kuman, K. 2019. The skull of StW 573, a 3.67 Ma *Australopithecus prometheus* skeleton from Sterkfontein Caves, South Africa. *Journal of Human Evolution* 134: 102634.

Clarke, R.J., Pickering, T.R., Heaton, J.L. & Kuman, K. 2021. The earliest South African hominids. *Annual Review of Anthropology* 50: 125-143.

Clarkson, C. 2013. Measuring core reduction using 3D flake scar density: a test case of changing core reduction at Klasies River Mouth, South Africa. *Journal of Archaeological Science* 40(12): 4348-4357.

Couzens, R.A. 2012.Spatial Modelling, formation and transformation of the Oldowan lithic artefact assemblages from Sterkfontein Caves, South Africa*.* Unpublished PHD dissertation. Johannesburg: University of the Witwatersrand.

Dag, D. & Goren-Inbar, N. 2001. An actualistic study of dorsally plain flakes: a technological note. *Lithic Technology* 26(2): 105-117.

de la Torre, I. 2009. Technological Strategies in the Lower Pleistocene at Peninj (West of Lake Natron, Tanzania). In: Schick, K. & Toth, N. (eds) *The Cutting Edge: New Approaches to the Archaeology of Human Origins*: 94-113. Gosport (IN): Stone Age Institute Press.

de la Torre, I. 2011. The Early Stone Age lithic assemblages of Gadeb (Ethiopia) and the Developed Oldowan/early Acheulean in East Africa. *Journal of Human Evolution* 60: 768-812.

de la Torre, I, Mora, R, Dominguez-Rodrigo, M, de Luque, L. & Alcala, L. 2003. The Oldowan industry of Peninj and its bearing on the reconstruction of the technological skills of Lower Pleistocene hominids. *Journal of Human Evolution* 44: 203-224.

de la Torre, I. & Mora, R. 2005. Unmodified lithic material at Olduvai Bed I: manuports or ecofacts? *Journal of Archaeological Science* 32 (2005): 273-285.

de la Torre, I., Mora, R. & Martinez-Moreno, J. 2008. The early Acheulean in Peninj (Lake Natron, Tanzania). *Journal of Anthropological Archaeology* 27: 244-264.

de la Torre, I. & Mora, R. 2009. Remarks on the Current Theoretical and Methodological Approaches to the Study of Early Technological Strategies in Eastern Africa. In: Hovers, E. & Braun, D.R. (eds) *Interdisciplinary Approaches to the Oldowan*: 15-24. Dordrecht: Springer.

de la Torre, I., McHenry, L., Njau, J. & Pante, M. 2011-2012. The Origins of the Acheulean at Olduvai Gorge (Tanzania): New Paleoanthropologial Project in east Africa. *Archaeology International* 15: 89-98.

de la Torre, I. & Mora, R. 2018a. Oldowan technological behaviour at HWK EE (Olduvai Gorge, Tanzania). *Journal of Human Evolution* 120: 236-273.

de la Torre, I. & Mora, R. 2018b. Technological behaviour in the early Acheulean of EF-HR (Olduvai Gorge, Tanzania). *Journal of Human Evolution* 120: 329-377.

de la Torre, I. *et al* (Editorial). 2018. From the Oldowan to the Acheulean at Olduvai Gorge, Tanzania – An introduction to the special issue. *Journal of Human Evolution* 120: 1-6.

de la Torre, I., Albert, R. M., Macphail, R., McHenry, L. J., Pante, M. C., RodrÍguez-Cintas, A., Stanistreet, I. G. & Stollhofen, H. 2018. The contexts and early Acheulean archaeology of EF-HR paleo-landscape (Olduvai Gorge, Tanzania). *Journal of Human Evolution* 120: 274-297.

de la Torre, I. & Mora, R. 2020. How many handaxes make an Acheulean? A case study from the SHK-Annexe Site, Olduvai Gorge, Tanzania. In Cole, J., McNabb, J., Grove, M. & Hosfield, R. (eds) *Landscapes of Human Evolution. Contributions in Honour of John Gowlett*: 64-91. Oxford: Archaeopress.

de la Torre, I., Benito-Calvo, A., Martín-Ramos, C., McHenry, L.J., Mora, R., Njau, J.K., Pante, M.C., Stanistreet, I.G. & Stollhofen, H. 2021. New excavations in the MNK Skull site, and the last appearance of the Oldowan and Homo habilis at Olduvai Gorge, Tanzania. *Journal of Anthropological Archaeology* 61: https://doi.org/10.1016/j.jaa.2020.101255.

de Mortillet, G. 1872. Classification des diverses périodes de l'âge de la pierre. *Revue d'Anthropologie* 1: 432–435.

Delagnes, A. & Roche, H. 2005. Late Pliocene hominid knapping skills: The case of Lokalalei 2C, West Turkana, Kenya. *Journal of Human Evolution* 48: 435-472.

Dibble, H.L. 1997. Platform variability and flake morphology: A comparison of experimental and archaeological data and implications for interpreting prehistoric lithic technological strategies. *Lithic Technology* 22(2): 150-170.

Dibble, H.L. & Rezek, Z. 2009. Introducing a new experimental design for controlled studies of flake formation: results for exterior platform angle, platform depth, angle of blow, velocity, and force. *Journal of Archaeological Science* 36: 1945-1954.

Dibble, H.L., Holdaway, S.J., Lin, S.C., Braun, D.R., Douglass, M.J., Iovita, R., McPherron, S.P., Olszewski, D.I. & Sandgathe, D. 2016. Major fallacies surrounding stone artifacts and assemblages. *Journal of Archaeological Method and Theory* 24(3): 813-851 .

Diez-Martin, F., Sánchez, P., Dóminguez-Rodrigo, M., Mabulla, A. & Barba, R. 2009. Were Olduvai hominins making butchering tools or battering tools? Analysis of a recently excavated lithic assemblage from BK (Bed II, Olduvai Gorge, Tanzania). *Journal of Anthropological Archaeology* 28: 274-289.

Diez-Martín, F., Yustos, P.S., Dominguez-Rodrigo, M., Mabulla, A.Z.P., Bunn, H.T., Ashley, G.M., Barba, R. & Baquedano, E. 2010. New insights into hominin lithic activities at FLK North Bed I, Olduvai Gorge, Tanzania. *Quaternary Research* 74(3): 376-387.

Diez-Martín, F., Sánchez Yustos, P., Uribelarrea, D., Baquedano, E., Mark, D.F., Mabulla, A., Fraile, C., Duque, J., Díaz, I., Pérez-González, A. & Yravedra, J. 2015. The origin of the Acheulean: The 1.7 million-year-old site of FLK West, Olduvai Gorge (Tanzania). *Scientific Reports* 5(1): 1-9.

Diez-Martín, F., Sánchez-Yustos, P. & de Luque, L. 2018. The East African Early Acheulean of Peninj (Lake Natron, Tanzania). In: Gallotti, R. & Mussi, M. (eds) *The Emergence of the Acheulean in East Africa and Beyond. Vertebrate Paleobiology and Paleoanthropology*: 129-151. Cham: Springer.

Drennan, R.D. 2009. *Statistics for Archaeologists: A Common Sense Approach.* Dordrecht: Springer.

Du, A. & Wood, B. 2020. Brain Size Evolution in the Hominin Clade. In Cole, J., McNabb, J., Grove, M. & Hosfield, R. (eds) *Landscapes of Human Evolution. Contributions in Honour of John Gowlett*: 9-17. Oxford: Archaeopress.

Duke, H., Feibel, C. & Harmand, S. 2021. Before the Acheulean: The emergence of bifacial shaping at Kokiselei 6 (1.8 Ma), West Turkana, Kenya. *Journal of Human Evolution* 159: https://doi.org/10.1016/j.jhevol.2021.103061.

Field, A.S. 1999. *An analytical and comparative study of the Earlier Stone Age archaeology of the Sterkfontein valley*. MSc dissertation. Faculty of Science, University of the Witwatersrand.

Gallotti, R. 2013. An older origin for the Acheulean at Melka Kunture (upper Awash, Ethiopia): techno-economic behaviors at Garba IVD. *Journal of Human Evolution* 65: 594-620.

Gallotti, R. 2016. The East African origin of the Western European Acheulean technology: fact or paradigm? *Quaternary International* 411: 9-24.

Gallotti, R. & Mussi, M. 2018. The emergence of the Acheulean in East Africa: Historical perspectives and current issues. In: Gallotti, R. and Mussi, M (eds) *The Emergence of the Acheulean in East Africa and Beyond. Contributions in Honor of Jean Chavaillon*: 1-12. Cham: Springer.

Gallotti, R. & Mussi, M. 2015. The unknown Oldowan: ~1.7-Million-Year-Old standardized obsidian small tools from Garba IV, Melka Kunture, Ethiopia. *PLoS ONE* 10: https://doi.org/10.1371/journal.pone.0145101.

Gaudzinski, S. 2004. Subsistence patterns of Early Pleistocene hominids in the Levant—taphonomic evidence from the Ubeidiya Formation (Israel). *Journal of Archaeological Science* 31(1): 65-75.

Geneste, J.M. 1985. Analyse lithique d´industries moustériennes du Périgord: une approche technologique du comportement des groupes humains au Paléolitique Moyen. Unpublished PhD dissertation. Université de Bordeaux.

Gibbon, R.J., Granger, D.E., Kuman, K. & Partridge, T.C. 2009. Early Acheulean technology in the Vaal River gravels, South Africa, dated with cosmogenic nuclides. *Journal of Human Evolution* 56: 152-160.

Gibbon, R.J., Pickering, T.R., Sutton, M.B., Heaton, J.L., Kuman, K., Clarke, R.J., Brain, B.K. & Granger, D.E. 2014. Cosmogenic nuclide burial dating of hominid-bearing Pleistocene cave deposits at Swartkrans, South Africa. *Quaternary Geochronology*. 24: 10-15.

Gowlett, J.A., Harris, J.W., Walton, D. & Wood, B.A. 1981. Early archaeological sites, hominid remains and traces of fire from Chesowanja, Kenya. *Nature* 294(5837): 125-129.

Gowlett, J.A. 1986. The Oldowan-Acheulian gradient. In: Bailey, G. N. and Callow, P. (eds) *Stone Age prehistory: studies in memory of Charles McBurney*: 243. Cambridge: Cambridge University Press.

Gowlett, J.A. 2009. The longest transition or multiple revolutions? In: Camps, M., Chauhan, P. (eds) *Sourcebook of Paleolithic transitions*: 65-78. New York: Springer.

Gowlett, J.A., Stanistreet, I.G., Albert, R.M., Blackbird, S.J., Herries, A.I., Hoare, S., Kogai, P., Komboh, C.K., Mark, D.F., Muriuki, R.M. & Murphy, H. 2022. New Oldowan localities at

high level within Kilombe Caldera, Kenya. *L'Anthropologie* 126(1): https://doi.org/10.1016/j.anthro.2021.102976.

Granger, D.E., Gibbon, R. J., Kuman, K., Clarke, R.J., Bruxelles, L. & Caffee, M.W. 2015. New cosmogenic burial ages for Sterkfontein Member 2 Australopithecus and Member 5 Oldowan. *Nature* 522(7554): 1-8.

Groves, C.P. & Mazák, V. 1975. An approach to the taxonomy of Hominidae: gracile Villafranchian hominids of Africa. *Casopis pro Mineralogii Geologii* 382: 225-246.

Harmand, S. 2009. Variability in raw material selectivity at the Late Pliocene sites of Lokalalei, West Turkana, Kenya. In: Hovers, E. & Braun, D.R. (eds) *Interdisciplinary Approaches to the Oldowan. Vertebrate Paleobiology and Paleoanthropology*: 85-97. Springer: Dordrecht.

Harmand, S., Lewis, J.E., Feibel, C.S., Lepre, C.J., Prat, S., Lenoble, A., Boë, X., Quinn, R.L., Brenet, M., Arroyo, A., Taylor, N., Clément, S., Daver, G., Brugal, J-P., Leakey, L., Mortlocks, R.A., Wright, J.D., Lokorodi, S., Kirwa, C., Kent, D.V. & Roche, H. 2015. 3.3-million-year-old stone tools from Lomekwi 3, West Turkana, Kenya. *Nature* 521: 310-316.

Harmand, S., Prat, S., Boes, X., Lewis, J., Feibel, C. & Roche, H. 2016. The missing Oldowan: New 2.3-2.0 Ma sites from the Nasura Complex, West Turkana, Kenya. In *European Society for the study of Human Evolution 6th meeting.* Madrid, Spain. 14 September 2016. ⟨hal-02966206⟩.

Hay, R.L. 1976. *Geology of the Olduvai Gorge: A study of sedimentation semiarid basin.* Berkeley: University of California Press.

Herzlinger, G., Wynn, T. & Goren-Inbar, N. 2017. Expert cognition in the production sequence of Acheulian cleavers at Gesher Benot Ya'aqov, Israel: A lithic and cognitive analysis. *PLoS ONE* 12(11): 1-14.

Hovers, E. & Kuhn, S. (eds). 2007. *Transitions Before the Transition: Evolution and Stability in the Middle Paleolithic and Middle Stone Age*. Santa Barbara: Springer Science and Business Media.

Hovers, E. 2012. Invention, reinvention and innovation: the makings of Oldowan lithic technology. *Developments in Quaternary Sciences* 16: 51-68.

Hovers, E., Gossa, T., Asrat, A., Niespolo, E.M., Resom, A., Renne, P.R., Ekshtain, R., Herzlinger, G., Ketema, N. & Martínez-Navarro, B. 2021. The expansion of the Acheulian to the Southeastern Ethiopian Highlands: Insights from the new early Pleistocene site-complex of Melka Wakena. *Quaternary Science Reviews 253* https://doi.org/10.1016/j.quascirev.2020.106763.

Inizan, M.L., Reduron-Ballinger, M., Roche, H. & Tixier, J. 1999. *Technology and Terminology of Knapped Stone.* Nanterre: CREP.

Isaac G.L. 1969. Studies of early culture in East Africa. *World Archaeology* I: 1-28.

Isaac, G.L. 1977a. *Olorgesailie. Archeological studies of a Middle Pleistocene lake basin in Kenya*. Chicago: University of Chicago Press.

Isaac, G.L. 1977b. Squeezing blood from stones. In: Wright, R.V.S. (ed) *Stone Tools as Cultural Markers: Change, Evolution, and Complexity*: 5-12. New Jersey: Humanities Press.

Isaac, G.L. 1981. Emergence of human behaviour patterns: archaeological tests of alternative models of early hominid behaviour: excavation and experiments. *Philosophical Transactions of the Royal Society of London. B, Biological Sciences* 292(1057): 177-188.

Isaac, G.L. 1986. Foundation Stone: Early artefacts as indicators of activities and abilities. In: G.N. Bailey & P. Callow (eds) *Stone Age Prehistory*: 221-241. Cambridge: Cambridge University.

Isaac, G.L., Harris, J.W.K. & Kroll, E.M. 1997. The stone artefacts: A comparative study. In: G.L. Isaac (ed) *The Koobi Fora Research Project: Volume 5*: 262-362. Oxford: Claredon.

Isaac, G.L. & Keller, C.M. 1968. Note on the proportional frequency of side- and end-struck flakes. *South African Archaeological Bulletin* 23 (89): 17-19.

Jansen, F.J. 1926. A new type of stone implement from Victoria West. *South African Journal of Science* 23: 818-825.

Jones, P.R. 1994. Results of experimental work in relation to the stone industries of Olduvai Gorge. In: M.D. Leakey & D.A. Roe (eds) *Olduvai Gorge, Vol. 5*: 254-294. Cambridge: Cambridge University Press.

Keeley, L.H. & Toth, N. 1981. Microwear polishes on early stone tools from Koobi Fora, Kenya. *Nature 293*(5832): 464-465.

Klein, R. 2000. The Earlier Stone Age of southern Africa. *South African Archaeological Bulletin* 55: 107-122.

Kleindienst, M.R. 1962. Component of the East African Acheulian assemblage: an analytic approach. In: Mortelmans, G. & Nenquin, J. (eds) *Actes du IV Congrès Pan Africain de Préhistoire et de l'Etude du Quaternaire, Leopoldville, 1959. Belgique Annalen*: 81-108. Tervuren: Musée Royal de l'Afrique Centrale.

Kleindienst, M.R. 1965. Components of the East African Acheulian: An analytical approach. In: G. Mortelmans & J. Nenquin (eds) *Actes du IVe Congrès Panafricain de Préhistoire*: 81–105. Tervuren: Annales du Musée Royal d'Afrique Centrale.

Krieger, A.D. 1944. The typological concept. *American Antiquity* 9(3): 271-288.

Kübler, S., Bailey, G., Rucina, S., Devès, M. & King, G.C. 2020. Rift dynamics and archaeological sites: Acheulean land use in geologically unstable settings. In: Cole, J., McNabb, J., Grove, M. & Hosfield, R. (eds) *Landscapes of Human Evolution. Contributions in Honour of John Gowlett*: 42-63. Oxford: Archaeopress.

Kuhn, S.L. 1991. "Unpacking" reduction: Lithic raw material economy in the Mousterian of West-Central Italy. *Journal of Anthropological Archaeology* 10: 76-106.

Kuman, K. 1994. The archaeology of Sterkfontein: past and present. *Journal of Human Evolution* 27: 471-495.

Kuman, K. 1996. The Oldowan Industry from Sterkfontein: raw materials and core forms. In: In: Pwiti, G. & Soper, R. (eds) *Aspects of African archaeology: papers from the 10th Congress of the PanAfrican Association for Prehistory and Related Studies*: 139-146. Harare: University of Zimbabwe Publications.

Kuman, K. 1998. The earliest South African industries. In: Petraglia, M. & Korisettar, R. (eds) *Early Human Behavior in Global Context: The Rise and Diversity of the Lower Palaeolithic Record*: 151-186. London: Routledge.

Kuman, K. 2001. An Acheulean factory site with prepared core technology near Taung, South Africa. *The South African Archaeological Bulletin* 56 (173/174): 8-22.

Kuman, K. 2007. The Earlier Stone Age in South Africa: site context and the influence of cave studies. In: Pickering, T.R., Schick, K. & Toth, N. (eds) *Breathing Life into Fossils: Taphonomic Studies in Honor of C.K. (Bob) Brain*: 181-198. Bloomington: Stone Age Institute Press.

Kuman, K. 2019. The Oldowan industrial complex. In: C. Smith (ed) *Encyclopedia of Global Archaeology, Vol. 8*: 5560-5570. New York: Springer.

Kuman, K. 2019. The Acheulean industrial complex. In: C. Smith (ed) *Encyclopedia of Global Archaeology, Vol 1.*: 7-18

Kuman, K., Field, A.S. & Thackeray, J.F. 1997. Discovery of new artefacts at Kromdraai. *South African Journal of Science* 93: 187-193.

Kuman, K., Sutton, M.B., Pickering, T.R. & Heaton, J.L. 2018. The Oldowan industry from Swartkrans cave, South Africa, and its relevance for the African Oldowan. *Journal of Human Evolution* 123: 52-69.

Kuman, K. & Clark, R.J. 2000. Stratigraphy, artefact industries and hominid associations, Member 5. *Journal of Human Evolution* 38: 827-847.

Kuman, K., Li, C. & Li, H. 2016. Large cutting tools in the Danjiangkou Reservoir Region, central China. *Journal of Human Evolution* 76: 129-153.

Kuman, K. & Gibbon, R.J. 2018. The Rietputs 15 site and Early Acheulean in South Africa. *Quaternary International* 480: 4-15.

Kuman, K., Granger, D.E., Gibbon, R.J., Pickering, T.R., Caruana, M.V., Bruxelles, L., Clarke, R.J., Heaton, J.L., Stratford, D. & Brain, C.K. 2021. A new absolute date from Swartkrans Cave for the oldest occurrences of Paranthropus robustus and Oldowan stone tools in South Africa. *Journal of Human Evolution* 156. https://doi.org/10.1016/j.jhevol.2021.103000.

Leader, G.M. 2009. Early Acheulean in the Vaal River basin, Rietputs Formation, Northern Cape, South Africa. Unpublished MSc dissertation. Johannesburg: University of the Witwatersrand.

Leader, G.M. 2014. New Excavations at Canteen Kopje, Northern Cape Province, South Africa: A techno-typological comparison of three earlier Acheulean assemblages with new interpretations on the Victoria West phenomenon. Unpublished PHD dissertation. Johannesburg: University of the Witwatersrand.

Leader, G.M., Kuman, K., Gibbon, R.J. & Granger, D.E. 2018. Early Acheulean organised core knapping strategies ca. 1.3 Ma at Rietputs 15, Northern Cape Province, South Africa. *Quarterly International* 480: 1-13.

Leakey, L.S.B. 1934. *Adam's Ancestors: An up-to-date outline of what is known about the origin of man*. London: Metheuen and Company.

Leakey, M.D. 1966. A review of the Oldowan culture from Olduvai Gorge, Tanzania. *Nature* 210(5035): 462-466.

Leakey, M.D. 1970. New finds at the Swartkrans Australopithecine site (contd): Stone artefacts from Swartkrans. *Nature* 225(5239): 1222-1225.

Leakey, M. 1971. *Olduvai Gorge: Volume 3, Excavations in Beds I and II, 1960-1963.* Cambridge: Cambridge University Press.

Leakey, M. 1975. Cultural Patterns in the Olduvai Sequence. In: Butzer, E. & Isaac, B (eds) *After the Australopithecines: Stratigraphy, ecology and culture change in the Middle Pleistocene*: 447-498. The Hague: Mouton.

Leakey, M.D. 1976. A summary and discussion of the archaeological evidence from Bed 1 and Bed II, Olduvai Gorge, Tanzania. In: Isaac, G. & McCown, E (eds) *Human Origins: Louis Leakey and the East African Evidence*: 431-459. California: W.A. Benjamin.

Leakey, M. & Roe, D. 1994. *Olduvai Gorge, Vol. 5, Excavations in Beds III, IV and the Masek Beds, 1968-1971.* Cambridge: Cambridge University Press.

Lepre, C.J. & Kent, D.V. 2010. New magnetostratigraphy for the Olduvai Subchron in the Koobi Fora Formation, northwest Kenya, with implications for early Homo. *Earth and Planetary Science Letters* 290: 362-374.

Lepre, C.J., Roche, H., Vent, D.V., Harmand, S., Quinn, R.L., Brugal, J-P., Texier, P-J., Lenoble, A. & Feibel, C. S. 2011. An earlier origin for the Acheulian. *Nature* 477: 82-85.

Leroi-Gourhan, A. 1964. *Le geste et la parole. I- technique et language. II- La mémoire et les rythmes*. Paris: Albin Michel.

Lewis, J.E. & Harmand, S. 2016. An earlier origin for stone tool making: implications for cognitive evolution and the transition to Homo. *Philosophical Transactions of the Royal Society B: Biological Sciences* 371(1698): http://doi.org/10.1098/rstb.2015.0233.

Li, H., Li, C.R. & Kuman, K. 2014. Rethinking the "Acheulean" in East Asia: evidence from recent investigations in the Danjiangkou Reservoir Region, central China. *Quaternary International* 347: 163-175.

Lombard, M., Wadley, L., Deacon, J. & Wurz, S. 2012. South African and Lesotho Stone Age sequence updated. *South African Archaeological Bulletin* 67(195): 123-144.

Lotter, M.G., Gibbon, R.J., Kuman, K., Leader, G.M., Forssman, T. & Granger, D.E. 2016. A geoarchaeological study of the middle and upper Pleistocene levels at Canteen Kopje, Northern Cape Province, South Africa. *Geoarchaeology* 31(4): 304-323.

Lotter, M.G. & Kuman, K. 2018. The Acheulean in South Africa, with announcement of a new site (Penhill Farm) in the lower Sundays River Valley, Eastern Cape Province, South Africa. *Quaternary International* 480: 43-65.

Lotter, M.G. 2020. Stuck in a loop: investigating fabric patterns in the Stone Age gravel sequence at Canteen Kopje, Northern Cape Province, South Africa. *Transactions of the Royal Society of South Africa* 75(1): 64-77.

Luyt, C.J. & Lee-Thorp, J.A. 2003. Carbon isotope ratios of Sterkfontein fossils indicate a marked shift to open environments c. 1.7 Myr ago. *South African Journal of Science* 99: 271-273.

Ludwig, B.V. 1999. A technological reassessment of East African Plio-Pleistocene lithic artifact assemblages. Unpublished PhD dissertation. Rutgers University.

Lycett, S. 2008. Are Victoria West cores “proto-Levallois”? A phylogenetic assessment. *Journal of Human Evolution* 56: 175-191.

Lycett, S.J. & Gowlett, J.A. 2008. On questions surrounding the Acheulean ‘tradition’. *World Archaeology* 40(3): 295-315.

Masojć, M., Kim, J.Y., Krupa-Kurzynowska, J., Sohn, Y.K., Ehlert, M., Michalec, G., Cendrowska, M., Andrieux, E., Armitage, S.J., Szmit, M. & Dreczko, E. 2021. The oldest Homo erectus buried lithic horizon from the Eastern Saharan Africa. EDAR 7-an Acheulean assemblage with Kombewa method from the Eastern Desert, Sudan. *PloS ONE* 16(3): 1-53.

Mason, R.J. 1961. The Acheulian culture in South Africa. *The South African Archaeological Bulletin* 16 (63): 107-110.

Mason, R.J. 1965. Makapansgat Limeworks fractured stone objects and natural fracture in Africa. *South African Archaeological Bulletin* 20 (77): 3-16.

McGuire, J. D. 1891. The stone hammer and its various uses. *American Anthropologist* 4(4): 301-312.

McNabb, J. 2001. The shape of things to come. A speculative essay on the role of the Victoria West phenomenon at Canteen Koppie, during the South African Earlier Stone Age. In: S. Milliken & J. Cook (eds) *A Very Remote Period Indeed:* 37-41. Oxford: Oxbow Books.

McNabb, J., Binyon, F. & Hazelwood, L. 2004. The large cutting tools from the South African Acheulean and the questions of social traditions. *Current Anthropology* 45(5): 653-677.

McNabb, J. & Beaumont, P. 2011a. *A report on the archaeological assemblages from excavations by Peter Beaumont at Canteen Koppie, Northern Cape, South Africa*. Southampton: Archaeopress.

McNabb, J. & Beaumont, P. 2011b. Excavations in the Acheulean levels of the Earlier Stone Age site of Canteen Koppie, Northern Cape province, South Africa. *Proceedings of the Prehistory Society* 78: 51-71.

McNabb, J. & Cole, J. 2015. The mirror cracked: Symmetry and refinement in the Acheulean handaxe. *Journal of Archaeological Science: Reports* 3: 100-111.

McNabb, J. & Kuman, K. 2015. Experimental stone tool replication at the early stone age site of Sterkfontein, Gauteng, South Africa. *Journal of Archaeological Science: Reports* 4: 44-53.

McPherron, S.J.P. 2000. Handaxes as a measure of the mental capabilities of early hominids. *Journal of Archaeological Science* 27: 655-663.

Mesfin, I.I., Lotter, M.G. & Benjamin, M.H. 2021. A new approach to quantifying raw material selectivity in the African Acheulean: perspectives from Angola and South Africa. *Journal of African Archaeology* 19(2): 205-234.

Mesfin, I.I. & Texier, P.J. 2022. Prepared Core Technology from the Early Pleistocene Site of Nyabusosi 18, Uganda. *SSRN Electronic Journal.* https://doi.org/10.2139/ssrn.4180245.

Moll, R.M. 2014. Towards an understanding of core reduction and flaking intensity in the Early Acheulean polyhedral quartzite core assemblage from Sterkfontein Caves, South Africa. Unpublished BA Honours dissertation. University of the Witwatersrand.

Moll, R.M. 2017. A technological study of the lithic artefacts from the Earlier Stone Age site of Maropeng in the Cradle of Humankind, Gauteng, South Africa. Unpublished MSc dissertation. Johannesburg: University of the Witwatersrand.

Mora, R. & de la Torre, I. 2005. Percussion tools in Olduvai Beds I and II (Tanzania): Implications for early human activities. *Journal of Anthropological Archaeology* 24(2): 179-192.

Morgan, T.J., Uomini, N.T., Rendell, L.E., Chouinard-Thuly, L., Street, S.E., Lewis, H.M., Cross, C.P., Evans, C., Kearney, R., de la Torre, I. & Whiten, A. 2015. Experimental evidence for the co-evolution of hominin tool-making teaching and language. *Nature communications* 6(1): 1-8.

Morrissey, P. 2015. A geoarchaeological investigation of the Earlier Stone Age site at Maropeng in the Cradle of Humankind. Unpublished BSc Honours dissertation. Johannesburg: University of the Witwatersrand.

Mourre, V. 2006. Émergence et évolution de la prédétermination au Paléolithique. In: L. Astruc, F. Bon, V. Léa, P.-Y. Milcent, S. Philibert (eds) *Normes techniques et pratiques sociale: de la simplicité des outillages pré-et protohistoriques*: 61-74. Antibes-Juan-les-Pins: XXVIe Rencontres Internationales d'Archéologie et d'Histoire d'Antibes.

Muller, A., Clarkson, C. & Shipton, C. 2017. Measuring behavioural and cognitive complexity in lithic technology throughout human evolution. *Journal of Anthropological Archaeology* 48: 166-180.

Newman, J.R. 1994. The effects of distance on lithic material reduction technology. *Journal of Field Archaeology* 21 (4): 491-501.

Odell, G.H. 1980. Butchering with stone tools: some experimental results. *Lithic Technology* 9(2): 39-48.

Ogola, C.A. 2009. The Sterkfontein Western Breccias: stratigraphy, fauna and artefacts. Unpublished PhD dissertation. Johannesburg: University of the Witwatersrand.

Owen, W.E. 1938. The Kombewa culture, Kenya Colony. *Man* 38: 203-205.

Panger, M.A., Brooks., Richmond, B.G. & Wood, B. 2002. Older than the Oldowan? Rethinking the emergence of hominin tool use. *Evolutionary Anthropology: Issues, News, and Reviews* 11(6): 235-245.

Pargeter, J. & Eren, M.I. 2017. Quantifying and comparing bipolar versus freehand flake morphologies, production currencies, and reduction energetics during lithic miniaturization. *Lithic Technology* 42(2-3): 90-108.

Partridge, T.C., Granger, D.E., Caffee, M.W. & Clarke, R.J. 2003. Lower Pliocene hominid remains from Sterkfontein. *Science* 300 (5619): 607-612.

Pelegrin, J. 1985. Réflexions sur le comportement technique. In: Otte, M. (ed) *La signification culturelle des industries lithiques. Actes du colloque de Liège du 3 an 7 octobre 1984*. *BAR International Series* 239: 72-91.

Pelegrin, J. 1990. Prehistoric lithic technology: some aspects of research. *Archaeological Review* : Cambridge 9: 116-125.

Pelegrin, J. 1991. Les savoir-faires: une très longue histoire. *Terrain* 16: 106-113.

Plummer, T. 2004. Flaked stones and old bones: Biological and cultural evolution at the dawn of technology. *American Journal of Physical Anthropology* 125: 118-164.

Plummer, T. 2004. Flaked stones and old bones: Biological and cultural evolution at the dawn of technology. *Yearbook of Physical Anthropology* 47: 118-164.

Pollarolo, L., Susino, G., Kuman, K. & Bruxelles, L. 2010. Acheulean artefacts at Maropeng in the Cradle of humankind world heritage site, Gauteng province, South Africa. *South African Archaeological Bulletin* 65 (191): 3-12.

Presnyakova, D., Archer, W., Braun, D.R. & Flear, W. 2015. Documenting differences between Early Stone Age flake production systems: an experimental model and archaeological verification. *PloS ONE* 10(6): 1-26.

Presnyakova, D., Braun, D.R., Conard, N.J., Feibel, C., Harris, J.W., Pop, C.M., Schlager, S. & Archer, W. 2018. Site fragmentation, hominin mobility and LCT variability reflected in the early Acheulean record of the Okote Member, at Koobi Fora, Kenya. *Journal of Human Evolution* 125: 159-180.

Proffitt, T. 2016. A technological analysis of the Oldowan and developed Oldowan assemblages from Olduvai Gorge, Tanzania. Unpublished PhD dissertation. London: University College London.

Proffitt, T. 2018. Is there a developed Oldowan A at Olduvai Gorge? A diachronic analysis of the Oldowan in bed I and lower-middle bed II at Olduvai Gorge, Tanzania. *Journal of Human Evolution* 120: 92-113.

Roche, H. 2000. Variability of Pliocene lithic productions in East Africa. *Acta Anthropological Sinica* 19: 98-103.

Roe, D.A. 1969. British lower and middle Palaeolithic handaxe groups. *Proceedings of the Prehistoric Society* 34: 1-82.

Roe, D.A. 1994. A metrical analysis of selected sets of handaxes and cleavers from Olduvai Gorge. In: M.D. Leakey & D.A. Roe (eds) *Olduvai Gorge, Vol. 5*: 146- 234. Cambridge: Cambridge University Press.

Rosenberg-Yefet, T., Shemer, M. & Barkai, R. 2021. Acheulian shortcuts: Cumulative culture and the use of handaxes as cores for the production of predetermined blanks. *Journal of Archaeological Science: Reports* 36: 1-16.

Rubio-Jara, S., Panera, J., Santonja, M., Pérez-González, A., Yravedra, J., Domínguez-Rodrigo, M., Bello, P., Rojas, R., Mabulla, A. & Baquedano, E. 2017. Site function and lithic technology in the Acheulean technocomplex: a case study from Thiongo Korongo (TK), Bed II, Olduvai Gorge, Tanzania. *Boreas* 46(4): 894-917.

Sánchez Yustos, P., Diez-Martín, F., Domínguez-Rodrigo, M., Duque, J., Fraile, C., Baquedano, E. & Mabulla, A. 2017. Diversity and significance of core preparation in the Developed Oldowan technology: reconstructing the flaking processes at SHK and BK (Middle-Upper Bed II, Olduvai Gorge, Tanzania). *Boreas* 46: 874–893.

Santonja, M., Panera, J., Rubio-Jara, S., Perez-Gonzalez, A., Uribelarrea, D., Dominguez-Rodrigo, M., Mabulla, A.Z.P., Bunn, H.T. & Baquedano, E. 2014. Technological strategies and the economy of raw materials in the TK (Thiongo Korongo) lower occupation, Bed II, Olduvai Gorge, Tanzania. *Quaternary International* 322: 181-208.

Santonja, M., Rubio-Jara, S., Panera, J., Pérez-González, A., Rojas-Mendoza, R., Domínguez-Rodrigo, M., Mabulla, A.Z. & Baquedano, E. 2018. Bifacial shaping at the TK Acheulean site (Bed II, Olduvai Gorge, Tanzania): new excavations 50 years after Mary Leakey. In: Gallotti, R. & Mussi, M. (eds) *The Emergence of the Acheulean in East Africa and Beyond. Vertebrate Paleobiology and Paleoanthropology*: 153-181. Cham: Springer.

Schick, K.D. & Toth, N. 1994. Early Stone Age technology in Africa: a review and case study into the nature and function of spheroids and subspheroids. In: R.S. & Ciochon, R.L. (eds) *Integrative Paths to the Past Paleoanthropological Advances in Honor of F. Clark Howell*: 429-449. New Jersey: Prentice Hall.

Sellet, F. 1993. Chaîne opératoire; the concept and its applications. *Lithic technology* 18(1): 106-112.

Semaw, S., Renne, P., Harris, J.W., Feibel, C.S., Bernor, R.L., Fesseha, N. & Mowbray, K. 1997. 2.5-million-year-old stone tools from Gona, Ethiopia. *Nature* 385(6614): 333-336.

Semaw, S. 2000. The world's oldest stone artefacts from Gona, Ethiopia: Their implications for understanding stone technology and patterns of human evolution between 2.6–1.5 million years ago. *Journal of Archaeological Science* 27: 1197-1214.

Semaw, S., Rogers, M. & Stout, D. 2009. The Oldowan-Acheulian transition: is there a "Developed Oldowan" artifact tradition? In: In: Camps, M., & Chauhan, P. (eds) *Sourcebook of Paleolithic Transitions*: 173-193. New York: Springer.

Semaw, S., Rogers, M. & Stout, D. 2013. Early Acheulian stone assemblages~ 1.7-1.6 Ma from Gona, Ethiopia. In: *International Workshop, The Emergence of the Acheulean in East Africa, Rome*. Rome: September 12-13, 2013.

Semaw, S., Rogers, M.J., Simpson, S.W., Levin, N.E., Quade, J., Dunbar, N., McIntosh, W.C., Cáceres, I., Stinchcomb, G.E., Holloway, R.L. & Brown, F.H. 2020. Co-occurrence of Acheulian and Oldowan artifacts with Homo erectus cranial fossils from Gona, Afar, Ethiopia. *Science Advances* 6(10): 4694.

Sharon, G. 2007. *Acheulian Large Flake Industries: Technology, Chronology and Significance*. Oxford: Archaeopress, British Archaeological Reports International Series 1701.

Sharon, G. 2008. The impact of raw material on Acheulian large flake production. *Journal of Archaeological Science* 35 (5): 1329-1344.

Sharon, G. 2009. Acheulian giant-core technology: A worldwide perspective. *Current Anthropology* 50 (3): 335-367.

Sharon, G. & Beaumont, P. 2006. Victoria West: a highly standardized prepared core technology. *Axe age: Acheulian toolmaking from quarry to discard. London: Equinox*: 181-200.

Sherwood, N.L. 2022. Lithic quality comparisons between Sterkfontein and Swartkrans in the Oldowan and Early Acheulean, South Africa. *South African Archaeological Bulletin* 76(215): 93-106.

Shipton, C. 2018. Biface knapping skill in the East African Acheulean: Progressive trends and random walks. *African Archaeological Review* 35: 107-131.

Shipton, C. 2020. The unity of Acheulean culture. In: Groucutt, H. (ed) *Culture history and convergent evolution*: 13-27. Cham: Springer.

Shipton, C., Clarkson, C. & Cobden, R. 2019. Were Acheulean bifaces deliberately made symmetrical? Archaeological and experimental evidence. *Cambridge Archaeological Journal* 29(1): 65-79.

Shott, M.J. 2003. Chaîne opératoire and reduction sequence. *Lithic technology* 28(2): 95-105.

Shott, M.J. & Weedman, K.J. 2006. Measuring reduction in stone tools: an ethnoarchaeological study of Gamo hidescrapers from Ethiopia. *Journal of Archaeological Science* 34(7): 1-20.

Shott, M.J., Lindly, J.M. & Clark, G.A. 2011. The epistemologies of different approaches to lithic analysis. continuous modelling of core reduction: Lessons from refitting cores from WHS 623x, an Upper Palaeolithic site in Jordan. *PaleoAnthropology*: 320-333.

Soressi, M. & Geneste, J.M. 2011. The epistemologies of different approaches to lithic analysis: The history and efficacy of the chaîne opératoire approach to lithic analysis: studying techniques to reveal past societies in an evolutionary perspective. *PaleoAnthropology*: 334-350. https://doi:10.4207/PA.2011.ART63.

Stout, D. 2011. Stone tool making and the evolution of human culture and cognition. *Philosophical Transactions of the Royal Society B* 366: 1050-1059.

Stout, D., Quade, J., Semaw, S., Rogers, M.J. & Levin, N.E. 2005. Raw material selectivity of the earliest stone toolmakers at Gona, Afar, Ethiopia. *Journal of Human Evolution* 48(4): 365-380.

Stout, D., Semaw, S., Rogers, M.J. & Cauche, D. 2010. Technological variation in the earliest Oldowan from Gona, Afar, Ethiopia. *Journal of Human Evolution* 58: 474-491.

Stratford, D.J. 2008. A study of newly discovered lithics from Earlier Stone Age deposits at Sterkfontein, Gauteng Province, South Africa. Unpublished MSc dissertation. Faculty of Science, University of the Witwatersrand.

Stratford, D. 2017. A review of the geomorphological context and stratigraphy of the Sterkfontein Caves, South Africa. In: Klimchouk, A., N. Palmer, A., De Waele, J., S. Auler, A. & Audra, P. (eds) *Hypogene Karst Regions and Caves of the World. Cave and Karst Systems of the World*: 879-891. Springer, Cham. https://doi.org/10.1007/978-3-319-53348-3_60.

Stratford, D.J., Bruxelles, L., Clarke, R.J. & Kuman, K. 2012. New stratigraphic interpretations of the fossil and artefact-bearing deposits of the Name Chamber, Sterkfontein. *South African Archaeological Bulletin* 67(196): 159-167.

Susman, R.L. 1991. Who made the Oldowan tools? Fossil evidence for tool behavior in Plio-Pleistocene hominids. *Journal of Anthropological Research* 47(2): 129-151.

Terradas, X. 2003. Discoid flaking method: Conception and technological variability. In: M, Peresani (ed) *Discoid Lithic Technology: BAR International Series* 1120: 19-32.

Texier, P.J. 1995. The Oldowan assemblage from NY18 site at Nyabusosi (Toro-Uganda). *Comptes Rendus - Academie Des Sciences, Serie II: Sciences de La Terre et Des Planetes* 320: 647-653.

Texier, P.J. & Roche, H. 1995. The impact of predetermination on the development of some Acheulean chaînes opératoires. In: Bermúdez de Castro, J.M., Arsuaga, J.L. & Carbonell, E. (eds) *Evolución Humana en Europa y los Yacimientos de la Sierra de Atapuerca, Vol 2*: 403-420. Valladolid Junta de Castilla y León.

Texier, P.J. 2018. Technological Assets for the Emergence of the Acheulean? Reflections on the Kokiselei 4 lithic assemblage and its place in the archaeological context of West Turkana, Kenya. In: Gallotti, R. & Mussi, M (eds) *The Emergence of the Acheulean in East Africa and Beyond. Contributions in Honor of Jean Chavaillon*: 33-52. Cham: Springer.

Thackeray, F., Gommery, D. & Braga, J. 2002. Australopithecine postcrania (Sts 14) from the Sterkfontein Caves, South Africa: the skeleton of 'Mrs Ples'?: news and views. *South African Journal of Science* 98(5): 211-212.

Tixier, J. 1956. Le hachereau dans l'Acheuléen Nord-Africain—Notes typologiques. *Congrès préhistorique de France. Compte-rendu de la XVème session Poitiers-Angoulême 15–22 juillet 1956*: 914–923.

Tixier, J. 2012. *A Method For The Study Of Stone Tools*. Luxembourg: Musée National d'Histoire et d'Art.

Tostevin, G.B. 2011. The epistemologies of different approaches to lithic analysis: Introduction. *PaleoAnthropology*: 293-296.

Toth, N. 1982. The stone technologies of early hominids at Koobi Fora, Kenya; An experimental approach. Unpublished PhD dissertation. University of California: Berkeley.

Toth, N. 1985. The Oldowan re-assessed. *Journal of Archaeological Science* 12: 101-120.

Toth, N. & Schick, K. 2019. Why did the Acheulean happen? Experimental studies into the manufacture and function of Acheulean artifacts. *L'Anthropologie* 123(4-5): 724-768.

Tryon, C.A., McBrearty, S. & Texier, P.J. 2005. Levallois lithic technology from the Kapthurin formation, Kenya: Acheulian origin and Middle Stone Age diversity. *African Archaeological Review* 22(4): 199-229.

Van Peer, P. 1992. *The Levallois Reduction Strategy*. Madison: Prehistory Press.

Van Riet Lowe, C. 1945. The evolution of the Levallois technique in South Africa. *Man* 45: 49–59.

Wentworth, C. K. 1922. A scale of grade and class terms for clastic sediments. *The Journal of Geology* 30: 377–392.

Wilkins, J. 2008. Prepared Core Technology at Kudu Koppie, South Africa and the Modern Human Behavior Debate. Unpublished Masters dissertation. Department of Archaeology, University of Calgary.

Wilkins, J., Pollarolo, L. & Kuman, K. 2010. Prepared core reduction at the site of Kudu Koppie in northern South Africa: temporal patterns across the Earlier and Middle Stone Age boundary. *Journal of Archaeological Science* 37(6): 1279-1292.

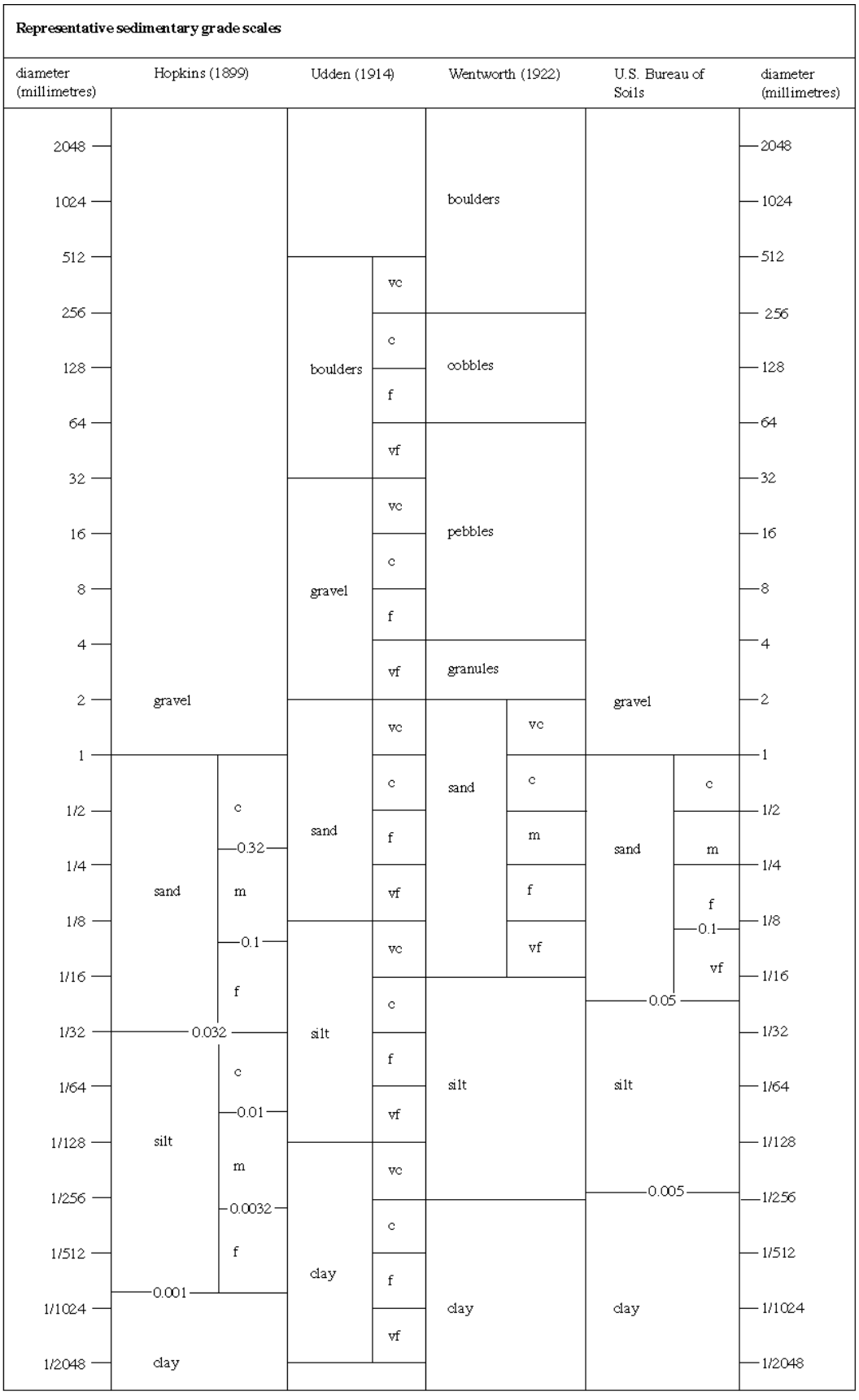
White, M. & Ashton, N. 2003. Lower palaeolithic core technology and the origins of the Levallois method in North-Western Europe. *Current Anthropology* 44: 598– 609.

White, M., Aston, N. & Scott, B. 2011. The emergence, diversity and significance of Mode 3 (prepared core) technologies. In: Ashton, N., Lewis, S. & Stringer, C (eds) *Developments in Quaternary Science, The Ancient Human Occupation of Britain* 14: 53-65.

Wynn, T. 1981. The intelligence of Oldowan hominids. *Journal of Human Evolution* 10(7): 529-541.

Wynn, T. 2002. Archaeology and cognitive evolution. *Behavioural Brain Sciences* 25: 389–438.

Appendix 1: Wentworth (1922) Scale



Appendix 2: Leader 2014 Table 5.2.2

Table 5.2.2 Three Acheulean Assemblages from Canteen Kopje Pit 6 Excavation.

Artefact Types	Prepared Core Technology Assemblage 210-410cm Layer B	Organised Core Assemblage 410-570cm Layer C & D	Basal Early Acheulean Assemblage 570-710cm Layer E
	Frequency (%)	Frequency (%)	Frequency (%)
Flake Types			
Whole Flake Toth Type 1	514 (6)	256 (4.6)	49 (4.6)
Whole Flake Toth Type 2	95 (1.1)	25 (0.4)	10 (0.9)
Whole Flake Toth Type 3	10 (0.1)	11 (0.2)	5 (0.5)
Whole Flake Toth Type 4	291 (3.4)	101 (1.8)	25 (2.3)
Whole Flake Toth Type 5	322 (3.7)	154 (2.8)	33 (3.1)
Whole Flake Toth Type 6	637 (7.4)	274 (4.9)	44 (4.1)
Core Trimming Flake	315 (3.7)	63 (1.1)	8 (0.7)
Flake - Indeterminable Info	1577 (18.3)	941 (16.9)	248 (23.1)
Blade	4 (<0.1)	0 (0)	0 (0)
Bipolar Flake	1 (<0.1)	0 (0)	0 (0)
Total	**3766 (43.8)**	**1825 (32.8)**	**422 (39.3)**
Flaking Debris			
Flake Fragment	3008 (35.0)	2487 (44.7)	322 (30)
Incomplete flake	182 (2.1)	64 (1.2)	4 (0.4)
Split Flake	16 (0.2)	3 (1.2)	0 (0)
Chunk	576 (6.7)	529 (9.5)	76 (7.1)
Chip	138 (1.6)	42 (0.8)	1 (0.1)
Blade Fragment	5 (0.1)	0 (0)	0 (0)
Split Cobble	20 (0.2)	34 (0.6)	2 (0.2)
Total	**3945 (45.8)**	**3159 (56.8)**	**405 (37.7)**
Other Tool Types			
Scraper	148 (1.7)	27 (0.5)	6 (0.6)
Denticulated/Notched Scraper	32 (0.4)	3 (0.1)	3 (0.3)
Heavy Duty Scraper	9 (0.1)	4 (0.1)	1 (0.1)
Flaked Flake	70 (0.8)	58 (1.0)	20 (1.9)
Convergent Scraper	2 (<0.1)	0 (0)	0 (0)
Roughout	26 (0.3)	12 (0.2)	3 (0.3)
Knife	14 (0.2)	1 (<0.1)	0 (0)
Hammerstone	1 (<0.1)	0 (0)	0 (0)
Uniface	1 (<0.1)	0 (0)	0 (0)
Bifacial Chopping tool	50 (0.6)	39 (0.7)	17 (1.6)
Total	**353 (4.1)**	**144 (2.6)**	**50 (4.6)**
Bifaces and LCT Flakes			
Pick	6 (0.1)	1 (<0.1)	1 (0.1)
Cleaver	76 (0.9)	39 (0.7)	18 (1.7)
Handaxe	35 (0.4)	30 (0.5)	7 (0.7)
LCT flake	52 (0.6)	17 (0.3)	7 (0.7)
Pick-like Handaxe	1 (<0.1)	2 (<0.1)	0 (0)
Total	**170 (2.0)**	**89 (1.6)**	**33 (3.1)**
Simple Core Types			
Boulder Core - Simple	7 (0.1)	1 (<0.1)	1 (0.1)
Casual Core	81 (0.9)	72 (1.3)	44 (4.1)
Chopper Core	39 (0.5)	22 (0.4)	10 (0.9)
Discoidal Core	17 (0.2)	23 (0.4)	6 (0.6)

Table 5.2.2. Continued.

Radial Core	14 (0.2)	6 (0.1)	4 (0.4)
Sub-radial Core	8 (0.1)	3 (0.1)	1 (0.1)
Sub-radial Core	8 (0.1)	3 (0.1)	1 (0.1)
Irregular Core	47 (0.5)	73 (1.3)	46 (4.3)
Polyhedral Core	32 (0.4)	46 (0.8)	11 (1.0)
Single Platform Core	7 (0.1)	2 (<0.1)	1 (0.1)
Core Fragment	35 (0.4)	42 (0.8)	13 (1.2)
Simple Large Surface Exploitation Boulder Core	8 (0.1)	16 (0.3)	11 (1.0)
Preferential Removal Core - Simple	3 (<0.1)	2 (<0.1)	4 (0.4)
Alternate Sequence Core	17 (0.2)	14 (0.3)	11 (1.0)
Total	**315 (3.7)**	**322 (5.7)**	**163 (15.2)**
Organised Core Types			
Asymmetrical Discoid	1 (<0.1)	2 (<0.1)	0 (0)
Asymmetrical with Preferential Removal	4 (<0.1)	8 (0.1)	0 (0)
Asymmetrical with Preferential Surface	5 (0.1)	3 (0.1)	0 (0)
Elongated Asymmetrical Exploitation	0 (0)	1 (<0.1)	0 (0)
Largest Surface Exploitation	12 (0.1)	12 (0.2)	1 (0.1)
Total	**22 (0.2)**	**26 (0.5)**	**1 (<0.1)**
Victoria West PCT Types			
Victoria West "hoenderbek"	30 (0.3)	0 (0)	0 (0)
Victoria West unstruck	3 (<0.1)	0 (0)	0 (0)
Total	**33 (0.3)**	**0 (0)**	**0 (0)**
Assemblage Total	**8604 (100)**	**5565 (100)**	**1074 (100)**

Appendix 3: Refinement Indices for Africa

From Kuman *et al.* (2016: 60)

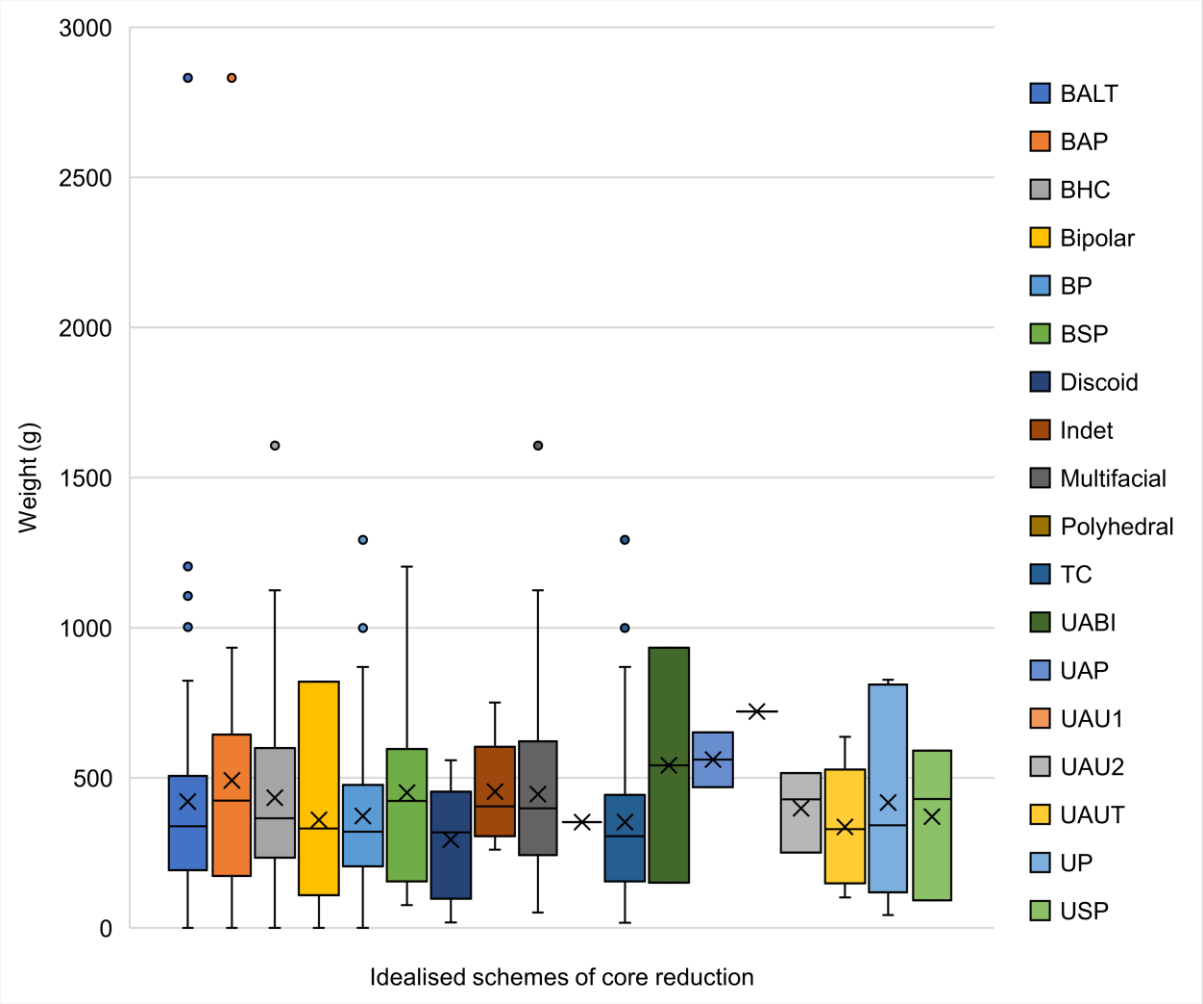
Metric and weight data available for handaxes in Africa, Western Europe and Asia. Measurements for Rietputs 15 have variable sample sizes because of breaks that particularly affected some tool measurements as these LCTs were retrieved from mining operations. The minimum ages published in Gibbon et al. (2009) are used as most accurate due to new statistical modelling available for cosmogenic nuclide burial dating (Gibbon, pers. comm.). The EF HR sample from Olduvai measured by Kuman was done in the Kenya National Museum in Nairobi in 2009 and not all handaxes were available. We, W and T in the sample size column stand for Weight, Width and Thickness. Weight is in grams and measurements in mm. References: A) Beyene et al. (2013); B) recorded by Kuman; C) Gibbon et al. (2009); D) Leakey (1971); E) Roe (1994); F) Kuman (1994); G) Kuman (1998); H) Field (1999); I) Leader (2013); J) Leader (2009); K) Petraglia and Shipton (2008); L) Potts et al. (1999); M) Marshall et al. (2002); N) Szabo et al. (1990); O) Norton et al. (2006); P) Huang (2003); Q) W. Wang et al. (2014); S.J. Wang et al. (2014); R) Wang (2007); S) Kuman et al. (2014); T) S.J. Wang et al. (2014).

Locality	Country	Age (Ma)	N	Weight			Thickness			Refinement Index (T/W)			References
				Mean	*SD*	*Median*	*Mean*	*SD*	*Median*	*Mean*	*SD*	*Median*	
Africa													
Konso KGA6-A1 Loc.C	Ethiopia	~1.75	4							0.41	0.13		A
Rietputs 15 Pit 1	So. Africa	1.72 ± 0.16	9				40.89	6.62	40.00	0.59	0.12	0.59	B,C
Konso KGA4-A2	Ethiopia	~1.6	19							0.55	0.13		A
Olduvai EF HR, Bed II	Tanzania	1.6	22W&T				46.91	10.25	45.5	0.56	0.15	0.51	B,D
Olduvai EF HR, Bed II	Tanzania	1.6	29	601.80	210.2								E,D
Sterkfontein	So. Africa	~1.6	10				47.00	9.51	47.50	0.63	0.13	0.61	B,F,G,H
Canteen Kopje basal EA	So. Africa	>1.5	7	402.90									I
Canteen Kopje EA	So. Africa	~1.5	30	399.70	225.2								I
Konso KGA 10-A11	Ethiopia	~1.45	16							0.53	0.10		A
Konso KGA7-A1,A2,A3	Ethiopia	~1.4	17							0.58	0.11		A
Rietputs 15 Pit 5 (A)	So. Africa	1.32 ± 0.21	74W/78T				42.00	9.70	40.00	0.53	0.10	0.52	B,C,J
Konso KGA 12-A1	Ethiopia	~1.25	30							0.54	0.15		A
Canteen Kopje Victoria W.	So. Africa	>1.0 Ma	35	618.00	108								I
Averages for available data, Early Acheulean				**505.60**			**44.20**			**0.55**			
Olorgesailie M1, FB	Kenya	0.99–0.97	15	180.87	116.11	137.00	34.60	8.44	33.00	0.60	0.14	0.56	K,L
Olorgesailie, M1, I3	Kenya	0.99–0.97	57	225.12	197.48	158.00	33.54	9.28	31.00	0.56	0.12	0.55	K,L
Olorgesailie M6/7, DE89A	Kenya	0.97–0.78	60	877.82	381.80	804.50	46.23	10.43	46.00	0.45	0.11	0.45	K,L
Olorgesailie M6/7, H9AM	Kenya	0.97–0.78	10	770.00	426.54	760.00	36.20	7.53	33.50	0.37	0.09	0.39	K,L
Grotte des Ours	Morocco	~0.4	40	390.40	133.39	383.00	43.81	6.79	43.60	0.57	0.10	0.55	M
STIC	Morocco	<0.7	82	704.68	292.96	677.00	54.64	10.64	54.50	0.59	0.12	0.56	M
Olduvai, Masek Beds	Tanzania	0.7–0.4	125	375.02	153.24	345.00	41.25	7.75	40.70	0.53	0.09	0.51	M
Elandsfontein	So. Africa	probably <0.6	232	355.54	250.65	302.50	40.13	11.19	38.75	0.53	0.10	0.52	M
Amanzi Springs	So. Africa	Middle Pleist?	133	751.41	356.82	730.00	53.69	11.22	53.40	0.58	0.10	0.57	M
Doornlaagte	So. Africa	probably >0.6	44	1147.93	527.55	1038.50	59.03	11.76	59.20	0.57	0.10	0.55	M
Averages for available data, Africa Acheulean ca 1.0 to 0.4 Ma				**577.88**			**44.31**			**0.53**			

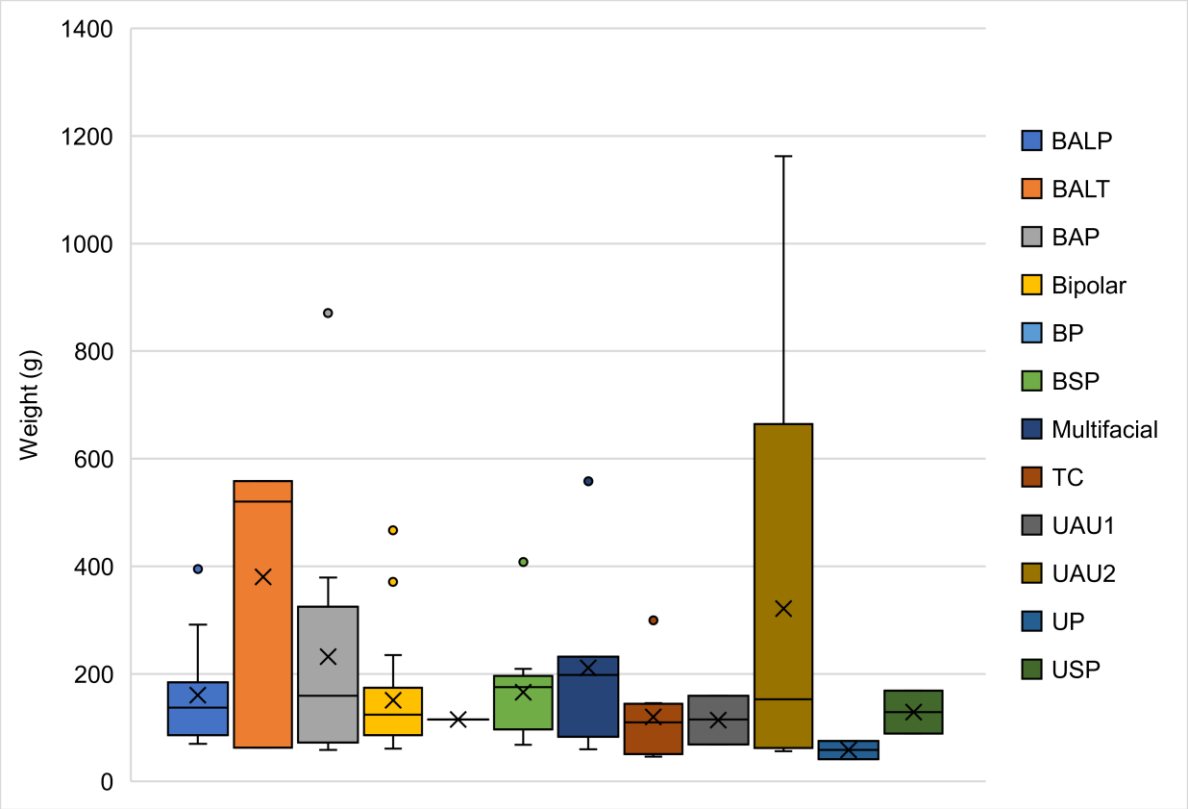
Appendix 4: Weight ranges of idealised schemes of core reduction

These are the weight ranges of individual idealised schemes, following the discussion in chapter 8.

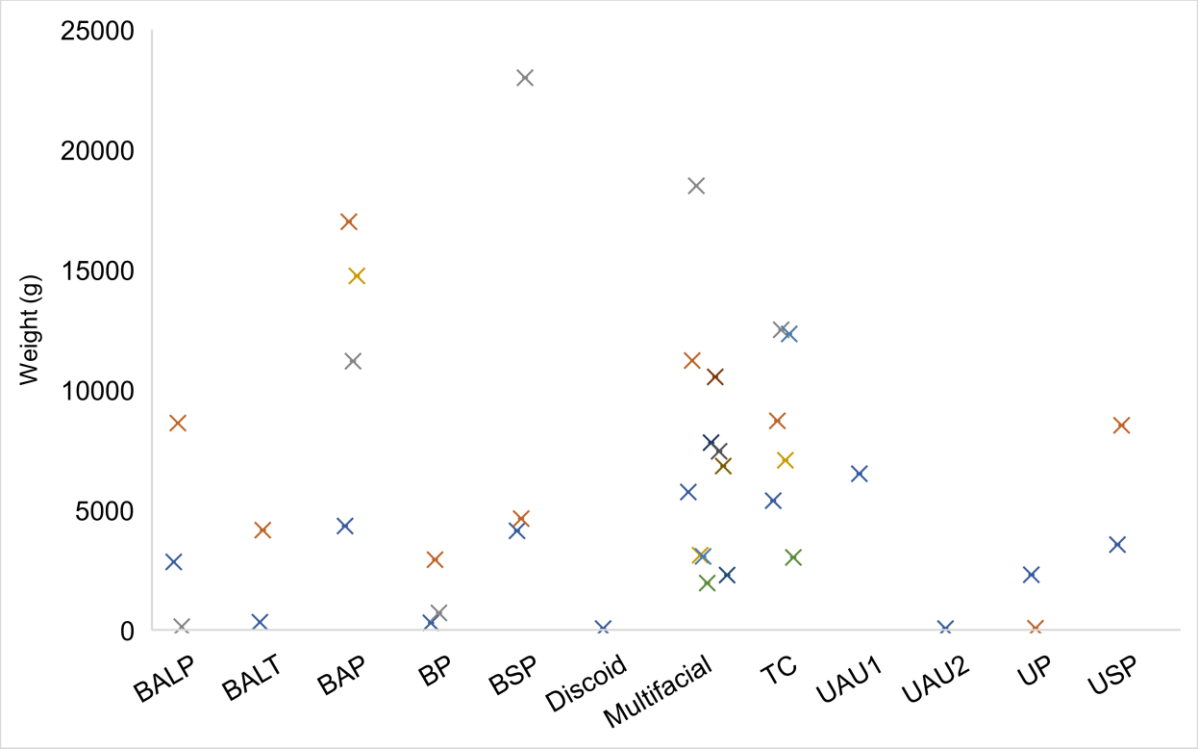
Sterkfontein



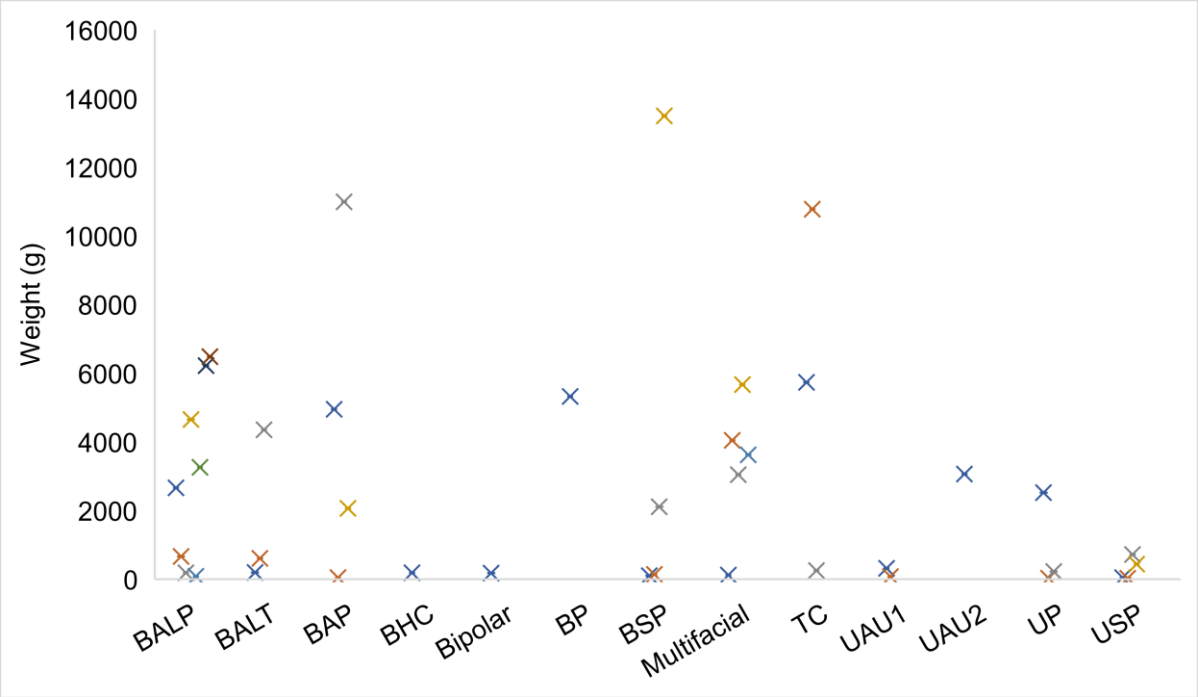
Rietputs 15 ACP



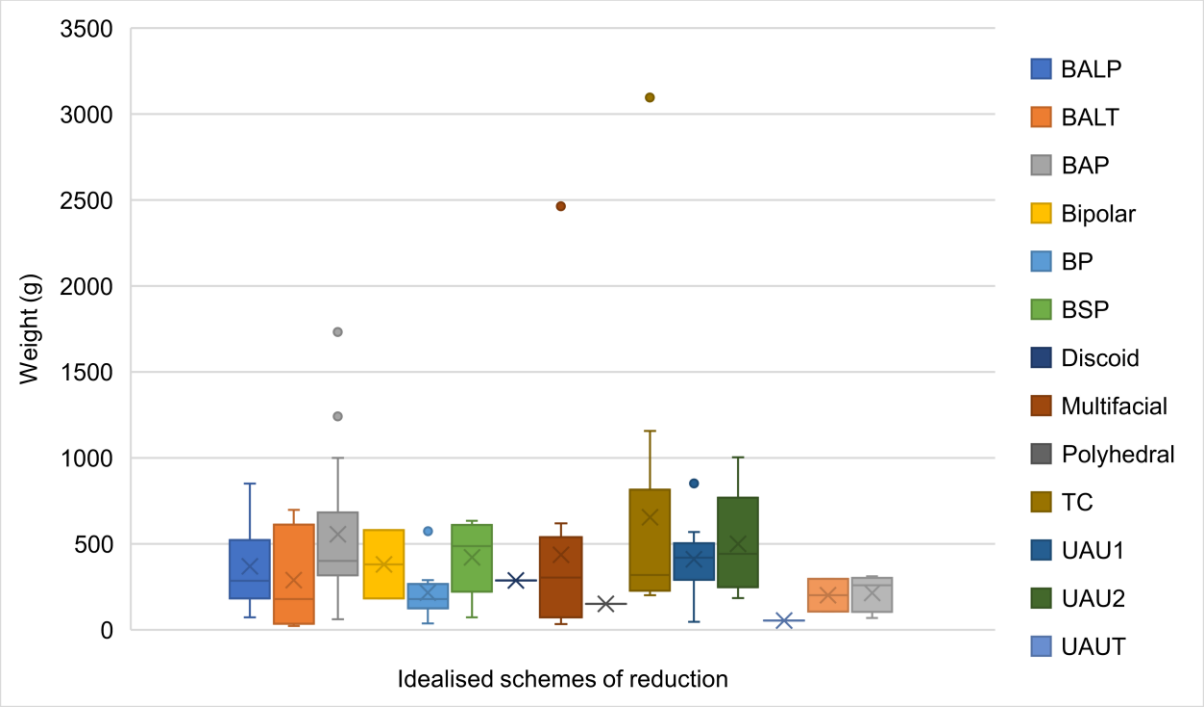
Canteen Kopje Basal Early Acheulean layer



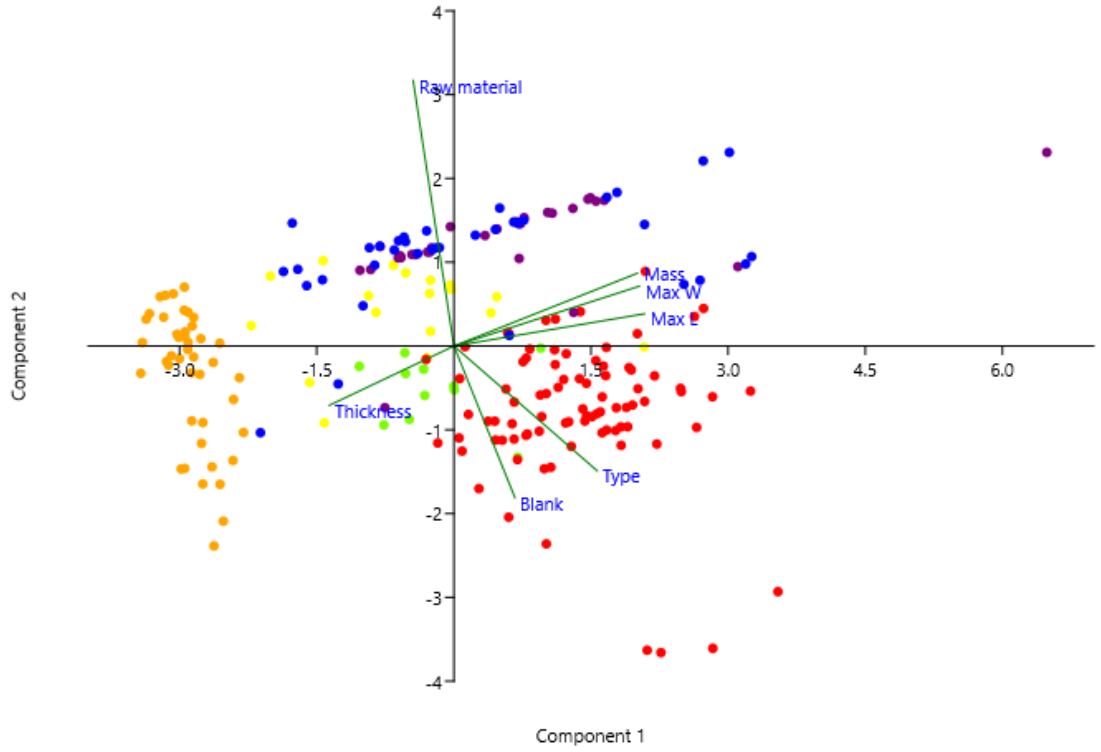
Canteen Kopje Organised Core Technology layer



EF-HR



Appendix 5: PCA of LCTs with Canteen Kopje assemblages



The Canteen Kopje Basal Early Acheulean layer assemblage is represented by the purple dots. The Organised Core Technology layer is represented by the blue dots.