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Community specialisation, standardisation and exchange in a hunter-gatherer society: a case study from Kalkadoon country, northwest Queensland, Australia.

By

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BSS (Hons)

Thesis submitted for the research degree of Doctor of Philosophy in the School of Anthropology, Archaeology and Sociology, Faculty of Arts, Education and Social Sciences, James Cook University.

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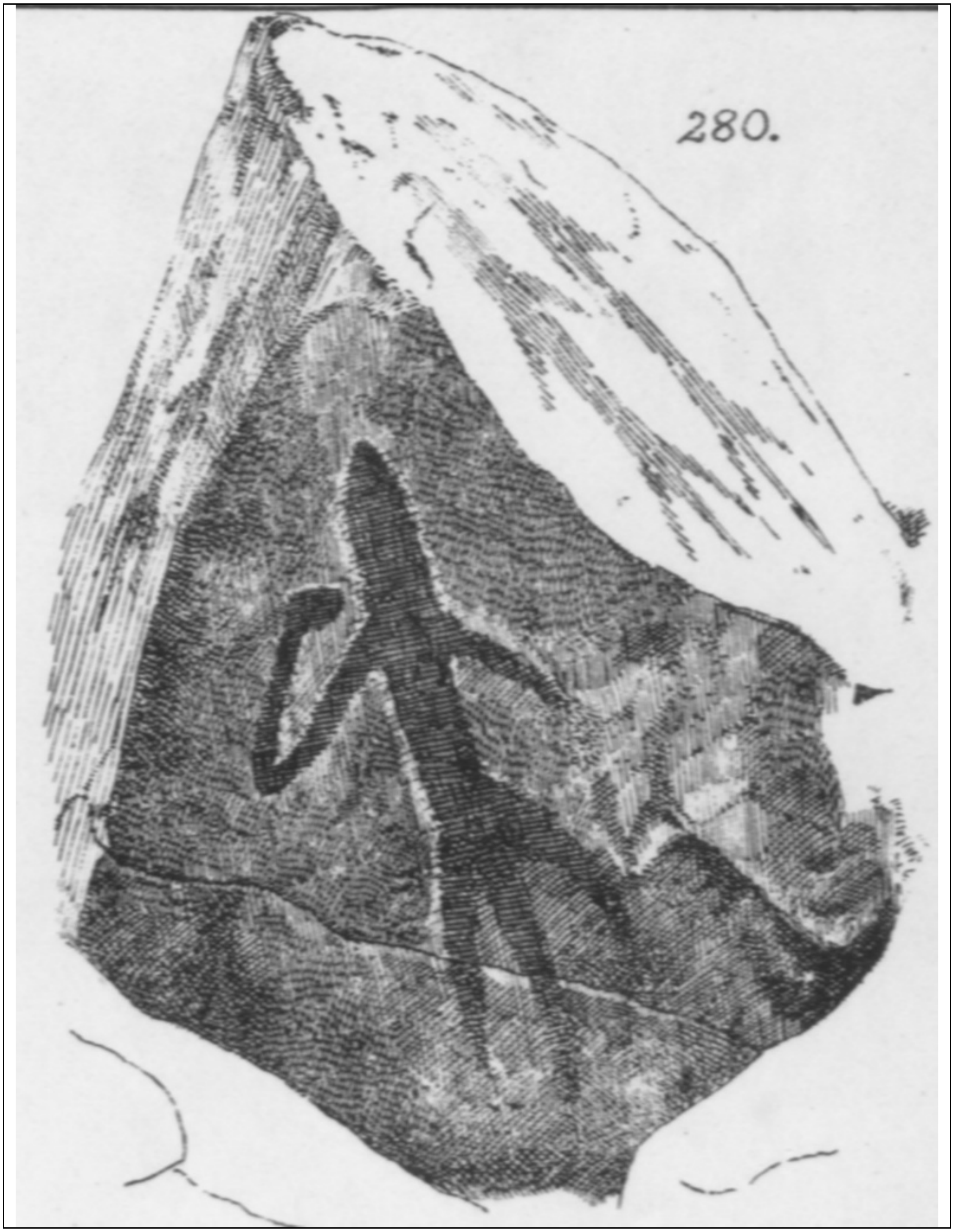

Kalkadoon figure with stone axe (from Roth 1904). This rock-painting is located on the border of Kalkadoon country near Cloncurry, northwest Queensland.

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Abstract

This thesis examines prehistoric Aboriginal production systems at Lake Moondarra, a major stone axe quarry in the semi-arid regions of northwest Queensland. At the time of contact with white settlers, the Kalkadoons, Aboriginal people from northwest Queensland participated in an expansive exchange network that spanned the continent from north to south (McCarthy 1939). When Roth (1896) was Superintendent of the Cloncurry and Boulia hospitals, his ethnographic studies left an excellent material record of northwest Queensland and he documented the presence of axe mining pits near the Bora Goldfield, present-day Lake Moondarra. Unfortunately, trade in stone axes had ceased by the time Roth recorded his observations.

Hiscock and Mitchell (1993:3) have suggested that contemporary researchers have neglected quarry studies due to the intrinsic difficulties involved in examining such sites. In addition, semi-arid regions present some difficulties for archaeologists as soil formation processes are minimal and increased erosion is caused by runoff during wet seasons. Nevertheless, the geology of Moondarra is unique and has left an indelible archaeological record that provides valuable insights into hunter-gatherer tool production, technology and society.

This thesis identifies the timing of the introduction of axe production for exchange at Moondarra as well as increases in axe production levels associated with the expansion of exchange networks in the region. Evidence for the standardisation of axe production is presented.

The thesis also challenges archaeological dogma that associates craft specialisation and standardisation with emergent complex societies, with the presentation of evidence that these also occur in hunter-gatherer societies.

The thesis also expands current archaeological distribution of large quartzite leiliras or macro-blades from Arnhem Land into northwest Queensland. Evidence suggests that

these may have been produced exclusively for exchange. Roth (1904) noted that ‘spear points’ (leiliras or macroblades) were obtained from Lawn Hill in northwest Queensland and exchanged at the Georgina River markets.

Current theory on the *organisation of technology* (Bamforth 1991, Binford 1979, Bleed 1986, Nelson 1991, Schott 1986, Torrence, 1989, 2002) is both critiqued and applied to explain stone tool procurement at Moondarra. The concept of *embeddedness* is confirmed in relation to subsistence tool-kits and rejected for axe and leilira blade production.

This thesis suggests that current theory of hunter-gatherer technology does not explain the full spectrum of hunter-gatherer behaviour in relation to artefact production. This may in part be explained by the specifics of ethnographic work in societies. (e.g. see Binford 1978, Lee 1976, Binford 1968, Gould 1968, Thompson 1949, Stanner 1933).

However, the arguments advanced here do not necessarily contradict previous studies. Rather, they are expanded by the suggestion that two models of production co-existed at Moondarra: an embedded production system for the subsistence tool-kit alongside a community-based specialised production system for the purpose of exchange. Both systems existed simultaneously. This alerts us to the simplicity of generalisations concerning Australian exchange systems and their relationship to ritual or ceremonial concerns. The extrapolation of anthropological and archaeological case studies to general interpretations by inferring similarities and ignoring differences in past Aboriginal behaviour can be misleading.

Acknowledgements

My first acknowledgement is to my academic supervisor Dr. Shelley Greer. She has provided me with continued support and encouragement, provided additional references to examine, commented on my field and theoretical approaches, read and advised on earlier drafts and was always willing to provide supervision. During the previous two years I was a remote student at James Cook University. Shelley’s ability to continue effective supervision of my PhD in these circumstances and her willingness to provide intense periods of supervision on visits to the University are very much appreciated.

Dr. Peter Veth was originally one of my supervisors and despite making a career move from James Cook University to the Australian Institute of Aboriginal and Torres Straight Islander Studies, he has continued to support me as a colleague and commented on the general outline of my theoretical approach to this research. Peter has provided me with intellectual support particularly in relation to some of the more complex issues involving Australian, Aboriginal archaeology in the arid zone.

Two other people to whom I owe special thanks are Mr. Richard Percy, Kalkadoon Elder, and Mr. Andrew Border, Cultural Heritage Manager, Environmental Protection Agency (EPA), Townsville. Over the past four years they have both acted in the role of cultural advisors to me.

Richard Percy has continually supported my PhD in meetings with the Kalkadoon Aboriginal Council (KAC) and was instrumental in obtaining the group’s permission to conduct research on the Lake Moondarra stone axe quarry. Richard has maintained this interest throughout my research was always willing to discuss how to approach issues and provided guidance in doing things the Aboriginal way. Andrew Border provided me with the opportunity to conduct a Conservation Plan for the Lake Moondarra site. This commission enabled the site to be surveyed and the impact of stock on the site to be comprehensively assessed. This introduction to practical Cultural Heritage Management and his subsequent advice on the roles of Archaeology and Cultural Heritage has

provided me with invaluable knowledge. Both Richard and Andrew have given me considerable support during the production of this PhD.

The Kalkadoon Aboriginal Council kindly gave permission for my research on Moondarra and participated in the Conservation Plan. In 2003, the National Trust, Queensland, recognized this collaborative approach to research between the KAC, the EPA and myself with the presentation of a Cultural Heritage gold award for excellence in works and actions.

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Clinton Percy and Roger Sullivan assisted during the site survey in preparation for mapping the site. This was extremely difficult work in hot conditions and to carry enough water for a summer’s day when temperatures often reached over 40 degrees and remain focused was sometimes challenging. Until we established the location of four-wheel drive tracks and sites in the area, finishing a day’s work with a two-hour walk back to the vehicle was always something we looked forward to.

Finally, my wife Susan supported my studies throughout the PhD. Her support and encouragement certainly enabled me to concentrate on the workload required in completing this research.

Publications, reports and conference papers associated with this thesis

Referred journals

Tibbett, K. 2002. Lake Eyre Basin: models of exchange. *Tempus, Vol. **7:**213-219.*

Tibbett, K. 2002. Archaeological analysis of stone axe exchange networks in the Lake Eyre Basin during the mid- to late Holocene. *Australian Archaeology, Vol **5:** 22-29.*

Tibbett, K. 2003. Hammer Dressed Stone Hatchets in the Lake Eyre Basin. *Archaeology in Oceania, Vol **3:**37-40.*

Tibbett, K. 2003. Risk and economic reciprocity: three regional food-sharing systems. *Australian Archaeology, Vol **57**:7-10.*

Tibbett, K. 2005. (Submitted) When east is northwest: expanding the archaeological boundary for leilira blade production. *Australian Archaeology.*

Non-refereed publications

Tibbett, K.E. and A. Border 2003. Lake Moondarra stone axe quarry. EQ Newsletter Issue 8 February 2003.

Unpublished Reports

Tibbett, K. E. and the Kalkadoon Aboriginal Council 2001. Results of the desktop study describing the cultural heritage values of the Lake Moondarra Stone Axe Quarry and its significance. Unpublished report to the Environmental Protection Agency (Qld) and the Natural Heritage Trust.

Tibbett, K. E. and the Kalkadoon Aboriginal Council 2001. Progress report: The Lake Moondarra Cultural Heritage Management Study. Unpublished report to the Environmental Protection Agency (Qld) and the Natural Heritage Trust.

Tibbett, K. E. and the Kalkadoon Aboriginal Council 2001. Final report: The Lake Moondarra Stone Axe Quarry. Unpublished report to the Environmental Protection Agency (Qld) and the Natural Heritage Trust.

Presentations at Conferences

December 2001. The Australian Archaeological Association's annual conference in Townsville, Queensland. This paper argued for increasing social complexity in Aboriginal society during the mid- to late Holocene.

December 2002. *Looking Forward, Looking Back*. (Presented with Mr. Andrew Border) At the Australian Archaeological Association annual conference at Jyndabyne, NSW. This paper is concerned with the importance of research in cultural heritage management plans.

December 2003 *Dual Procurement Systems in a Hunter-Gatherer Society*. At the Australian Archaeological Association annual conference at the University of New England, Armidale, NSW.

The search for a ‘forager technology’ or any technology defined only by a society’s food-getting habits, is unlikely to be fruitful, because material or tool manufacture is a resource in the same sense as are plants and animals: its nature and distribution fundamentally condition the ways in which it can be exploited. To understand technological organisation, we must examine these aspects of lithic resources in conjunction with the way in which humans are or were organised to satisfy their other needs. (D.B. Bamforth 1986:40)

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Chapter 1 Introduction

1.1 Introduction to the thesis

The Lake Moondarra stone axe quarry (herein called Moondarra) is a large complex of archaeological sites including quarries, mining pits, reduction floors and habitation sites, located in northwest Queensland. Descendants of the language group who mined the Moondarra basalt at the time of contact with settlers recognize themselves as Kalkadoons. This basalt quarry was the source of most of the stone axes provenanced to the Lake Eyre Basin (McBryde 1997, McCarthy 1939, Tibbett 2000) and is located between northern Australia where edge ground axe technology has been present for 35,000 years, and southern Australia where the oldest dates for this technology is 5,000 years (Morwood and Hobbs 1995).

This research employs intensive survey, excavation and other archaeological techniques to examine the quarry complex. It focuses on defining the commencement of stone axe manufacturing at the site, changes in the intensity of site use and the social, cultural and technological organisation of the prehistoric Aboriginal miners and traders. The survey was the basis for a spatial analysis of quarries and reduction floors, providing insights into the relationship between these. Excavation of Aboriginal mining pits and reduction floors provided comparative data aimed at detecting changes in production methods, and the intensity of site use.

I propose that intensive production of stone axes at Moondarra was undertaken as part of an extensive exchange system and that this provided the economic stimulus for specialised production resulting in a standardised technology. This analysis of Moondarra Aboriginal axe production, particularly the technical methods used (after *organisation of technology* in Bamforth 1991, Binford 1979, Bleed 1991, Nelson 1991, Shott 1986, Torrence 1989) suggests that the hunter-gatherer exchange system that operated within this semi-arid environment was more complex than generally is recognised.

The notion of a mobile hunter-gatherer society applying intensive production using specific routines to produce standardised size axes apparently tests Torrence (1986:82-3), who stated that an element of commercialisation is required before standardisation in production occurs. Hiscock's (forthcoming) demonstration of standardised axe production at Moondarra may be interpreted as challenging Torrence's (1986) association between standardisation and commercialism. He cites Allen (1984, 1985) and Burton (1984) as case studies where intensive production for exchange has occurred within egalitarian societies, suggesting that Moondarra provides further evidence of this.

This thesis argues that a high level of uniformity in reduction techniques or relative homogeneity and standardisation in the size of axes occurred at Moondarra, and advances the argument that commercial exchange systems may have existed in some Australian hunter-gatherer societies. Technological standardisation is based on metrical analyses for axes produced at three sources. It is suggested that Hiscock's (forthcoming) idea of standardised production in an egalitarian society, and Torrence's (1986, 2002) suggestion that standardisation occurs in conjunction with commerce might not be diametrically opposed. This research argues that two procurement systems operated simultaneously at Moondarra. First, an embedded production system existed for re-provisioning the subsistence tool-kit, and second a specialised procurement system operated to purposely produce goods for exchange. The subsistence tool-kit describes tools used to the satisfaction of basic or primary needs and is not related to the surplus production of artefacts.

Progressive or intensification theories that argue for increasing complexity in mobile hunter-gatherer social organisation are not explicitly discussed here. However, it is suggested that specialised and standardised production systems, usually considered to be indicators of cultural complexity can exist in mobile hunter-gatherer societies. Hunter-gatherer social systems might be capable of becoming increasingly complex, without aligning with a trajectory that leads to agriculture (see Rowley-Conway 2001).

1.2 Research questions, aims, methods and theoretical issues in this thesis

1. To determine the nature of all archaeological sites at the Moondarra complex including any that may not have been directly the result of axe quarrying and manufacturing activity.

2. To examine the techniques and processes used to manufacture axes at Moondarra.

3. To establish what mining techniques were used at the site and to examine whether specialisation was practised in terms of axe quarrying and manufacturing.

4. Establish a temporal framework for the site to determine whether change in production occurred over time. This was based on discard densities, any changes in artefact size and variations in assemblage composition.

5. Examine recent *organisation of technology* theory in the light of the archaeological evidence for technological methods used in the production of axes at Moondarra.

The mammoth size of Moondarra in combination with the range of activities conducted at the site made it extremely complicated to analyse. The research design for this dissertation had to be thoroughly considered before fieldwork commenced. The sheer quantity of cultural material at the site made it extremely difficult to interpret, but a structured approach to research questions provided invaluable data for understanding hunter-gatherer material culture.

1.3 Structure of the Thesis

To comprehend the limitations, possibilities and rhythms that environmental factors impose on hunter-gatherer social organisation it is necessary to understand the physical environment of the study area. Chapter 2 describes the study area and its environmental characteristics focussing on geology, topography, soils, vegetation, fauna, the palaeoenvironment, rainfall land systems and land use. This assessment is significant to the discussion, in relation to issues such as embeddedness, time stress, hunter-gatherer mobility, raw material availability and specialisation. ‘Embeddedness’ is a term used by Binford (1979) to describe the procurement of subsistence tools in hunter-gatherer societies. He argued that subsistence tools were procured in association with other activities Binford (1979). Chapter 2 Moondarra also introduces the Kalkadoon people who are the traditional owners of the northwest Highlands. It outlines their history particularly during the early years of contact and suggests that the Kalkadoons were a resourceful group who initially withstood the encroachment of settlement.

The third chapter places Moondarra within the context of research at stone axe quarries and stone artefact distribution in Australia. It commences with a review of the social context of distribution and distributional studies in Australia. The focus then moves to an examination of known chronology of edge-ground stone axe technology in Australia followed by an appreciation of the complexities involved in archaeological research at quarries. The following part of this chapter reviews past research at Moondarra including Brayshaw (1989), Hiscock 2005, Innes (1991), Simmons (1991), and Tibbett (2000). In addition, interpretations of practical and prestige exchange, risk and technology, exchange, raw materials, curation and time stress that are relevant to this thesis are also presented.

Chapter 4 describes the methods and approaches used in the thesis. It discusses aspects of site identification, surveying techniques, debitage classification and definitions used are also discussed (see Glossary for additional detail). The constraints and conditions set by the Kalkadoon Aboriginal Council (KAC) and the impact these had on my research methods at the site are also discussed.

The main empirical chapters (Chapters 5 to 10) are presented as a series of related yet independent results of the archaeological work undertaken at Moondarra. Chapter 5 provides a spatial analysis of all archaeological sites at Moondarra including those not directly related to axe quarrying and manufacturing. Surveying the complex was extremely important, as individual sites had not previously been mapped. This analysis was foundation for understanding past quarrying behaviour at the site and the inter-relationship between different activity areas.

Broad descriptions of 32 sites located during the survey are presented. These are described in relation to the activities undertaken, with vegetation types, the impacts of development including cattle grazing, stock routes and roads, mining activities, and the construction of Lake Moondarra itself. The site is compared to other stone axe quarries in northwest Queensland, (e.g. Gunpowder) and the United Kingdom where similar survey methods have been applied to establish the spatial boundaries of stone axe quarries. This comparative analysis is designed to demonstrate how Moondarra compares spatially to large axe quarries in Australia and the United Kingdom.

Chapter 6 discusses a range of techniques used at Moondarra including Aboriginal mining and excavation, axe production and techniques to break large boulders. Roth (1904) suggested that firing blocks of basalt may have occurred at the site, but he cautioned that settlers had not witnessed this behaviour while firing has been frequently reported as a method of breaking quartzite blocks (Paton 1994, Elkin 1948, Jones and White 1988, Thompson 1949) at quarries, it seems that percussion and wedging were the methods used at Moondarra. A generalised reduction sequence for axes is outlined and these categories are linked to different stages in the manufacturing process. Archaeological evidence is presented to suggest that both axes and trimming flakes reduce in the size with progressive stages of reduction compared with earlier stages.

Chapter 7 focuses on archaeological excavations at the reduction floors known as R3 and R4. It commences with a comprehensive evolutionary history of landforms at both sites so that pre and post-depositional factors can be interpreted. The geographical setting and raw materials found at both sites are summarized to provide an understanding of the relationships between these reduction floors and basalt quarries.

The chapter continues with a descriptive analysis of surface and sub-surface artefacts to establish whether there are temporal changes in discard rates, temporal changes in the percentages of artefact types and any variation in artefact size at the site. Fluctuations in flake discard rates may demonstrate variation in intensity of site use, changing composition in artefact raw material may reflect changes in site use and variation in flake size may possibly suggest changes in artefact reduction technology.

Chapter 8 defines axe production at Moondarra. It commences with an estimation of the number of axes produced at the site, and an empirical and theoretical analysis of platform variables on the axe trimming flakes to estimate the fracturing predictability of Moondarra basalt. The chapter continues with an analysis of dates obtained from the three excavations, which may reveal how axe production expanded across the complex and incorporated new methods of quarrying. Dating the site and a geological assessment of northwest Queensland appears to suggest that Moondarra is not associated with the transfer of stone axe technology from the Kimberleys or Arnhem Land to southeastern Australia. Finally, an argument for changing penetrability is advanced to interpret the effects of cattle trampling at R3.

Chapter 9 interprets the presence of leiliras at Moondarra. The ethnographic and archaeological evidence for these large blades is examined and the archaeological distribution of these stone tools in Australia is significantly expanded. It is also proposed that artefact length may be used to determine the difference between these two classes of blades at Moondarra.

Chapter 10 was inspired by Hiscock’s (forthcoming) work on standardisation in both technology and production. at Moondarra. Innes (1991) also examined standardisation in production at Moondarra. This chapter explains definitions of standardisation and expands on Hiscock’s (forthcoming) analysis utilizing some 486 axes provenanced to

Moondarra, Boulia, Glenormiston and the northwest of New South Wales to assess levels of standardisation. The coefficient of variations for Moondarra axes suggests a high level of standardisation. This established a benchmark for axes produced for exchange. This process enables the degree of standardisation for axes produced primarily for exchange to be compared with those produced for own use. Both systems produce axes that are used as functional or subsistence tools (functionality can be detected from the wear patterns on axes in museum collections and those discarded in the Mt Isa district). However, this method determines the difference between optimal standardisation in the production of subsistence artefacts for own use and functional (and possibly intrinsic ceremonial value) produced primarily to meet the demands of market exchange. Associated with these evaluations are arguments involving the number of knappers involved in the production process and craft specialisation.

Chapter 11 is a discussion on dual production systems in hunter-gather societies. The chapter commences with an examination of hunter-gatherer procurement systems, which have concentrated on the economics of the subsistence tool-kit. This thesis argues that at Moondarra, axes were produced *primarily* for exchange, and macro-blades were produced *exclusively* for exchange. It is proffered that embedded procurement (after Binford 1979) is emphasised in the subsistence tool-kit, and specialised procurement for exchange is demonstrated by production for exchange.

This thesis proposes that the degree of complexity in axe production indicates that goods were being produced for a competitive market, rather than ceremonial exchange to obtain desired social and/or utility goods as suggested by Thompson 1949 and Stanner 1933. A more competitive or economic approach is not intended to be purely functional, diminishing the significance of Aboriginal ceremony and ritual in the transaction process, or ignoring the issue that some axes are clearly produced as ceremonial objects (see Altman 1982, Brumm 2000, Tacon 1991). However, the exchange relationship between axes, grindstones, ochre, shells, fishing nets, spears, coolamons, tulas, stone knives, spearpoints, ceremony and ritual, and in particular the narcotic pituri may indicate that a great deal of planning and effort was invested in producing goods for exchange. The effects that pituri had on exchange systems in northwest Queensland may result in an *extreme* case study in Australian archaeology, but as Binford (1979:255) argues, these extreme instances promote “an appreciation of variability *between the extremes* better than does an understanding of a *modal* case” (Binford 1979:255).

Arguments are also formulated suggesting that standardisation in technology might produce axes of known quality in the mindset of both the trader and receiver, by establishing a benchmark for quality and expected value of the produced item. These inherent values may have been become more important for down-the-line transactions.

Chapter 12 summarizes the major arguments presented in the thesis and in particular emphasises the degree of standardisation in hunter-gatherer axe production and the implications of this analysis for an understanding of prehistoric procurement systems.

Chapter 2 Land and People: background

2.1 Introduction

This research explains how Aboriginal people at the Lake Moondarra Stone Axe Quarry utilised their labour and natural resources to produce stone axes. The descendants of these ancient miners identify themselves as Kalkadoon people in English and Kalkatungu in their native language (Blake 1969). The quarry lies in the heart of Kalkadoon country (Native Title Claims QC 99/32 A and B).

To comprehend the limitations, possibilities and rhythms that environmental factors set on hunter-gatherer social organisation, it is necessary to understand the physical environment of the study area. The first part of this chapter describes the study area and its environmental characteristics focussing on geology, topography, soils, vegetation, fauna, palaeoenvironment, rainfall land systems and land use. This is followed by a summary of late 19th century Aboriginal history of the early years of contact. This review suggests that the Kalkadoons were a resourceful group that initially withstood the encroachment of settlement.

2.2 The study area

The study area focused on the Lake Moondarra area is located in the Upper Leichardt River catchment about 20km north of Mount Isa (Figure 2.1). The site is on a pastoral lease held by Calinta Holdings, a subsidiary of Estrata (formerly Mount Isa Mines). Mt Isa is situated in northwest Queensland, 1811km from Brisbane, 887km west of Townsville by road and 129km east of the Northern Territory border (Figure 2.1). Moondarra is situated to the east of Stone Axe Creek (Figure 2.2), a tributary of the Leichardt River, which has been dammed to form the lake. Brayshaw (1989) and Innes (1991) suggested that the site with an area of eight square kilometres, is the largest known stone axe quarry in Australia.

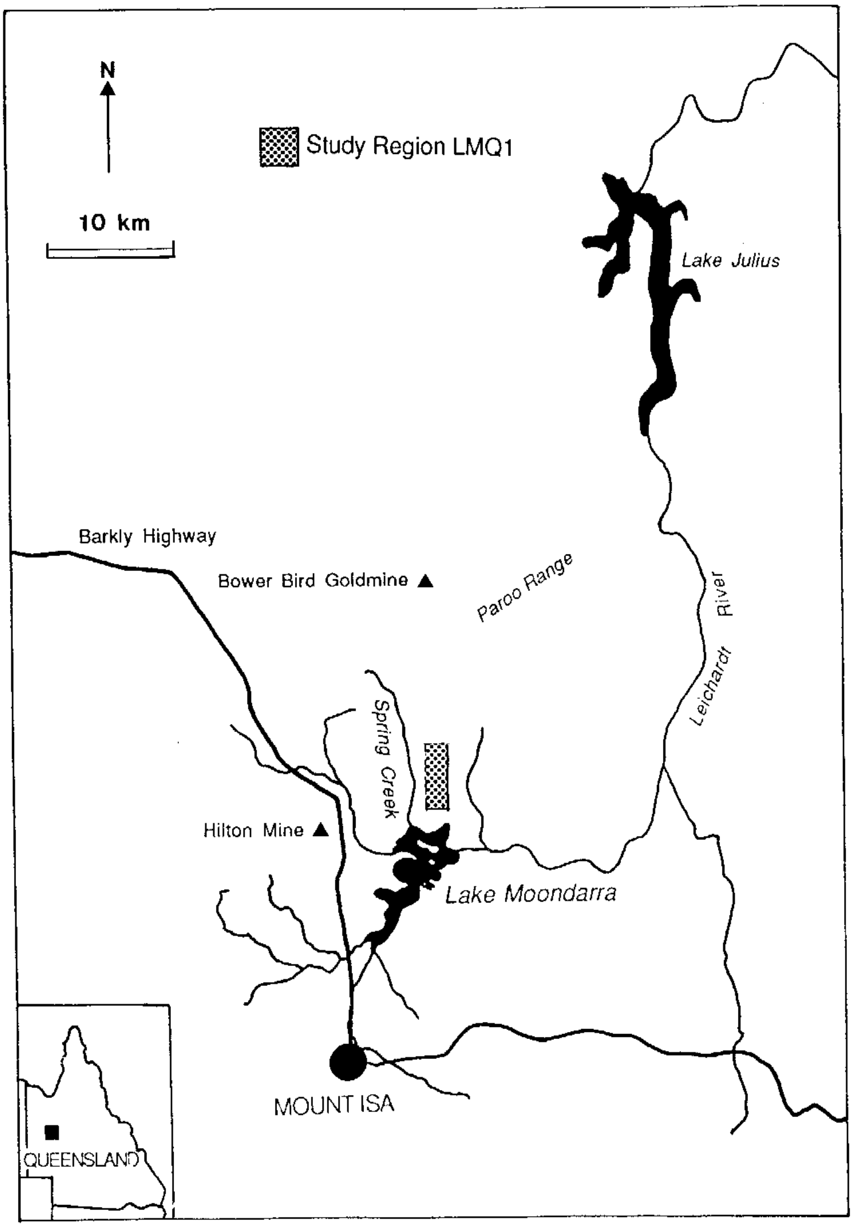


Figure 2.1. Lake Moondarra stone axe quarry (from Innes 1991:1).

2.3 The natural environment

An understanding of the natural processes that have impacted on the environment in the past and how pastoral and mining might have affected these, is the first step to understanding recent changes that have occurred at the site. Moondarra and associated archaeological sites were formed under certain environmental conditions. More recent changes to the natural environment have almost certainly increased water runoff and are possibly damaging the sites. Land use in the study region has changed dramatically since the 1860s when pastoralism first impacted upon the natural environment.

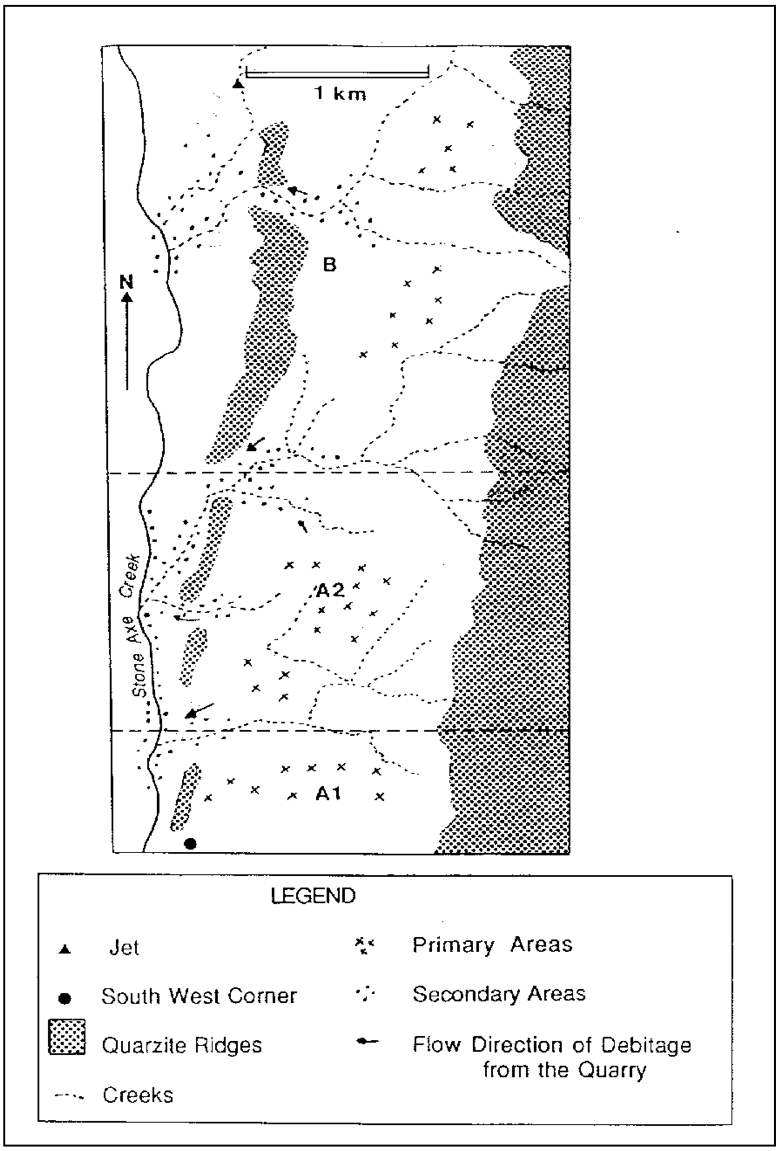


Figure 2.2. Outline map of Moondarra (from Innes 1991:37).

Mining operations and mineral exploration are generally localised in the landscape and have minimal effect on the site. Nevertheless, the close proximity of Moondarra to the artificial Lake Moondarra has increased cattle stocking rates across the site with the presence of permanent water and improved pastures. Higher stock holdings and mining have to some degree impacted on the natural environment of the site. The impact of these will be interpreted in subsequent chapters.

2.4 **Geology**

Geologically the study area is part of the Mount Isa Inlier formation that consists of ancient Palaeozoic rocks with volcanic intrusions (Horton 1976:6). The Mt Isa Inlier is a structural unit in the northwest of Queensland. From the time of the major shifts in the Lower Proterozoic period (1600-1800 million years ago) the area has been above sea level (Horton 1976:6). The wide range of rock types and minerals is due to very complex system of faulting, which continued over long periods of time. Figure 2.3 shows the Precambrian rock outcrops of northwest Queensland. The Kalkadoon Native Title Claims encompass the southern part of these ancient rock formations (Native Title Claims QC 99/32 A and B), which stretch for 450 km south to north (latitude 22 degrees South to 19 degrees South) and spread 120km east to west 140 degrees (50 minutes East to 138 degrees East).

The oldest rocks in the Mount Isa Inlier are in the north-trending Leichardt Block which contain acid and basic meta-volcanics and minor arenaceous meta-sediments that have been faulted, folded and intruded by acid plutons and several intersecting swarms of dolerite dykes. The western fold belt containing metamorphosed arenaceous and basic rocks are overlain by a pelitic and dolomitic sequence, which is host to the major copper and stratiform silver-lead zinc deposits at Mt Isa (Queensland Resource Atlas 1976:35).

Eastern Creek Volcanics is a colloquial geological term used to describe the unique rock formations that comprise the Mt Isa Inlier. The eastern belt of the Mt Isa Inlier on which the Lake Moondarra quarry is sited contains a structurally complex sequence of basic meta-volcanics, quartzite, jaspilite, calc-silicate rocks, slate, schist and gneiss (Queensland Resource Atlas 1976:35). Large areas have been metamorphosed with more resistant metamorphosed volcanic rocks and quartzites stabilising within the higher ridges.

The uplands show an approximate north-south pattern, following the underlying strike of the metamorphic rocks. In other places, older sedimentary rocks overlie the metamorphic strata and it is here that the silver and lead is found in the Mt Isa shale (Queensland Resource Atlas 1976:21).

Aboriginal people have quarried the ancient rock formations of the exposed meta-basalts on the ridgeline to the east of Stone axe creek (Figure 2.2). They obtained both fine and coarser-grained basalts from the ancient formations (Tibbett 2000). Three broad grain size categories are recognised by Bishop *et al*. (1999:149). Fine-grained averages less than 0.1mm, medium-grains less than 0.2mm and are recognisable by the naked eye, and coarse-grains that average more than 0.2mm. Pickwick basalt and greenstone are other terms that refer to the type of basalt used in axe production.

The field relationship between rocks that are similar, but which have different grain sizes must be considered so that stone axes that were once exchanged from Lake Moondarra can be correctly sourced. Both rock types form in lava flows and the thickness of the lava flow directly results in different granular formation (Bishop *et al*. 1999:17). At Moondarra, both types of basalt were quarried in close proximity to each other. The larger grain size of the dolerite does not result in less plasticity, but the larger grains can result in chipping on the edge ground bevel when force is applied to the stone axe. Both rock types were used, but the finer-grained basalts were the dominant type of rock used to manufacture the edge ground stone axes.

The basalts from Mt Isa have the capability to withstand the repeated application of physical force that makes it suitable for use as stone axe heads. Conversely, the geology of the surrounding areas are comprised of sedimentary rocks (Atlas of Australian Resources 1980) which Horne and Aiston (1924) suggested were brittle and unsuitable for stone axe manufacture. These sedimentary rocks extend north into the Gulf of Carpentaria and western Cape York, east into the black-soil plains and south into the expansive Lake Eyre Basin. These brittle sedimentary rocks that surrounded the northwest highlands suggest that high quality Moondarra axe heads might have been in high demand in Aboriginal prehistory.

The edge-ground stone axes at Lake Moondarra were manufactured from Pickwick metabasalt (Hiscock 2005, Innes 1991, Tibbett 2000), an abbreviation of the words metamorphic and basalt. Another term used widely in the literature to describe axes from Mt Isa is greenstone. Some geologists refer to Mt Isa basalts as Eastern Creek Volcanics but this is a general definition of basalt types and includes rocks not used in axe production.

The field relationship between the fine and medium grained basalt should be considered to explain why they occur in close proximity to each other. Both metabasalts and metadolerites can form in narrow dykes and sills (Bishop *et al*. 1999: 173-75) and lava flows (Bishop *et al*. 1999:175). This field relationship means that the two different granular textures can arise from the same source, depending on the thickness of the lava. The varied granular textures of these two rocks do not necessarily denote different quarry sites, but possibly different areas on the same site. Binns and McBryde (1972:44) and Whittow (1984:53) considered it appropriate to group the coarser grained dolerite as basalt. The axes at Lake Moondarra are all manufactured from basalt, however hand specimen tests can readily identify at least four colours of this fine-grained greenstone basalt. Different coloured basalts occur at particular areas on the quarry.

2.5 Topography

The ancient rock formations that form the rugged landscape in the northwest highlands are its most visible topographic feature. As erosion has weathered the landscape over the last 1800 million years the rock formations on some ridges have been exposed (Armstrong 1981:42). Figure 2.3 shows the extent of the Precambrian rock outcrops. The hill country stretches for 450 km south to north and spreads 120km east to west.

The Precambrian Ranges contrast with the surrounding low-lying regions. These comprise grass plains to the east and west, the Gulf country to the north and the arid Lake Eyre Basin to the immediate south. The steeper slopes of the Mt Isa Inlier are a mixture of rounded and rugged hills having large areas without soil cover, gorges, and narrow winding valleys. These steep rocky slopes result in high rates of runoff into the waterways during the wet season (Horton 1976:5). The main streams flowing in a northeasterly direction to the Gulf of Carpentaria are Gunpowder Creek and the Dugald, Leichardt and Corella Rivers (see Figure 2.3). Numerous smaller tributaries drain southwest from the northwest highlands into the Georgina River, that flows southwards into the Lake Eyre Basin.

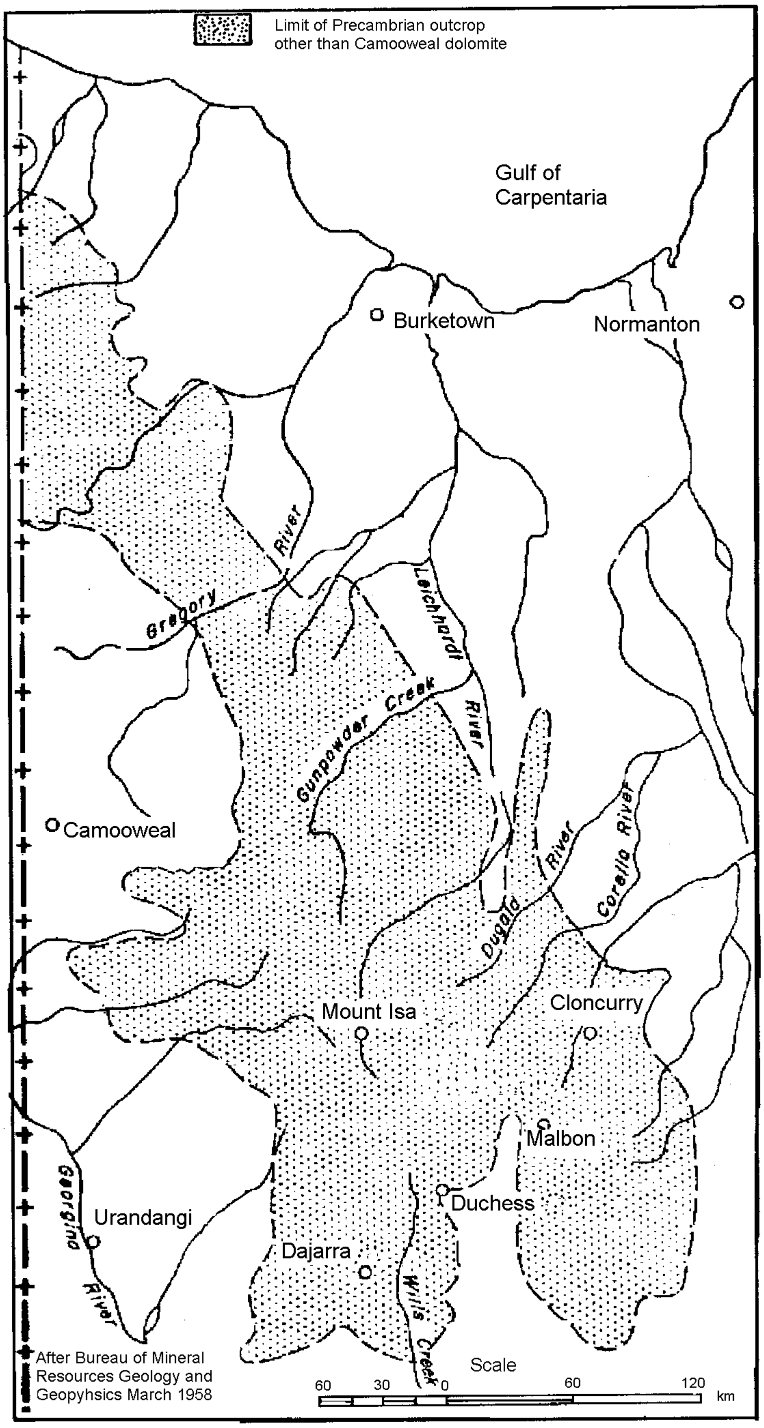


Figure 2.3. Precambrian ranges northwest Queensland (from Horton 1976:7).

2.6 **Soils**

The two dominant soils in the Mount Isa region are lithosols and red-earths. The Queensland Resource Atlas (1976:40-41) describes lithosols as shallow stones or gravelly soils lacking profile differentiation. The red-brown earths are texture contrast soils with a weakly structured loam to clay-loam surface, and shallow, bleached-red duplex soils, generally alkaline in reaction. Adjacent to the rock outcrops are shallow, gravelly loams while loamy red earths of greater depth occur on creek beds and flats. Plate 2.1 shows the eastern side of Stone Axe Creek and clearly illustrates the red-brown loamy soils. This soil type occurs on flatter parts of the landscape where the velocity of the water runoff slows thereby dropping the suspended load eroded from the higher ground and creating an alluvial flat. In summary, the Mt Isa district is best described as hard, broken, rocky country with thin lateritic soils.

2.7 **Flora**

The Australian Heritage Commission Interim Biographic Regions Report (1995) identified Mt Isa and the surrounding ranges as the Mount Isa Inlier. The semi-arid hill country of Mt Isa has an extremely wide range of flora. As the hills rise, spinifex (*Triodia pungens*) the dominant native pasture and snappy gums (*Eucalyptus brevifolia*) are widespread. The pastures are ‘native’ (endogenous) which in Queensland is defined as natural vegetation that has not been fertilised and is grazed by domestic stock (Burrows *et. al.* 1988:1). Tree height varies from 4.5m to 12m and much of the region is covered by open woodland. The northern part of the region receives increased rainfall compared with Mt Isa. This variation is noticeable 30km to 40km north of the city where more species of tropical plants grow (Horton 1976:16). Moondarra is about 20km due north of Mt Isa.

Hundreds of shrubs, creepers and low growing herbs and grass species make up the vegetation types in the region (Horton 1976, Wilson 2000) and Roth (1901 Bulletin 8:9) documented that the Aboriginal diet in northern Queensland comprised 240 plant species. When grazing pressure is increased markedly in the northwest Highlands and excessive firing occurs, the diversity and density of the plant species that grow between the tussocks of spinifex are decreased (Burrows *et. al.* 1983:183). Under excessive cattle stocking rates the only surviving grass is spinifex (Bishop 1973, Turner 1978). However, Border (2001 pers. comm.) suggests that firing is not a management strategy in the Estrata lease (Moondarra) and that bush firing only occurs naturally.

Plate 2.1. Eastern side of Stone Axe Creek (from Innes 1991:Plate 4.11).

This suggests that any decrease in the diversity and density of plant species in the study area may be attributed to overstocking. Burrows *et. al*. (1983) suggested that seasonality and reduced firing increases the biotic levels of scrubs and grass. Current evidence indicates that overstocking is a significant factor in reducing grass cover and causing erosion on Moondarra (Tibbett 2001). Fencing around reduction floors near Stone Axe Creek has been undertaken in response to this to prevent cattle traversing these sites daily when moving to water at Lake Moondarra (Tibbett 2001). This has resulted in a dramatic increase in vegetation cover despite two years of *El Nino* (see Plate 2.2).

2.8 **Fauna**

The different types of fauna in the Mt Isa district are too numerous to mention individually. For a comprehensive listing of faunal types see Horton (1976) and Wilson (2000). Horton documented 130 types of non-Passerine birds, 76 perching or song-birds (Passerines), over 50 different reptiles and 24 mammals. The building of dams (such as Lake Moondarra) in the region has provided new feeding grounds for the water birds, especially in the dry season when the creeks and waterholes are dry. Eighty-four species of birds have been recorded at Lake Moondarra. The mammals are fewer in species number than the birds and reptiles, but probably contributed a major source of protein to Aboriginal diets before European settlement (see Roth 1897). The larger species of mammals include the red kangaroo (species), euro or roan wallaroo (species), agile or sandy wallaby (species) and the purple-necked rock wallaby (species). The number of mammal species and sub species identified include, mice, rats, bats, dingoes and echidnas.

Plate 2.2. Contrast in vegetation between fenced and unfenced areas at Moondarra.

2.9 Summary of the palaeoenvironment

A palaeoenvironmental reconstruction based on the studies of Magee, Bowler, Miller, and Williams (1995) Magee and Miller (1998) applying a range of research methods, has presented a general consensus regarding past climatic regimes in northern Australia and Lake Eyre prior to the Holocene. From 50-35 kya was a lacustral episode followed by a deflationary regime dominated by evaporation from

35-10kya. Mean average temperature was about 8º C lower and evaporation rates increased during the LGM.

A diminished lacustral regime commenced by the start of the Holocene. Different Holocene climatic episodes for various locations along the northern coastline and the interior are expected results across a wide geographic area. However, there appears to be some consensus for locations of similar latitude. Bowdery’s (1998) dates for Holocene climatic change at Groote Island agree with Shulmeister (1995). The drier period from 3,700-1,000 BP at Cobourg Peninsula suggested by Shulmeister (1995) predates the drier spell of 2,600-1,000 BP advanced by Lees *et al.* (1988), but the latter hypothesised that the magnitude of this decrease could not be estimated accurately. Increasing precipitation from the start of the Holocene with a drier episode at about 4 kya appears to be supported by the research of Gillespie (1991); Magee *et al.* (1995); Magee *et al.* (1988) and Shulmeister (1995) and a higher precipitation phase is suggested by Lees *et al.* (1988) at 1,800 BP and by Shulmeister (1995) at 1,000 BP. A palaeoenvironmental reconstruction of sites across northern Australia and the interior provides an estimation of past climatic regimes at Moondarra.

During the Holocene, Lake Eyre has been experiencing a shallow, semi-permanent lacustral regime and northwest Queensland is a catchment area for this region. It appears that Moondarra may have experienced a drier spell from approximately 3,700-2,600 BP changing to a precipitation similar to present climatic conditions at about 1,800-1,000 years BP.

2.10 Present climatic conditions at Moondarra

The average rainfall at Moondarra ranges from 400mm to 500mm, but the weather systems are unpredictable in this semi-arid zone (Horton 1976). According to Commonwealth Scientific and Industrial Research Organisation (CSIRO), Centre for Arid Zone Research, Mt Isa is located in an arid zone. The climate of arid Australia is more variable than in arid lands anywhere else in the world, with highly erratic rainfall, extremes of long dry periods and flooding deluges (CSIRO. 2006). In many climates regimes there is a predictable and consistent cycle of rainfall during the year related to the latitudinal migration of the wind and pressure systems (Briggs *et al*. 1996:101).

The average rainfall at Moondarra ranges from 400mm to 500mm. Sub-monsoonal, sub-cyclonic, and sub-mediterranean belts influence the study (Gentelli 1972:272). The bulk of Australia's landmass is positioned between 15 and 35 degrees south of the Equator and lies in a zone of sub-tropical anticyclones where most of the world's deserts are located (Pigram 1986:15). Nevertheless, four main rainfall systems influence the climatic conditions at Moondarra. These influences are; monsoonal, local thunderstorms, cyclonic, and light rainfall from the south.

In spite of the influence of these four rainfall systems, Mt Isa remains a semi-arid region with a marked degree of variation in rainfall. Highly localised variation in annual rainfall rather than low rainfall is the cause of drought.

The geographic position of the northwest ranges determines why rainfall is so unpredictable. The monsoonal trough reaches a normal position across the south of Cape York Peninsula. Precipitation from the monsoons decreases with increasing distance to the south. In some years the effect of the weather systems is limited. Cyclones usually weaken into rain depressions after crossing the coastline. Being well inland, the amount of rainfall received in the ranges is often less than near the coast. Local thunderstorms bring heavy localised rainfall to the region, but they are also associated with the monsoons and occur during the summer season. Over 70% of rainfall in the study region falls between December and March. During the dry season there is practically no surface runoff, followed by the wet season, when runoff is extensive. The steep slopes and low-density of vegetation cover increase the amount of runoff in the Mount Isa region and has the potential to erode archaeological sites.

When the tropic monsoons and rain depressions bring heavy falls in the same season, massive flooding occurs in the Lake Eyre Basin (as occurred in 2000). Mt Isa experiences many of nature's most extreme phenomena particularly droughts, tropical rain depressions, and severe storms, but remains a typical Australian semi-arid climate. Rainfall is strongly seasonal in character with a marked monsoonal wet summer and a dry winter. Figures 2.4 and 2.5 highlight the seasonal character of rainfall in the study region.

Latitude and distance from the sea are the two main factors governing temperature in the Northwest Queensland Ranges. The maximum temperature range in Mt Isa is from 27° C in mid-winter to 42° C in mid-summer, the minimum from 5° C to 21° C (Horton 1976:17). At Mount Isa frost occurs during the winter months and especially during the period from July to August. Lower temperatures are primarily latitudinal, but the higher altitude at Mt Isa (330m) overrides some of the effects of higher latitude.

High temperatures during the summer months and dry winds from the southeast during winter result in extremely high evaporation rates in the Mount Isa region. The average evaporation rate is 2,500mm per year (Long 1974). The normal daily temperature ranges for summer and winter are shown in Figures 2.7 and 2.8 respectively.

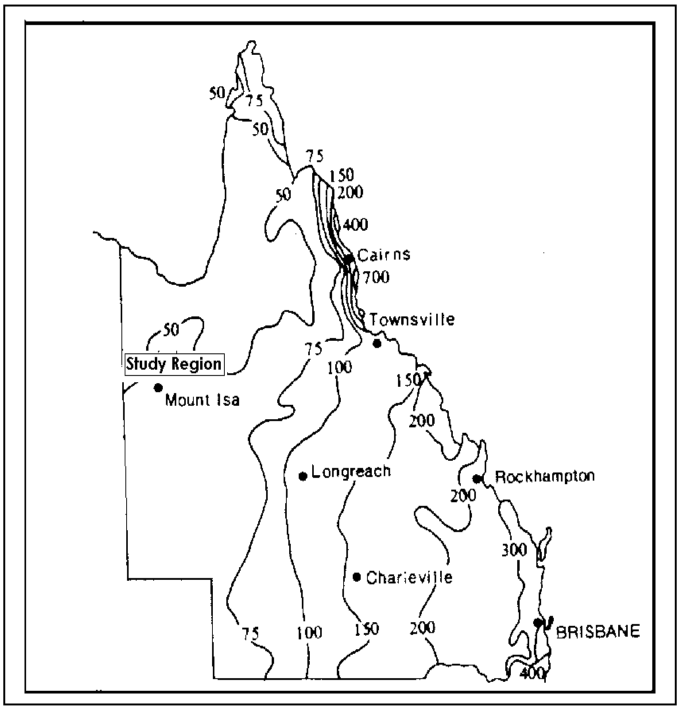


Figure 2.4. Average Mt Isa winter rainfall in mm (from Burrows *et al.* 1998:15).

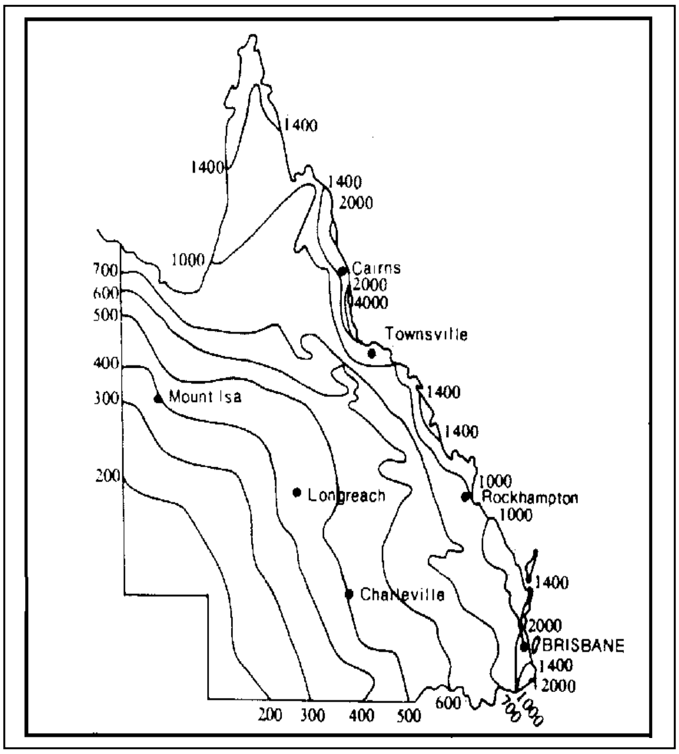


Figure 2.5. Average Mt Isa summer rainfall in mm (from Burrows *et al.* 1988:14).

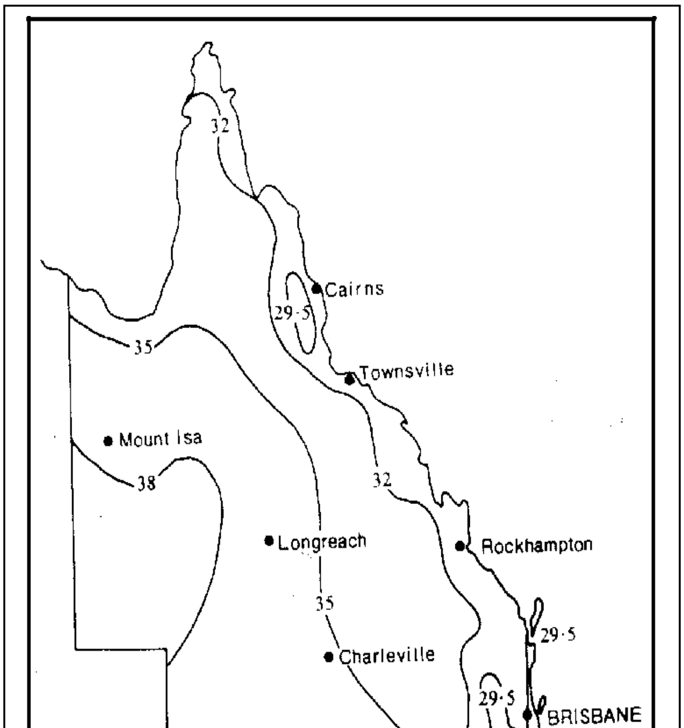


Figure 2.6. Average summer temperatures at Mt Isa In degrees C (from Burrows *et al.* 1988:16).

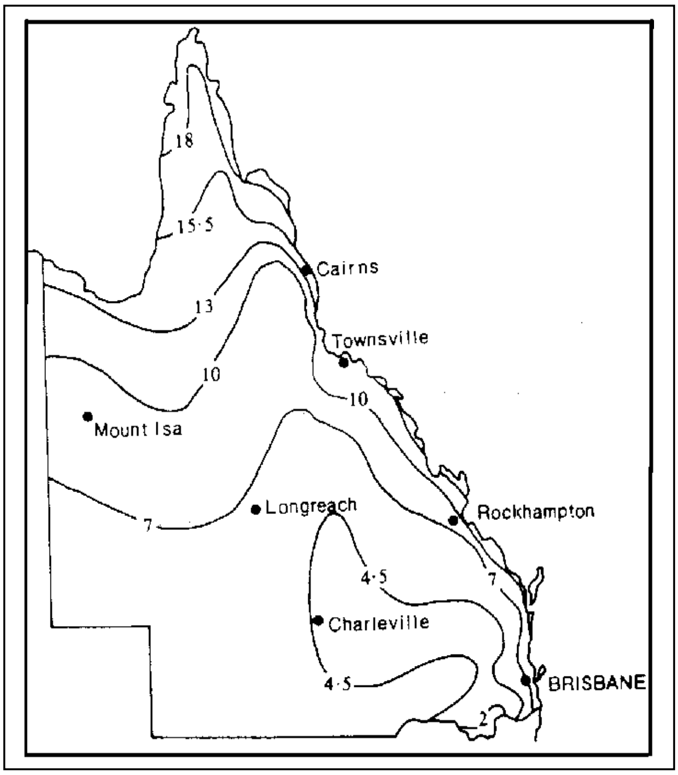


Figure 2.7. Average winter temperatures at Mt Isa
In degrees C (from Burrows *et al.* 1988:17).

2.11 **Early contact**

In January 1861, the explorers Burke and Wills exploration passed through the eastern boundaries of Kalkadoon country and Pearson (1948) a local historian, was informed by some Kalkadoon Elders that as young men they had observed the expedition. Apparently the Kalkadoon were spoiling for an attack on the intruders, but were dissuaded by the awesomeness of the camels (Pearson 1948:198). Burke's records near Cloncurry are limited, as he made notes occasionally, but never kept a journal. Consequently, there is no record that he observed Aboriginals near Cloncurry. Burke's Camp 102 was discovered in 1960 nineteen kilometres west of the Cloncurry River which borders Kalkadoon country (Armstrong 1981:68).

Among the numerous search parties sent out to find Burke and Wills two or possibly three of the searchers traversed the Cloncurry district. John McKinlay (Adelaide), William Landsborough (Brisbane) and possibly Frederick Walker (Rockhampton) passed through the Cloncurry district and in his journal McKinlay (1862:79-80) recorded:

> There is abundance of water in many of the minor as well as the main creeks, mussels in all. Magnificent pastures all round, and lots of game, but wild… a specimen of copper picked up in one of the creeks; a great abundance of quartz and mica strewed everywhere.

These early observations of the region's wealth in pastures and minerals were to rapidly impact on the culture of the traditional owners. In 1867 Ernest Henry discovered copper on the Cloncurry River, a find that heralded the establishment of the Mt Isa-Cloncurry region as a focus of mining activities.

Initially, the Kalkadoons did not molest the gold and copper fossickers as they were low in number and offered no direct threat to their lifestyle. Kalkadoons guided Henry to the copper find and he paid them to work for him with steel axes and blankets. The first cattle holdings to be taken up in the heart of Kalkadoon country was Bridgewater Station on the Malbon River by the brothers W. and T. Brown in 1874. Again, they had no trouble with the Kalkadoons, but were forced to give up their holdings as, the water was not permanent (Pearson 1948:201). The early miners were not a threat to the Kalkadoons who sometimes worked for the prospectors.

2.12 **Kalkadoon resistance and pastoralism**

The settler's livestock polluted the sparse, but large waterholes that were the refuges for the Kalkadoon during the dry summer months. The survival and lifestyle of the Indigenous people was essentially related to the availability of drinkable water (Armstrong 1980:124). In 1860, 71% of Queensland revenue and 94% of exports were derived from the rural sector (Armstrong 1980:13). In the 1870s the Queensland's economy was completely dependent upon pastoralism (Armstrong 1980:13). Alexander Kennedy took up Buckingham Downs Station in 1877 and it is about this time that cattlemen began to encroach upon Kalkadoon territory in large numbers and a guerrilla war flared up (Pearson 1948:198).

It was suggested by Armstrong (1980:61) that the Kalkadoons were sufficiently resourceful to change their form of organisation and tactics to face the crises that pastoralism posed to them.

The first report of an escalation in the frontier violence was in December 1878 when a man named Molvo and three of his men were murdered by the Kalkadoons. They were on their way from Boulia to Sulimen's Creek, which is at the south of Kalkadoon country. A white vigilante group led by Alexander Kennedy joined forces with a troop of Native Mounted Police from Boulia who were commanded by Sub-Inspector Eglinton and they rode into the Selwyn Ranges to apprehend and 'disperse' Molvo's assailants (Hardy 1984:15). Retribution against the Kalkadoons was swift and brutal, Laurie (1959:170) commented: 'A fight took place and scores of blacks were killed, but the tribe remained unconquered'. Hardy (1984:15) suggests that in retaliation, for the next five years the Kalkadoons speared and stampeded every cattle herd they could and apparently murdered settlers when the opportunity for ambush arose.

As a consequence of this, Kennedy travelled to Brisbane to convince the Government of the economic and physical danger that the Kalkadoons posed to the district's pastoralists (Hardy 1984:16). As previously mentioned, the newly formed Queensland Government (1859) was heavily dependent upon the revenue from the pastoral industry. In response to this lobbying, the Queensland State Government stationed a detachment of Native Mounted Police at Cloncurry under the command of Sub-Inspector Beresford. This alleviated the necessity of sending the Mounted Police detachments from Boulia and Etheridge each time an incident was reported. On the night of the 24 January 1883 Beresford and four of his troopers camped on the banks of the Fullarton River near Farleigh Station. During the day, Beresford had trapped a party of Aboriginals in a gorge, who he believed were involved in the murder of a European. After dark the Kalkadoons escaped, found weapons and attacked the Mounted Police. In the bloody skirmish, Beresford and three of his troopers were killed and one escaped. Sub-Inspector Eglinton and his Native Police troop from Boulia came up to Ranges to search for the offenders, but according to Fysh (1933:141) the Kalkadoons were already secreted in their hill fortresses. After these events a state of open warfare existed between the Kalkadoons and the white settlers (Armstrong 1980:130-32).

During the following 12 months, Kalkadoons again reigned supreme over most of their tribal lands. The settlers were in fear for their lives and Sub-Inspector Urquhart who replaced the unfortunate Sub-Inspector Beresford at Cloncurry reported to Police Headquarters in March 1885 that friendly Aboriginals in the main street of Cloncurry had informed him of Kalkadoon threats on his life (Letter No 2369:1885). Two separate incidents in 1884 heralded the beginning of the end for the traditional Kalkadoon lifestyle. Firstly, the Kalkadoons killed James White Powell, part-owner with Alexander Kennedy of Calton Hills Station. Once again Kennedy, with a heavily armed party, joined forces with the Native Mounted Police and mounted reprisals against the Kalkadoons. Second, in September 1884 a Chinese shepherd on Granada Station was murdered and Sub-Inspector Urquhart with his mounted troopers and all the able bodied men he could muster went out to ‘disperse’ the Kalkadoons (Hardy 1984:17). At Prospector Creek about 100km north of Cloncurry and 22km southwest of Kajabbi they engaged in combat with them. This place remains extremely significant to the Kalkadoons and is still today known as ‘Battle Mountain’.

The Kalkadoons stood their ground (Armstrong 1980), but spears and rocks were no match for carbines. The exact number of Kalkadoons who fell at Battle Mountain is unknown, but undoubtedly the tribe was decimated. Urquhart’s report to Cloncurry (8 March 1885), after requests from the Police Commissioner for information seems to be intentionally vague on the events at Battle Mountain. He did report that the five alleged offenders were among those killed, but provided only sketchy information on the events before and after the main battle. After Pearson (1948), Blainey (1965:23) suggested that at Battle Mountain the Kalkadoons were slaughtered in such numbers that for decades the hill was littered with the bleached bones of Aborigines. The battle irreversibly decimated the tribe and the immediate dispersal that followed hastened the demise of traditional hunter-gatherer mode of life for the Kalkadoon people.

In the decade following the Kalkadoons were forced by a number of issues beyond their control to ‘come in’ to the stations. When the Native Police gained open access to the ranges the Kalkadoon became little more than prey for the Mounted Police as Percival Walsh of Iffley Station reports:

> …boys are quite willing to go with the white man, and is that not better than their running about the bush and living from hand to mouth and being prey for the native police. (Queenslander 1884:259)

By aligning themselves to cattle stations the Kalkadoons not only continued ties with their traditional lands, but protection was afforded from the excesses of the Native Mounted Police.

During the period 1885-92 Cloncurry was afflicted, like most of Australia by the Great Drought (Hardy 1984:18). The calamitous effects of a severe drought on a hunter-gatherer society was compounded by livestock polluting the remaining water-holes and grazing cattle competing for grass with the wild animals which were the traditional source of protein for Aboriginals. In usurping the land from the Aboriginals the pastoralists were in effect separating them from their means of production and subsistence (May 1983:92).

2.13 Early Kalkadoon labour in primary industry

The Kalkadoons had assisted the 19th century prospectors in locating the rich copper resources. They had initially worked for them and apparently had good relationships, however these prospectors did not employ them when they were forced to turn away from their traditional life. In contrast, the pastoralists who they had engaged in open battle did eventually offer some employment opportunities for the dispossessed people. This complex outcome was partly explained by Wegner who noted that on the Etheridge River field: ‘no conciliation was effected on the mining frontier, conflict continuing to the mid 1880s when the starving remnants of the tribes *came in* to the various mining towns (cited in May 1983:93). According to May (1983:93), in the pastoral industry the initial impetus for employing Aboriginals in northwest Queensland was to conserve capital rather than to obtain workers. It must be remembered that the Kalkadoons were engaged in a successful economic conflict against the pastoralists, taking a heavy toll on sheep, cattle and stores. Reynolds (1978) and Loos (1976) both considered that Aboriginal resistance presented a many-pronged threat to the economic viability of the frontier squatters. As previously mentioned this was the reason Kennedy went to Brisbane to present the cattlemen’s case to the Queensland Government. In the mining industry were capital was less vulnerable and valuable, no efforts where made to bring in the Aboriginals (May 1983:93).

2.14 **Land systems and land use**

Settlement in the region from the late 1860s by pastoralists and miners has undoubtedly impacted on some areas within Moondarra. The construction of a windmill and water-troughs for cattle beside Spring Creek provided a permanent watering point and enabled stock levels to be increased. The construction of Lake Moondarra for the mines and their supporting infrastructure have directly impacted on Moondarra. These post depositional changes are interpreted in subsequent chapters. In addition, the steep slopes on the hillsides, limited vegetation cover, precipitation infiltration rates and the fluvial process must be evaluated when estimating the number of potential archaeological sites in a particular land system and how they might be affected by recent changes to the environment. The Precambrian residual rock is the dominant feature of the hill country. The rock outcrops, pebbled surfaces, boulders, angular rock edges, bare rock surfaces and dry rock strewn watercourses cut through winding valleys. The marked decrease in vegetation cover in parts of the quarry has possibly increased the erosion of topsoil. The effects of cattle grazing and browsing on vegetation are generally difficult to quantify, but adverse effects are detectable in the mid to long-term when runoff commences to create rills in the surface of the soil. This usually occurs when vegetation cover is markedly reduced as shown in Plate 2.2.

Water availability has been central to human life since people commenced hunting and gathering around the watercourses in the northwest Highlands. The Leichardt River and the other major streams usually stop flowing after the summer wet season. However, the Leichardt riverbed and other major watercourses are marked by numerous large water holes up to 300m-400m in length. The Aboriginal peoples relied extensively on these refuges during the drier months.

2.15 **Conclusion**

This chapter has provided a background of land and people relevant to the study area. It is aimed at providing an understanding of the conditions that northwest Queensland Aboriginal societies experienced. The focus has been on geology, topography, soils, vegetation, fauna, palaeoenvironment, rainfall and land systems, history and elements of culture contact.

The geology of the northwest Highlands and the surrounding areas are essential in understanding why Moondarra might have become a centre of large scale axe production in Aboriginal prehistory. The northwest Highlands are an extensive Precambrian landmass surrounded by hundreds of kilometres of sedimentary rocks to the north, east and south. These neighbouring materials are unsuitable for axe production. The topography and soils of the Precambrian Ranges are distinctive from the surrounding lowlands. This landscape, that rises up to 400m ASL, contrasts starkly with the surrounding ancient seabeds. The steeper basalt slopes at Moondarra are a mixture of rounded and rugged hills and the major soil types are primarily lithosols and red earths.

The northwest ranges form an identifiable bioregion with an extremely wide range of flora. Over 200 types of birds inhabit the Mt Isa region and the mammals are fewer in species but would have contributed a major source of protein to Aboriginal diets before European settlement.

A discussion of climatic regimes in northern Australia and Lake Eyre suggest that a lacustral episode from 50-35 kya was followed by a deflation regime dominated by evaporation from 35-10kya. Mean average temperature was about 8º C lower and evaporation rates increased during this drier episode during the LGM. A shallow, semi-permanent lacustral state commenced at the start of the Holocene with climatic conditions possibly remaining stable since the mid-Holocene.

The northwest Highlands form one homogeneous land system but the effects of mining, cattle grazing and browsing since the 1860s is difficult to quantify. In subsequent chapters an analysis of the effects of mining and grazing infrastructure at Moondarra will be presented.

Armstrong (1980:61) suggested that the Kalkadoons were able to adapt their social organisation and tactics to face the crises that pastoralism posed. Although, group solidity and strategies may have been required to fight what was initially a successful guerrilla campaign (see Pearson 1948), a high degree of social organisation may have already existed in Aboriginal society from the mid to late-Holocene. Major social change might not have been needed for northwest Aboriginal people to operate as a cohesive tactical unit.

Chapter 3 Previous distributional studies, axe studies, production and exchange

3.1 Introduction

This chapter defines and sets out the questions of the archaeological data from Moondarra and supports the theoretical and conceptual issues that underpin this research. There are four major issues discussed in this chapter. First, a review of earlier studies of production and exchange in Australia where the dominance of ceremonial aspects has been emphasised. Second, that exchange may take a number of forms and these are defined. Third, that all exchanges have both ceremonial and social aspects, involving, for instance delayed obligations. Finally, concepts involved in distance decay models might have to be modified where, direct long-distance exchange trading relationships exist but distance-decay measures may be able to demonstrate where this is and is not the case.

3.2 Earlier theories of production and exchange

In Australia, archaeologists and anthropologists have a propensity to explain Australian hunter-gatherer exchange networks as being either reciprocal or ceremonial. Although these terms provide an acceptable description in most circumstances, it is suggested that these terms may not be applicable in explaining some regional interpretations of exchange. Pan continental interpretations of exchange suggesting that ceremonial and/or reciprocity can comprehensively explain the full spectrum of Aboriginal material culture appear to neglect some of the finer details of research by Berndt and Berndt (1964), Stanner (1934-5), and Altman (1982) who have all argued for the existence of both ceremonial and economic exchange at a range of levels in some Aboriginal language groups. Economic exchange or negative reciprocity is characteristic of interactions between distant groups and is the attempt to maximise utility at the expense of the other party (Seymour-Smith 1986:241).

In suggesting here that economic exchange or trade is identifiable in the archaeological record for Moondarra, it is acknowledged that economic exchange probably operated for certain times of the year, at the inter-group level and was conducted less frequently, in comparison with intra-group reciprocity. But, the critical issue regarding exchange is the archaeological evidence suggesting inter-group economic exchange in northwest Queensland. In hunter-gatherer societies, separating the social and economic objective of exchange is difficult. However, it is argued that some types of exchange appear to embrace a pronounced economic intention.

Berndt and Berndt (1999:122-134) completed a comprehensive study of Aboriginal economic exchange and trade for the Daly River. They recognized six types of exchange and suggested that two of these involve ceremonial gift exchange. Each type varies slightly and one type specifically described exchange as being wholly for economic reasons. More importantly, they did not subsume trade relations (variation 5), as some other researchers have, under the general category of ceremonial exchange. Berndt and Berndt (1999:122-129) described the six variations of exchange as such:

1. Essentially on the basis of kinship. Ordinarily, a person knows just what is due to various relatives, close and distant, and what he can expect from them...

2. Gifts made to settle grievances or debts, arising from an offence by a single person or group of persons…

3. Gifts in return for services, or for goods…

4. Formalized gift exchange, involving trade between various defined partners, in a series, which may cover a wide area… Any one person in the chain may retain the goods only temporally. Choice of partners may be voluntary, or outside a person's control…

5. Trade. If we look at any given locality in Aboriginal Australia, in traditional terms, we can see that there is more or less constant movement of goods, some coming from one direction and some from another. These follow what is called roads or paths (as in category 4). From the perspective of people in one place, they appear to centre on that place. But if we plan

> them all out, those on which we have information, we can see that they criss-cross the whole Continent, usually along water-hole routes... Among some tribes, for example the Wuroro (Love 1936:191-3), there was usually no separate individual bartering, but series of group exchanges. The hosts and visitors, after preparing their goods, might sit down about a cleared space. First the visitors would place on a growing heap all the goods they had brought, then the local people would come forward individually and heap up in front of the visitors what they propose to give them…

6. There is also a further category which could be termed the economics of sacred life…

Berndt and Berndt (1999) viewed ceremonial exchange as involving categories 4 and 6 and documented complex social obligations associated with *merbok* and *kue* exchange cycles in the Daley River region. Australian archaeologists have often overlooked their distinction between numerous categories of exchange and the more general term of ceremonial, which according to Berndt and Berndt (1999 did not include trade.

Thompson (1949) described Aboriginal exchange in eastern Arnhem Land in the general terms of ceremonial and also referred to the routes that the *gerri* (valuable good) passed along as paths or roads fixed by tradition. He described exchange in eastern Arnhem Land as:

> This ceremonial exchange provides the basis for a great cultural movement that has for its motive force the all-powerful ‘drive’ rather than obligations of mere economic exchange, which although an important accompaniment, is subservient to the ceremonial aspect. It is the basis for a great cultural movement. (Thompson 1949:68-9)

Berndt and Berndt’s (1999) interpretation of exchange is appreciably different to Thomson’s (1949:70-81) they argue that:

> *Thomson’s phrase ‘Ceremonial Exchange Cycle’ is misleading, in that the economic exchange is nearly always subordinated to the ritual and ceremonial significance.* (1999:132)

McCarthy (1939:178) has summarised Aboriginal barter as being carried out between contiguous and distant hordes and tribes to obtain desired raw materials, finished articles, corroborees and songs. He says that these actions were carried out at recognised market places, feasts, ceremonies and other gatherings. However, the exchange of articles tended to be ritualised throughout the continent (McCarthy 1939:178-9). Elkin (1934:12) noted that the presentation of food, ornaments and weapons is related to the kinship system and forms a necessary adjunct to betrothal, marriage and initiation in Aboriginal culture.

Stanner (1933-34) studied exchange in the Madngella and Mulluk Mulluk tribes of the Daley River, Northern Territory. He recognised that history and the corrosive nature of culture contact had impacted on the study region and that this contact had nearly obliterated native culture in the eastern states (Stanner 1933-4:156). He documented two exchange networks still in operation. First, he described the *merbok* as:

> In essence the merbok is a complex system of delayed economic exchange between individuals in the same tribe and different tribes… it is more than merely economic exchange on a utilitarian basis it has a specific, though subdued, ‘ceremonial content’. (Stanner 1934-35:157)

Second, he explained the *kue* exchange system as:

> … ceremonial gift exchange with sacramental and legal function in marriage. (Stanner 1934-35:157)

Stanner (1933-34) also observed that if a man was lagging in his *merbok* responsibilities then his exchange partner would take the first opportunity to make a casual reference to the situation. The exchange of articles to areas where craftsmen that any tribe possessed could readily duplicate the goods being received was another issue suggesting that *merbok* was not solely utilitarian in form.

Ritual, reciprocity, ceremony, and barter are common terms used to describe Aboriginal exchange between groups. An economic interpretation for particular type of exchange is

clearly defined by Berndt and Berndt (1999). However, the general consensus is for subsuming exchange under the context of ceremony, as explained by McCarthy (1939:178-9), Elkin (1934:12), Stanner (1933-34) and Thompson (1949).
McBryde (1997:604) believed that limited resource availability did not adequately explain the distribution of exchange items in the Lake Eyre Basin. Nevertheless, she acknowledged that raw material suitable for axe production is entirely absent from the region (1997:603). McBryde (1997:604-5) suggested that the exchange items had symbolic rather than utilitarian values and carried social meanings and that they maintained the political, social and ceremonial alliances between various groups. She also argued that in this region exchange might have served as a survival strategy in the uncertain desert environment as suggested by Gould (1980:60-87). In times of stress, these social alliances might guarantee the support of kin or trading partners (McBryde 1997:605).

The symbolic and risk minimization strategy suggested by McBryde (1997) appears to be a rational interpretation. Large apparently unused axes in museum collections and the presence of large blanks suggest that ceremonial axes were produced at Moondarra. Delayed return obligations in the form of risk minimisation have been noted by archaeologists (see Gould 1980:66, Gould and Saggers 1985). These issues certainly prevent a solely economic analysis of exchange. Nevertheless, before dismissing a more pronounced economic role of exchange in Aboriginal societies the alternate view of Altman (1982) requires some examination.

Altman (1982) emphasised economic motives in explaining inter-group exchange and was explicit in his criticism of ceremonial explanations, specifically those of Stanner (1933-34) and Thompson (1949). His alternative definition of economy involved an examination of production, consumption, distribution and exchange of goods and services (Altman 1982).

Altman (1982) considered the major flaw in the interpretations of Stanner (1933-34) and Thompson (1949) was to assume that contact had not altered the Indigenous exchange system in their respective study regions. In the outstation that Altman (1982) studied, the Aborigines had access to pensioner and other funds, and could purchase goods from the shop or on order. He expressed this concern in his dissertation as:

> One of the major contentions in this thesis is that the social relations of subsistence production in eastern Gunwinggu society have remained primarily unaltered and central to production organisation in the post-contact era. (Altman 1982:158)

In turning his attention to examining the band's external economic or exchange relations he was unambiguous in stating that he did not perceive economic and social exchange as separate issues. He suggested that the movement of material goods was balanced by invisible social returns or by returns that were not immediate (Altman 1982:338). He proposed that in eastern Gunwinggu society there has been a definite transformation in trade as termed 'ceremonial exchange' by Berndt (1951) and Thompson (1949), which has been superseded in the contemporary, post contact period by a 'market exchange' institution Altman (1982:338).

After Sahlins (1972), Altman (1982:340) viewed theoretical market exchange as being at one end of a continuum between negative and positive reciprocity. He described market exchange as being a highly visible, economic activity without non-economic market mechanisms such as interpersonal or social exchange. However, he accepted that in reality the market is often substantially distorted from this ideal (Altman 1982:340). Altman (1982:341) and Blainy (1975:209-214) postulated that early ethnographers, particularly Stanner (1933-34) and Thompson (1949), by placing ceremonial exchange at the other end of the reciprocal trajectory confused how and why this system worked. Altman (1982:341) suggests that the ceremonial economic considerations are deliberately suppressed and the sociable ceremonial context become dominant.

He noted that in general the eastern Gunwinggu society do not have exchange partners as documented by Thompson (1949:61-81) in eastern Arnhem Land (Altman

1982:346). He emphasised the issue that individuality is not institutionalised and there are no customary names among the eastern Gunwinggu to regulate such exchanges. He argued that when the eastern Gunwinggu participated in external economic exchange it was usually conducted at the group level and was formalised ceremonial exchange (Altman 1982:347).

Whereas Stanner (1933-34) and Thompson (1949) suggested that utilitarian issues could not wholly explain the exchange of goods to regions where they could be readily produced, Altman (1982:348) argued that the economic function of the exchange cycle was to distribute scarce goods over long distances. He believed that it was an efficient system because Aborigines throughout Arnhem Land gained access to scarce resources without having to travel long distances. Nevertheless, during the time of his study he noted that the contemporary significance of ceremony lies more in the ‘social’ than ‘economic’ function of these ceremonies and that this issue is demonstrated by the almost identical bundles of trade goods currently exchanged (Altman 1982:369).

Altman’s (1982) arguments for a more economic approach to Aboriginal exchange partly supports by the Berndts (1999) classification of trade as a separate type of exchange. Interestingly, their explanation of trade being conducted at the inter-group level seems to lend additional support to Altman’s (1982) argument. In his description of the *merbok,* Stanner (1933-34) identified the presence of some economic aspects of exchange with a subdued ceremonial context.

As noted by Altman (1982:340), in reality market exchange may be substantially distorted from theoretical explanations for exchange. This distortion may mean that focusing interpretations on one exchange activity or a particular type of exchange may ignore subsequent responsibilities to complete the exchange cycle. Overarching behaviour such as a delayed obligation to return other items may be masked by social interaction. Conversely, barter conducted at the group level without specific exchange partners as described by Altman (1982) and Love (1936) may represent a more idealistic model of economic exchange with the apparent finalisation of the transaction at the time of exchange.

The Berndts (1964), McBryde (1984:267), Elkin (1934); Stanner (1933-34); and Thompson (1949) have all stressed the complexity and difficulty of divorcing social and economic aspects of hunter-gatherer exchange. The separation of trade and ceremony, material gain and invisible return, may be impossible to decipher as either positive or negative reciprocity. The essential complexity in preventing a precise interpretation is that when the material exchange is finalized, future obligations commence.

3.3 **Practical and prestige exchange**

In endeavouring to understand precisely how the term ‘ceremonial exchange’ should be interpreted, it might be helpful to examine a recent paper on practical and prestige items by Hayden (1998) who distinguishes ceremonial and utilitarian exchange.

Hayden (1998:1) used design theory and cultural evolution to analyse both practical and prestige technologies, and he believed that prestige items were essential elements in ‘aggrandiser strategies’. He identified the magnitude of difference between these two technologies and the effect each has on the evolution of technology and cultural systems in general (Hayden 1998:1).

He argued that the purpose of prestige artefacts is not to carry out a practical task but to display wealth, success, and power. The rationale for prestige items is to resolve social problems such as attracting prospective mates, labour and allies or bonding members of a social group via displays of success (Hayden 1998:11). He advocated that the logic and strategy for producing prestige items is fundamentally different to practical artefacts. The primary goal of prestige technologies is to employ as much labour as possible to create objects that will appeal to others and attract people to the possession of these objects due to the admiration for economic, aesthetic, ethnical, or other skills (Hayden 1998:11).

Prestige items are frequently used as objects to lure individuals and families into debt or reciprocal obligations (Hayden 1998:12). Hayden suggested that in prestate societies, prestige items constituted the infrastructure of social and political hierarchies without which the hierarchies would collapse and be impossible to retain (Hayden 1998:12). In Cape York Peninsula, Sharpe (1974) [1952] argues that the manufacture of axes and their use and trade maintained the hierarchical position of the elder males. Hayden (1998) suggests that the ensuing hierarchical indebted relationships can be viewed as a secondary function of prestige technologies. Hayden (1998:12) proposed that a tertiary function of prestige objects was the ability to store surplus production and labour in a transformed state.

It is argued here that the people of Moondarra might have used their trade goods to gain both an economic benefit and a delayed return. The latter being gained through reciprocity in the form of a risk minimization strategy. However, it is important that the scale of production and social behaviour are viewed as separate issues. It cannot be assumed that the time and energy spent in the production of axes in northwest Queensland represented a culture for an emerging chiefdom. The essential difference between the Aboriginal production described here and, Hayden’s (1998) explanation for prestige goods is the scale of production, which is discussed later in this chapter.

The role of indebtedness or balanced reciprocity suggested by Hayden (1998) may have been part of the Kalkadoon strategy. The term ‘indebtedness’ as used by Hayden (1998), aligns closely with Sahlins (1972) theory of balanced reciprocity, which is at the midpoint between positive and negative reciprocity and is less formal and moral and more economic in type.

According to Hayden (1998:13), the types of objects often associated with these valued displays are shiny or bright objects such as mica, clear crystals, native metals, teeth, horns, and polished bone or sea shells are some of the most common objects that indicate prestige and success in both egalitarian subsistence alliance rituals, and hierarchical feasts. Hayden (1998:13) cited studies by Clarke (1986:5-6), Coss and

Moore (1990), Hamel 1983, and Tacon (1991) who advocated that most people are attracted to, or impressed by items that sparkle, shine, or transmit light.

Hayden (1998) believed that ideological symbols are not necessarily prestige items as they can be produced with minimum cost such as tying two sticks together to make a cross (Hayden (1998:15). Hayden explained that the few prestige items that are noted in the ethnography of Central Australian Desert are stone churingas and rock paintings and that these were used in ritual contexts to bond members of subsistence alliances covering extensive areas (Hayden 1998:15-6). He argued that the low frequency and low cost of these symbols did not involve significant amounts of group surpluses and therefore, they are probably not based on surplus competition.

Hayden (1998:15-6) stated that ritual objects or non-competitive prestige items were made and used among generalised hunter-gatherer societies in order to reinforce subsistence alliances (such as in Central Australian Desert). On the other hand, prestige items were made and used for surplus-based competition among complex hunter-gatherer and other trans-egalitarian communities.

Essentially, in addition to emphasising some of the differences between prestige and practical items, Hayden (1998) argues that the more time and effort involved in the production of a particular item, the higher it would be on a trajectory between practical and prestige. Notwithstanding, some labour intensive tasks relate to practical problems of survival and comfort. Hayden’s (1998) arguments are useful insights into the changing relationships along the continuum between utilitarian and prestige items.

For a range of reasons, the production of axes at Moondarra may align with some aspects of Hayden’s concept of prestige items. First, these artefacts are produced for medium and long-term strategies not immediate tasks to hand. Although this role does change when the recipient or end user obtains the implement and uses it for a combination of maintenance and extractive purposes (see Binford and Binford 1969:71). Second, significant amounts of raw material, time and energy have been exhausted in their production. Therefore, the transformed state of the raw material represents significant economic effort. Third, luring individuals and families into debt or reciprocal obligations might not support social and political hierarchies in this case, but perhaps it reinforces and maintains existing social relationships between different groups. In maintaining these exchange relationships potential social problems during times of food scarcity can be partly alleviated.

3.4 **Risk and technology**

According to Bamforth and Bleed (1997:115), most previous studies that explicitly combine risk and technology usually refer to Torrence (1989). Her explanation of optimisation theory is: ‘The strategy which produces the most favourable ratio of benefits to costs, calculated in terms of the chosen currency (e.g. time, energy), is then the one defined as optimal’. She described the positive side of this theory as allowing technology to be incorporated into a broader view of behaviour and be studied alongside and in the same way as subsistence, settlement, or social organisation (Torrence 1989:2).

This approach may lead to an understanding of how various human strategies operate in respect to each other rather than viewing them as entirely separate entities (Torrence 1989:2). Torrence suggested that stone tools have the potential to make a significant contribution to the study of human behaviour and defined technology as: ‘… comprising physical actions by knowledgeable actors who use chosen materials to produce desired outcomes’ (Torrence 2002:74).

Wiessner (1982:172-3) has identified four general types of behaviour to reduce risk: prevention of loss, transfer of loss, storage, and pooling of resources. While recognizing that social strategies such as exchange relationships are better suited for transferring loss and pooling resources, Torrence (2002:77) suggested that most of these descriptions involve risk minimization strategies that occur on relatively long time scales of weeks, seasons and years. She believed that tools are most useful in solving problems in a shorter time scale such as minutes or hours (Torrence 2002:77).

This approach assumes that tools are more effective in solving immediate tasks and identified that hunter-gatherers used different strategies such as the acquisition, sharing and passing on of knowledge about resource distribution, methods of tracking game and mobility for longer- term survival strategies (Torrence 2002:77). The argument that stone tools are manufactured to solve short-time problems may be correct in most instances. However, the combination of purposeful scheduling and production of tools for inter-group exchange, in association with social relationships involving indebtedness or reciprocity is a sophisticated long-term survival strategy. Therefore, tool production, exchange and long-term subsistence strategies can be directly inter-related.

3.5 **Stone axe research in Australia**

Morwood and Hobbs (1995) mapped the chronological and geographical distribution of edge-ground axes in Greater Australia (Figure 2.1). Carmel Schire (1982) suggested that edge-ground stone axe technology has been present in northern Australia for 30,000 years, however the earliest date for southern Australia is 5,000 years ago. Based on chronological and latitudinal criteria, Moondarra is chronologically positioned between the Pleistocene dates for axes to the north and mid-Holocene axes to the south (Figure 2.1).

Axes are associated with quarries for both extracting the raw material and carrying out the initial preparation of axe blanks. Hiscock and Mitchell (1993:3) suggested that contemporary researchers have neglected quarry studies due to intrinsic difficulties in examining them. These are perhaps summed up by Ericson (1982:2) who described this as:

> … the result of technical and methodological limitations imposed by a shattered, overlapping, sometimes shallow, non-diagnostic, un-dateable, unattractive, redundant and at times voluminous material record.

Ericson's (1984) depiction of the complexities in technical and methodological limitations are valid for most quarry sites at Moondarra however, some of the reduction floors have stratified deposits. These are located near quartzite ridges that have eroded forming colluvial fans along Stone Axe Creek. These formations cover cultural material with quartzite grains that over time form stratified deposits in a few locations. This colluvial process will be explained in more detail in Chapter 6.

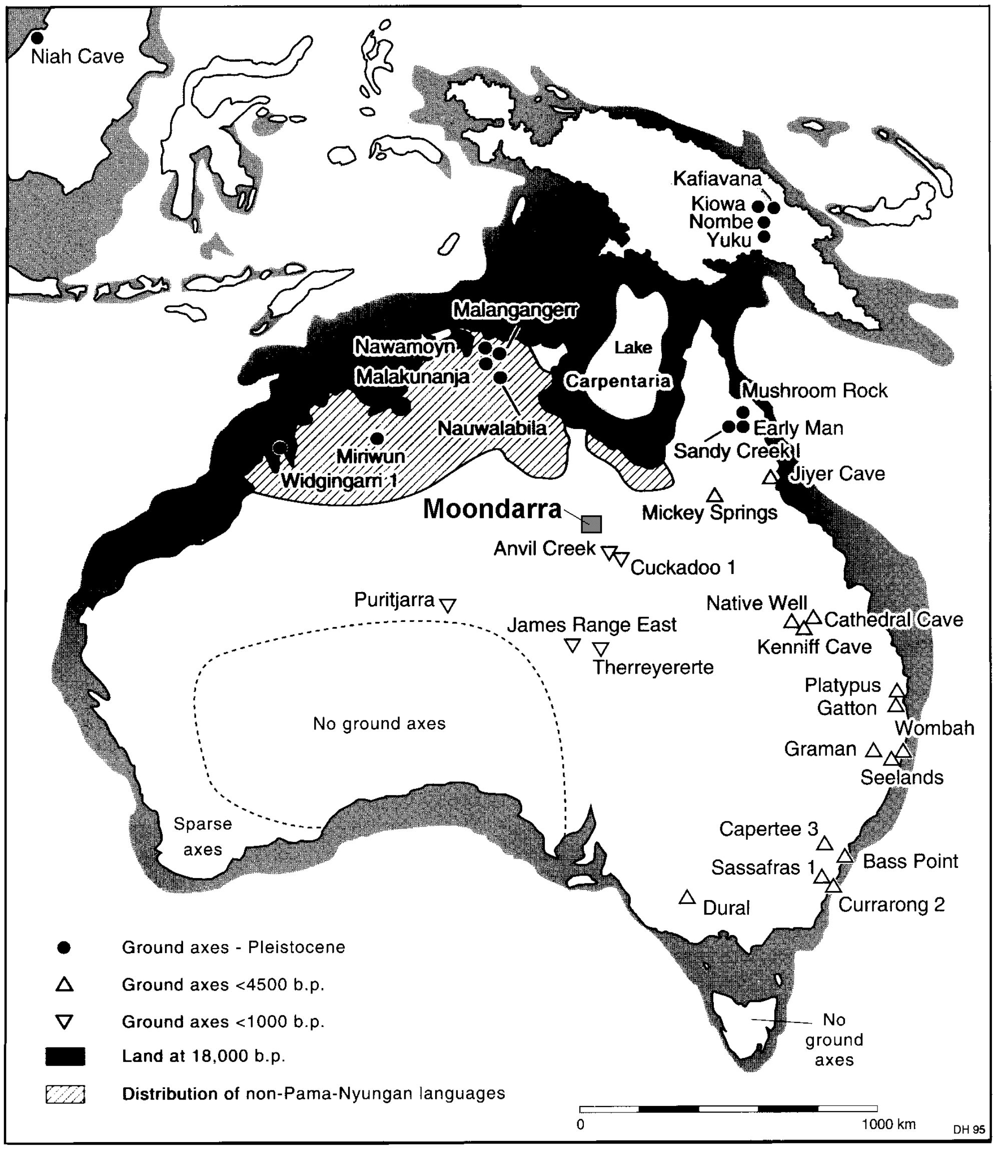


Figure 3.1. Chronological and Geographical Distribution of Stone Axes in Greater Australia and the location of Moondarra (after Morwood and Hobbs 1995:748).

Researchers investigating stone axe quarries in Australia have examined the social relationship between production and exchange, geology and type profiles. McBryde's research in southeastern Australia (1976, 1984, 1987, 1997), explored the social contexts of production and distribution by considering the archaeological evidence against that provided by ethnography, linguistics, ethnohistory and geology. Binns and McBryde (1972) conducted a petrological survey of stone axes from museums and private collections in New South Wales. This research resulted in a substantial publication that linked geological types to possible quarry sites. McBryde and Watchman (1976) carried out a similar geological survey at Mt William and Mt Camel stone axe quarries in Victoria. These quarry studies emphasised the social and geological contexts of distribution.

3.6 Axe size and distance decay

McBryde and Harrison (1981) noted the affects of increasing distance from the source with implement size. They studied the basalt axes from Mt William, and the andesite axes from Berrambool in Victoria. They argued that the fined-grained greenstone and andesite both provided ideal raw material and hardness that made them suitable for edge-ground heavy-duty implements.

McBryde and Harrison's (1981) noted that directional trends for axe exchanged from Mt William does not relate to raw material availability (geology). They suggest that 'distance decay' in their analysis is characteristic of Renfrew's (1977) 'down the line exchange' for Mt William and his 'directional trade' by the concentrational effects associated with redistribution centres (McBryde and Harrison 1981:187). However, they emphasised the social aspects of exchange. The ethnographic evidence of Howitt (1904:311-2) suggested that access to Mt William was restricted and the stone worked by specialists/professionals who held requisite social status and kin affiliation. McBryde (1984) suggested that quarry ownership and permission to use it served as both a source of material and social purposes with the flow of goods being socially determined. The

Nillipidji quartzite blade quarry in Arnhem Land had similar conditions on access according to Thompson (1949).

McBryde and Harrison’s (1982:Fig13.11) analysis demonstrated that axes sourced to Berrambool increased in mass as distance from the source increased although this was within a 30 kilometres radius of from the source. However, the greenstone axes from Mt William were only minimally reduced in mass as distance increased (McBryde and Harrison 1982:Fig 13.11). They explained this phenomenon as one of ‘valued good’ for the Mt William ‘greenstone axes’ rather than ‘valued stone’ for the Berrambool axes. They argued that valued stone is readily available, easily acquired and has little exchange value in comparison to valued goods, which are more difficult to obtain and have a higher exchange value (McBryde and Harrison 1982:196). Artefacts made from valued stone might be discarded earlier in their use life, particularly when damaged or broken, demonstrating scant concern on the part of the owner to conserve material (McBryde and Harrison 1982:201).

Conversely, distance-decay curves for their distribution appear to form a curvilinear pattern with mass increasing slightly on those axes away from the source and decreasing minimally in size as distance increases from the quarry. The different mass/distance of Mt William axes may be explained by ‘valued good’ that results in near uniformity in mass over distance. The shorter distance from the source of andesite axes maybe explained by early discard into the archaeological record (McBryde and Harrison 1982).

Graphic representations of the curvilinear pattern of Mt William axes and the increased mass of the Berrambool axes represents a significant departure from results obtained in Hughes (1977), Strathern (1969) and Chappell (1966) for distance decay. However, it is supported by Tibbett’s (2000, 2002a, 2002b) analysis of stone axe exchange in northwest Queensland. Axes located at Moondarra are smaller than those exchanged from the site. This marked increase in the size of the Moondarra stone axes away from the immediate source and minimal reduction in dimensions as distance from the source increases, can be interpreted as a curvilinear trend between Mt Isa and Gason, which is 770km south of Mt Isa in a direct line (see Figure 3.2). The similar length of axes at Kopperamanna and Glenormiston is explained by the existence of a direct exchange relationship between Glenormiston and Kopperamanna. Down the line exchange may explain the steadily decreasing length of axes between Glenormiston and Gason, and Kopperamanna and Lake Eyre.

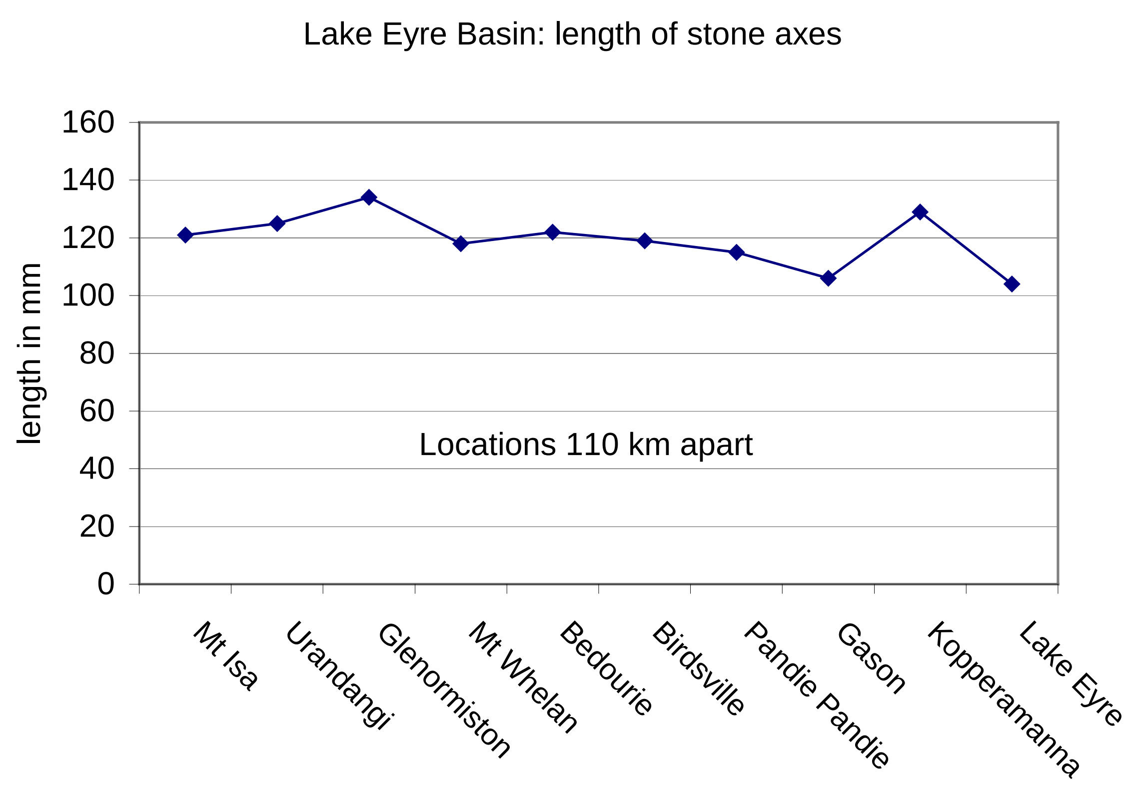


Figure 3.2. Stone axe lengths between Mt Isa and Lake Eyre (from Tibbett 2000:23).

The way axes enter the archaeological record can constrain the type of interpretations that are possible. As noted by Gould (1980:207) a limitation in axe studies at Mt William was the relatively few numbers of ethnographic or archaeological samples in museum collections and the reliance on surface finds. Chronological change in distribution patterns may not be possible with this type of data (Gould 1980:207). This restriction applies to the data presented in this thesis.

3.7 Other lithic distance decay studies

Byrne (1980) examined the distribution of silcrete artefacts from the lower Murchison in Western Australia and his research is relevant to distance decay studies. He analysed the distribution of Pillawarra silcrete over 45 habitation sites within a 27 kilometres radius from the raw material source. He suggested that the assemblages reflected the ‘flow’ of artefacts through the Aboriginal cultural system as articulated by Gould (1977b), Schiffer (1972), and Sheets (1975). This ‘flow’ shows markedly decreasing size of artefacts within relatively short distances from the raw material source. The importance of Byrne’s (1980) observation is that it differs to studies involving long distance axe exchange where minimal decreases are noted over hundreds of kilometres ((McBryde and Harrison 1982, Tibbett 2000).

Byrne assumed that he was dealing with the dispersal of raw material and finished tools in the form of cores and primary flakes from the quarry. He suggested these tool forms in the light of ethnographic evidence for the significance of un-retouched items used as implements (Hayden 1977, Horne and Aiston 1924, and Gould 1971). Hayden (1977:179) argued that secondary retouch may amount to maintenance of cutting edges. Therefore, instead of establishing a dichotomy between worked and unworked material, he used a model based on ‘a continuum of increasing modification of stone material depending upon such variables as the intended function and the duration of use on implements’ (Byrne 1980:113).

Byrne (1980) hypothesised that two procurement methods may explain how tools entered the archaeological record at sites. Direct procurement involving transportation of material from the quarry to individual sites, and indirect procurement where the material arrives at the site as part of the ‘curated stock’ in the form of cores and implements. He suggested that a ‘fall off curve’ was related to cores being reduced in size with distance from the quarry that also resulted in smaller flakes being struck from the cores. Byrne’s (1980:118) analysis indicated that the flow of raw material from the source resulted in reduced availability and diminished supply.

3.8 **Defining trade routes in the Lake Eyre Basin**

Numerous ethnographers and archaeologists verify the assumption that stone axes were exchanged from northwest Queensland (Horne and Aiston 1924, McCarthy 1939, McBryde 1997, McConnell 1976, Roth 1897). The earliest documented axe production at the Bora Goldfield (Moondarra) was by Roth 1897. Despite describing axe manufacturing in some detail and collecting numerous specimens that are now located at The Australian Museum (Sydney), he did not describe axe trade routes as their manufacture and use had largely been discontinued by 1896 when he gathered the data. However, he did describe the expansive Aboriginal 'markets' that operated at Boulia, Upper Georgina, Leichardt Selwyn Ranges and Cloncurry (Roth 1897:134). The items exchanged at these markets included, pituri (a narcotic substance associated with ritual), coolamons, spears, human hair, stone knives, grind-stones, possum twine, boomerangs, hook boomerangs, leaf shaped wommeras, painted shields, pearl shell, eagle-hawk feathers, blankets, yellow ochre, and red ochre (Roth 1897). It is reasonable to assume that stone axe exchange had previously taken place at these locations.

Horne and Aiston (1924:34) recognized a connection between the stone axes from Cloncurry and Kopperamanna, near Lake Eyre. They suggested that Kopperamanna was the Aboriginal 'bartering post' for stone axes entering the Lake Eyre region. They believed that the axe heads were traded because the local stone was unsuitable for grinding and polishing. The rock formations in the Lake Eyre Basin are essentially sedimentary (1980, Atlas of Australian Resources) and probably unsuitable for use as axe-heads. Aiston (letters 27/2/1921) also referred to the Kopperamanna 'Aboriginals' receiving their tomahawks from a quarry near Cloncurry. This was the nearest township to Moondarra prior to the discovery of silver, lead and zinc by John Miles at the location now named Mt Isa in February 1923.

McCarthy (1939:101,423) argued for an almost direct exchange route for stone axes between northwest Queensland and South Australia. He suggested that the direction of the trade route was through the Mitakoodi country, across the Leichardt-Selwyn Range and down the Burke and Wills River (now the Burke River) to Boulia, into the territory of the Pitta Pitta, and thence down the Georgina River and Coopers Creek passing through Bedourie, Birdsville and Kopperamanna (see Figure 3.3). The Molonga corroboree, fluted boomerang, hooked boomerang, pituri, stone axes, and baler shell were apparently exchanged along this pathway (McCarthy 1939). To support his proposed networks McCarthy relied extensively on ethnographic reports and considered that physical geographical features determined the direction of the trunk trade routes. He believed that features such as deserts were only crossed when water was available and that the riverine corridors were highways (McCarthy (1939:176).

McConnell (1976) did not refute axe exchange between Mt Isa and Lake Eyre but she suggested that the axe exchange pathway between western New South Wales and Lake Eyre might have been of similar volume. She (1976:87) generally agreed with McCarthy’s (1939) suggested trade routes, but recommended the term ‘direction’ rather than ‘route’, to overcome the necessity to demarcate rivers as the only possible exchange pathways. She viewed an exchange route for edge-ground axes, from northwest New South Wales to the Lake Eyre Basin as a distinct possibility. McConnell (1976:30) argued that a stone axe trade route between Cloncurry and Lake Eyre proposed by Horne and Aiston (1924), Tindale (1950), and McCarthy (1939) is evenly matched by the proposition by Basedow (1925:362) and Aiston (Letters: 27/3/1921) who suggested a trade route from western NSW into the Lake Eyre region. She perceived Basedow’s (1925) report (1976:30) as a conspicuous omission from McCarthy’s (1939) study and challenged McCarthy’s evidence on the basis that he had not incorporated this material. Basedow (1925:362) suggested that the morphology of the axes around Coopers Creek were very similar to that of the axes from New South Wales. A morphological and geological examination of stone axes from western New South Wales and northwest Queensland suggested that these axes are not comparable (Tibbett 2000).

McBryde’s (1997:10) demarcation of the exchange route for stone axes in the Lake Eyre Basin suggested that the route moved southwest from Mt Isa to Glenormiston before reaching Boulia. This interpretation deviated significantly from previous work including McCarthy (1939), McBryde (1987, 1989) and Roth (1897). This pathway was southwest from Mt Isa through the pituri-growing region along the Mulligan River (Glenormiston) before reaching Boulia (Figure 3.3). From Boulia southwards, the exchange route followed the course suggested by previous work. Preliminary research by Tibbett (2000, 2002a) based on a statistical analysis of axes provenanced to the Lake Eyre Basin supported McBryde's (1997) suggestion that axes were traded southwest from Mt Isa directly to Glenormiston.

Previous researchers have supported an exchange route for stone axes from northwest Queensland into the Lake Eyre Basin. Nevertheless, Tibbett (2000) suggested that smaller axes, provenanced to the Boulia district, were not exchanged into the arid region. This is further discussed in Chapter 10.

3.9 **Previous research at Moondarra**

Roth carried out extensive material observations of Aboriginal culture in Northwest Central Queensland when he held the position of Surgeon at the Cloncurry and Boulia Hospitals. He subsequently published these accounts in 1897 and made numerous mention of Kalkadoon social and material culture including the greenstone axes (Pickwick basalt) they once produced in the Leichardt-Selwyn Ranges.

Despite the excellent material records of Kalkadoon culture, Roth (1897) declared there was a paucity of data on stone axes and their manufacture. He recorded the demise of axe production as:

> The stone tomahawk used to be made years ago, previous to the advent of the whites and their more serviceable metal ones, by the Kalkadoon, Mitakoodi &, from a kind of greenstone obtained in the Leichardt-Selwyn Ranges. (Roth 1897:151)

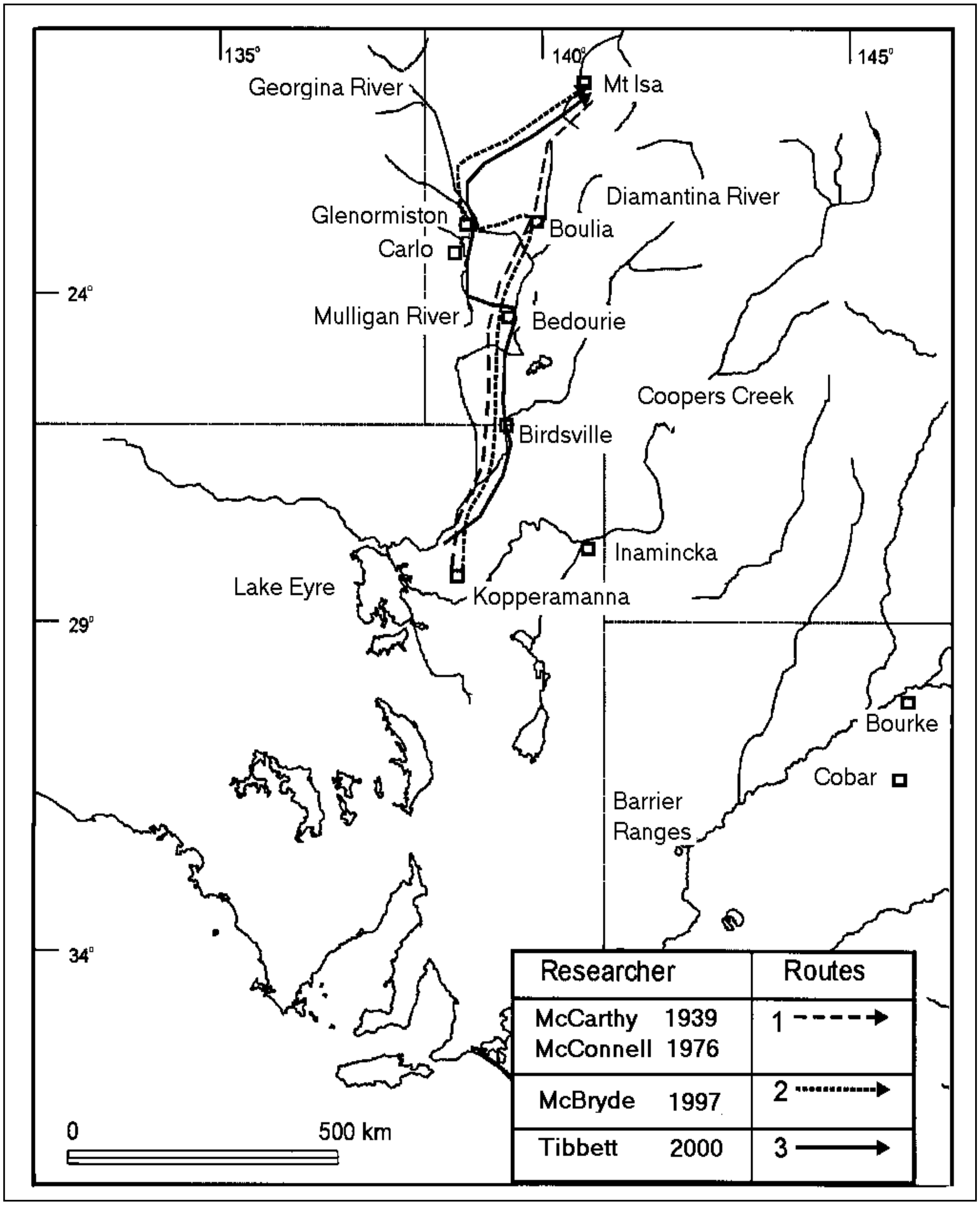


Figure 3:3. Exchange Routes for stone axes in the Lake Eyre Basin (from Tibbett 2000:58).

Nevertheless, Roth was aware that a large quarry existed at a place called Bora near the Bower Bird goldmine on the upper Leichardt River and he documented that there was a pit where the Kalkadoon miners quarried for basalt to manufacture greenstone axes. The place Roth refers to as ‘Bora’ is to the immediate north of Moondarra. A roadway to the vestiges of the Bower Bird Goldfield passes through a reduction floor at the northwest boundary of the Moondarra quarry complex.

In 1989 Lake Moondarra was nominated to be registered on the National Estate, but Mount Isa Mines (Company name now changed to Xstrata) who held pastoral, mining and exploration leases at the quarry site objected to its registration. As a result Brayshaw was commissioned by MIM to assess the significance of Moondarra. As part of this consultancy she published a map of the site that consequently became the baseline for my field survey. In 1989 the selective availability of the earlier Global Positioning Systems (GPS) would have made mapping by GPS problematic. Nonetheless, Brayshaw (1989) compiled a useful sketch map and she confirmed that Moondarra was a culturally significant Aboriginal site. Brayshaw’s (1989) cultural heritage assessment is significant in the recent history of Moondarra. Her affirmation of the site as culturally significant while consulting for MIM endorsed the EPA’s recommendations to the National Estate and possibly limited mining exploration to seismic exploration at the site. Mining survey pegs from this era are present along some sections of Stone Axe Creek, but it is unknown whether these pre- or post-date Brayshaw’s (1989) report.

Innes (1991) and Simmons (1991) examined aspects of Moondarra for their Honours theses and supplied data to the EPA to be utilised for management strategies. Innes examined the spatial distribution of axes at Moondarra, though he did not survey outside the known precincts set by MIM and Brayshaw (1989). This acceptance of earlier demarcations resulted in two reduction floors (located outside the accepted boundary) being overlooked. Nevertheless, Innes’ thesis provides an interesting synopsis of Torrence’s (1986) interpretation of middle range theory at quarry sites and that ethnographic material from Irian Jaya (Langa) and Papua New Guinea (Tuman quarries) may be useful in relation to the quarrying activities at Moondarra. Innes (1991) argued that the standardised production of stone axes from Jimi and Middle Wahgi valleys, where an individual-based exchange system was incorporated within an egalitarian society, was a counter to Torrence's suggestion that an increase in the 'complexity of the society' results in more effective exchange networks and an increase in levels of social stratification.

Simmon's (1991:1) thesis examined the distribution of lithic material away from the quarry. He investigated the area surrounding the main quarry in order to locate the sources of raw material. He also explored the arguments of Binford and Torrence with respect to time stress, scheduling and embeddeded behaviour in lithic procurement.

I have suggested elsewhere that at Moondarra, stone axes were produced primarily for exchange (Tibbett 2000, 2002a, 2002b). Simmon's examination of quarried material within 10 kilometres of the southwest corner of the site is thus viewed as an imprecise method of gauging time stress, scheduling and embeddedness when the main purpose of the quarry appears to be the manufacture of axes for exchange outside the group/s home estates.

In 2001 the Natural Heritage Trust (NHT) and the Environmental Protection Agency, Queensland (EPA) commissioned a long-term plan of management for Moondarra and its associated sites including appropriate conservation strategies. This project (Tibbett 2001) was aimed at increasing knowledge regarding cultural heritage values of the site, identifying particular management issues, promoting cultural heritage conservation in the area and delivering information that could be used for general input into land management planning and conservation. It also assessed the condition of the sites and the impact that stock, mining, roadways, erosion and public access were having at the quarry. All quarries and reduction floors were identified recorded and mapped. This project provided a sound basis for research undertaken in this thesis.

Hiscock and Mitchell (1993) have also conducted research at Moondarra to identify quarry type profiles. Hiscock (2002) has an unpublished paper titled *The ancient miners of Mount Isa,* which outlines a general description of axe production and distribution in northwest Queensland.

3.10 **Conclusion**

This chapter introduced ethnographic and archaeological evidence such as previous distributional studies, practical and prestige items, risk and technology, previous studies at Moondarra, and distance decay. An analysis of previous theories of exchange, the forms that exchange might take, the combination of both social and ceremonial aspects associated with exchange and the concepts involved with distance-decay models and how this may be applied to distinguish long-distance exchange were presented. This information provides a foundation for subsequent analysis in this thesis.

Chapter 4 Methods and approaches

4.1 Introduction

This chapter describes methods and approaches used in the thesis. One of the biggest issues for the Lake Moondarra site is that despite being perhaps the largest stone axe quarry in Australia, it had not been comprehensively mapped. A range of different methods were applied including mapping, surveying, statistical analysis and experimental archaeology. Other considerations were site definitions, selection of sites for surveys and excavations, excavation methods, raw material types used at the site, artefact distribution and recording and a method of classifying debitage.

The constraints and conditions on research set by the Kalkadoon Aboriginal Council (KAC) was another important aspect of this research. This chapter provides a foundation for understanding the methodologies applied in subsequent chapters regarding site survey and excavation.

The conditions were negotiated over a number of meetings with the Kalkadoon Aboriginal Council (KAC). The principal provision was that cultural material was not to be removed from the landscape. Similar requests are becoming established procedure among traditional owners in northwest Queensland and are intended to preserve Aboriginal cultural environments (see Barton 2001:179).

This requirement necessitated that all cultural material was recorded in the field without the benefits of subsequent analyses in a laboratory. As a result, field technological analyses were restricted to predefined questions. This necessitated an expedient system of artefact classification and considerable planning and organisation in the field. However, this had an advantage in that research questions remained sharply in focus.

4.2 Definitions: quarries, reduction floors and habitation sites

Sites were identified as quarries or reduction sites in general agreement with the type profiles suggested by Hiscock and Mitchell (1993:23, 29). They defined a quarry as ‘a location of an exploited stone source’ and a reduction site as ‘the location of early stage stone artefact manufacture i.e. those stages of reduction that precede use’ (Hiscock and Mitchell (1993:32).

Hiscock and Mitchell (1993:21) sought clear definitions for ‘quarry’ and ‘reduction site’. They suggested that quarry definitions align with three broad categories:

(a) any source of stone used in the production of artefacts,

(b) only those sources of raw material at which there is evidence for extraction of stone, and

(c) both the source of raw material and the artefact scatter associated with it.

However, the definition of a reduction site requires some refinement to differentiate between these and quarries at Moondarra. At some quarries the knapping processes may continue to a more advanced reduction stage, with resulting debris being found at quarry sites. In spite of this, these two sites types can be distinguished.

In this thesis, quarrying areas are defined as: 1. locations where basalt is in natural formations. 2. where large anvils and hammer-stones are present. 3. where blocks with negative conchoidal scars occur. 4. unretouched flakes (reject preforms). 5. that have evidence of Aboriginal mining, and 6. where large flakes that are the debris from primary reduction of axe blanks are present. Conversely, ‘reduction sites’ do not have features such as these. In addition, reduction sites are located near creeks and they are separated from the raw material sources.

Hiscock and Mitchell’s (1993) definition of reduction site is accepted in relation to axe production, but the presence of hearths and subsistence type tools suggests that they were also camping or habitation sites.

4.3 **Survey and mapping techniques**

A Global Positioning System (GPS) was used to identify locations during the survey in conjunction with a Garmin 3.03 Mapsource computer program used in the field. GPS position accuracy was improved by averaging the coordinates. The recorded data was then converted into a format compatible with ArcView 3.2. Maps of all the recorded sites were produced in ArcView and projected onto conjoined air photographs. ArcView is a powerful program that enables GPS waypoints of individual sites to be connected with polygons that represent the spatial dimensions of each site. In addition, the program can calculate the area of each polygon or site and precisely measure distance between two or more points. In combination, this equipment provided accurate areal measurement of the dimensions of sites.

The 1:100,000 topographic map for Mary Kathleen, (the smallest scale available) has a contour interval of 40m which means that vertical detail of the sites is reduced if the Arc View map is projected over the topographic map. Air photographs were used as they highlight the horizontal features in more detail and provide some visualisation of vertical characteristics, although specific heights cannot be calculated.

The Gamin 1200XL GPS unit used during the survey documents accuracy to within ±15 metres. This conservative measure of error is calculated by squaring the maximum possible error ($\pm 3.87\text{m}^2 = \pm 15\text{m}$). While the GPS may result in some inaccuracy, the spatial relationship between points in the survey may be accurate to within ± two metres. The boundaries of reduction floors adjacent to recognisable features such as creeks and roadways were projected onto the aerial photographs with the degree of accuracy at approximately two metres. This is a comparatively accurate method of mapping sites in extremely rough terrain with limited intervisibility. However, ArcView

3.2 cannot transfer elevations recorded in GPS readings to maps. Therefore, the site map cannot show contour lines or elevation.

The survey at Moondarra was aimed at resolving the following issues:

(a) What are the spatial dimensions of the different activity areas?
(b) What are the site boundaries?
(c) Are specific landforms associated with specific site types?
(d) What types of stone were quarried at Moondarra?
(e) Were axes the only artefacts manufactured at the site?

Sections of the landscape were traversed within and outside the known boundaries to ensure that the survey encompassed all activity areas associated with Moondarra. This involved a 100% ground survey of the site and surrounding areas. The original boundaries (4km x 2km) identified by Brayshaw (1989) were re-surveyed with special attention directed towards waterways and ridges. Every watercourse was examined for sites along both banks. GPS waypoints were recorded as sites were identified to provide an accurate areal interpretation of Moondarra. Additional reduction sites and quarries were found by tracking debitage in the creek-lines and gullies back to their primary depositional location. After mapping, these sites were identified as contiguous quarry or reduction floors.

Site boundaries were recorded by walking around the perimeter of quarries and reduction floors and entering waypoints into the GPS at approximately every seven to eight metres, or more frequently if the boundary deviated from a straight line. Quarry sites with an area of less than 10 square metres were not recorded, which eliminated extremely small sites where sometimes only a few pieces of basalt had been assayed or quarried. Frequently, axe production at these small sites did not appear to proceed after these initial assessments. The exclusion of these smaller sites from the survey did not significantly reduce the total area of the quarries in percentage terms and their inclusion might be inappropriate indicators of past quarrying activity when only rock quality had been tested.

Each site was identified alpha-numerically. For example, reduction floors were identified as R1 through to R6 and quarries from Q1 to Q26. These alpha/numerical survey references are used throughout the thesis to identify particular sites.

Following the major site survey and mapping, specific surveys were undertaken at various quarries and reduction floors to address three research questions. First, this was to enable comparative analysis of relative homogeneity in production to be assessed. Metrical analysis was conducted for 130 axes from six different quarries and 91 axes from reduction floor two (see Appendix B). Second, two basalt hardstone quarries were examined to determine if negative percussion scars had been struck from fractured planes or prepared platforms. In both cases three 20m x 3m sections were investigated. This assessment was aimed at assessing whether firing or percussion were responsible for fracturing the basalt. In particular, firing would split the stone and form planes suitable for platforms from which flakes could be knapped. Third, detailed surveys were conducted on most sites identified during the original survey to create an understanding of the inter-relationships between sites.

An offsite survey was conducted at Gunpowder another significant axe quarry approximately 50km north of Moondarra. This was to provide comparative data for Moondarra. Surveys were also conducted at a silcrete blade quarry and an andesite axe quarry near Lagoon Creek, which is about 20km south of Moondarra, and at a quartz quarry about four kilometres west of Moondarra.

Innes (1991) and Simmons (1991) used transect surveys in their Moondarra research, however their objectives did not include mapping the site. Brayshaw’s (1989) survey was not completed by GPS and did not include some sites but it provided a useful baseline for this investigation. Transect surveys were deemed inappropriate for this research as the intention was to survey all archaeological sites associated with the complex. This was necessary so that the relationship between different activity areas could be defined and interpreted.

4.4 Selection of sites for excavation

Two sites reduction floor 3 and reduction floor 4 were excavated for this thesis. R3 and R4 were selected for excavation because they had reduced evidence of cattle trampling and less apparent effects of erosion in comparison with others. Erosion was a major problem and at two reduction floors, runoff across the site was increased by water channelling down the roadways after land clearing. Plate 4.1 shows a track running through the centre of R1, where a cattle trampling has changed the topsoil into a fine powder-like form known as bulldust. Excavation of sites where dramatic post-depositional processes may have removed substantial depths of topsoil and artefacts is obviously problematic.

Plate 4.1. The effects of roadwork and cattle trampling at R1. Clinton Percy standing beside the track cutting through the centre.

These issues precluded the employment of a random sampling strategy to the selection of excavation sites impractical. However, within chosen sites, a random sampling was used to select areas for excavation.

4.5 **Excavation methods**

Excavation methods similar to those outlined by Hobbs (1983) were applied during excavations. A 5m x 5m area was grided in one-metre squares and a surface collection was undertaken across the entire area (see Table 4.1). Three squares were then randomly selected for excavation. A card was allocated to each surface square and spit number that recorded the attributes of every artefacts recovered (see Appendix 1 for detail), the weight of soil and rock excavated from each spit was also recorded.

5	A5	B5	C5	D5	E5
4	A4	B4	C4	D4.	E4
3	A3	B3	C3	D3	E3
2	A2	B2	C2	D2	E2
1	A1	B1	C1	D1	E1
Row	**A**	**B**	**C**	**D**	**E**

Table 4.1. Diagram showing relative squares at R3 and R4.

Excavations were undertaken in one-metre squares on the reduction floors. At the Aboriginal mining pit on Q12 (MP1), the area of excavation changed from 1m x 50cm to 50cm x 50cm. When change occurs, notations are provided. During excavation, spits were numbered sequentially from the surface down to the basal spit. A dumpy level was used to measure elevation. Each artefact was attributed an individual identification number which refers to the site, square number and spit number e.g. an artefact from Reduction floor 4, Square A3, Spit 4 would be recorded as R4A3 Spit 4 and then numbered sequentially (see Appendix A). Stratigraphic layers were not visible during the three excavations. Therefore, excavations progressed applying arbitrary 2cm spits.

At R3 and R4 and, excavations continued to 10 centimetres below the basal layer of cultural material. In the semi-arid environment of northwest Queensland this depth was considered appropriate given the minimal soil formation process. Prior to the excavation of MP1 a test pit was conducted to determine a site's depth, and contents prior to a major excavation.

All excavated material was screened through two nested sieves with mesh sizes of 3mm and 1.6mm respectively. The smaller sieve was intended to retain minuscule charcoal deposits as it was anticipated that this might be necessary in an open site. Few charcoal samples were excavated in association with artefacts, and these were extremely small in mass (the largest sample was 0.031gm) as a result, Accelerated Mass Spectrometry (AMS) was used for dating. The excavated soil and rock was bulk-weighed before sieving and the rocks weighed after sieving, which facilitated the calculation of the total weight of excavated soil. Electronic scales were used at the R3 excavation and spring scales and electronic at R4.

Given the constraints imposed by the traditional owners, sorting, analysis and recording was undertaken in the field. Charcoal samples were retained for subsequent testing. Excavated data were transferred from completed site sheets to a computer spreadsheet daily (Appendix A, B). Such checks were important as excavated materials were reburied at the end of the field season preventing additional laboratory checks. The excavated artefacts were reburied when the excavation stage and artefact recording was completed in the spits they had been excavated from. Heavy-duty plastic sheeting was placed about 10cm below the surface to indicate that the site was superimposed.

4.6 Categorising raw material

At Moondarra, the artefacts recorded from quarries and reduction floors consisted of four stone types. Basalt was chiefly represented but two types of quartzite, quartz and chert were also recorded. Descriptions of the four material types are given in Table 4.2. These material types are identified in Appendix 1 as:

(a) Basalt = 1,
(b) Quartzite = 2,
(c) Quartz = 3, and
(d) Chert = 4.

Type	Raw Material	Description
1	Basalt	Basalt is the stone used at Moondarra and was used in the manufacture of stone axes. The majority of axes are olivine in colour, but at least five variations can be noted.
2	Quartzite	Quartzite was used extensively in tool manufacture at Moondarra. Quartzites are metamorphosed quartz sandstones and are median- to coarse-grained.
3	Quartz	Quartz at Moondarra is a white or milky variety. It has a trigonal crystal system. Crystals are usually six sided prisms and are terminated by six faces. It has a hardness of seven under the Mohs scratch scale (Bishop *et al*. 1999). Quartz has conchoidal fracture properties (Bishop *et al*.1999) but is usually undiagnostic in attempts to classify pieces as flakes.
4	Chert	Chert is a very fined-grain smooth rock with conchoidal fracture properties (Bishop *et al*. 1999). It is a siliceous sedimentary rock that occurs as nodules, lenses or layers in limestone and shale (Hiscock 1988:318).

Table 4.2. Material types used in artefact manufacture at Moondarra.

4.7 Artefact attributes and recording

Artefact attributes and the conventions used to measure them are shown in Table 4.3. This refers to axes (which are flakes) struck from cores, trimming flakes struck off axes during further reduction, subsistence tools on reduction sites (small blades), and leilira blades. To distinguish trimming flakes struck from axes from other types of flakes, the term trimming flake is used. At excavation sites R3 and R4 surface collections are presented in tables in the result chapters and in Appendix A. Where excavations were conducted, surface data for that particular square is shown as surface data before the descending spits.

Attribute	**Measurement convention used**
Flake Length	Callipers were used to measure the percussion length of flakes from the ring-crack to the distal margin, and measurements were recorded to the nearest millimetre. According to Hiscock (1988:366), the surface area of the fracture can be calculated by multiplying the length and width of an artefact.
Flake Width	Two methods were used to measure percussion width. First, all artefacts except axes were measured at right angles to the mid point along the percussion length. This measurement is not always the widest point of a flake but when calculated in conjunction with length provides a more accurate estimation of the ventral surface area. Second, axe percussion width was measured at right angles to length axis at the widest point. In most instances this variation did not significantly alter the width, as the axes are generally discoid in shape. The maximum width was recorded so that comparative analyses could be conducted with data from the Lake Eyre Basin collections provenanced to Mt Isa (Tibbett 2000).
Flake Thickness	The thickness of artefacts was measured with callipers to the nearest millimetre. This measurement was taken at the mid point between the ring-crack and the distal margin.
Platform Width	The width of the platform was measured with callipers on the platform surface between the margins to the nearest millimetre.
Platform Thickness	Platform thickness was also measured with callipers to the nearest millimetre from the ventral to the distal faces in alignment with the ringcrack. Platform thickness measures the thickness of the flake at the ringcrack and the distance of the point of force from the core. Hiscock suggested (1988:371) that the location of the point of force is significant as it determines the area (size) of the fracture plane and ultimately the flake size. In conjunction with platform width, platform area can be measured. Hiscock (1988:371) also suggested, that similar to platform width, platform thickness may indicate increased control of the placement of blows, possibly related to overhang removal.
Weight	The weight of artefacts was measured to the nearest gram using electronic scales. A known weight is part of the calculation of mass, which is the probable measure for the quantity of matter in a body. Mass is an indicator of factors such as inertia and size but does not measure shape (Hiscock 1988:36).
Platform Angle	Platform angle is the measurement of the angle between the platform and core face on the producer immediately before the flake is struck (Hiscock 1988:373). Hiscock suggested that this might determine the amount of force required to create the flake (Hiscock 1988:373). Platform angles were measured using an engineer's metal protractor that measures solid angles to within one degree of accuracy. This accuracy is possible as the solid angle being recorded is extended from the artefact being measured to the graduated semicircular instrument or goniometer. Whenever the relationship between the platform and ventral surface seemed irregular, two or more measurements were taken and the average angle recorded.

Table 4.3. Artefact attributes and measurement conventions.

4.8 **Debitage classification**

Recording debitage by type enables subsequent analysis on breakage patterns such as trampling, post-depositional issues, and comparative analysis between complete and broken flakes. Measuring artefact length, width, thickness, platform width, platform thickness, edge angle and weight allows for changes in artefact size, type, density, correlation between variables and reduction strategies to be examined.

Two approaches to debitage analysis were utilised. First, the system applied by Sullivan *et al*. (1985) to analyse debitage was adopted (with a slight modification), as this method enabled rapid field analysis of debitage into types. Sullivan *et al*. (1985:758) argued that debitage analyses should be conducted with interpretation-free categories to enhance objectivity and replicability. They applied three dimensions of variability, each with two naturally dichotomous attributes (Sullivan *et al*. 1985:758).

Their first dimension of variability is the ‘Single Interior Surface’ indicated by positive percussion features such as ripple marks, force lines or a bulb of percussion (see also Speth 1972:35). Sullivan *et al*. (1985:758) suggested that if these features are not reliably determined or if there are multiple occurrences of them, a single interior surface could not be distinguished.

Their second dimension of variability is the ‘Point of Applied Force’. On debitage with intact striking platforms, the point of applied force occurs where the bulb of percussion intersects the striking platform. When only fragmentary striking platforms remain, the point of applied force is indicated by the origin of force line radiation. When the striking platform is absent, the point of applied force is not present (Sullivan *et al*. 1985:758).

According to Sullivan *et al*. (1986:759) the third dimension of variability refers to ‘margins’. Debitage margins are intact if the distal end exhibits a hinge or feather termination and if lateral breaks (if present) do not interfere with accurate width measurement. Conversely, if these attributes are not present, then the debitage margins are not intact. This dimension does not apply to artefacts where the single interior surface is not discernable and the point of applied force is absent.

The four mutually exclusive debitage categories defined by these three dimensions of variability are complete flakes, broken flakes, flake fragments and debris. Sullivan *et al*. (1985) suggest that these four categories are interpretation free, because they are not linked to a particular technological production or imply a particular reduction sequence. Figure 4.1 outlines the technological attributes used to define the four debitage categories.

Essentially, three artefact categories were used in the analysis (see Appendix A). These types are:
a) 1 = complete flake,
b) 2 = broken flake, and
c) 4 = debris.

Category one, two and four are synonymous with the debitage terms ‘complete’, ‘broken’ and ‘debris’ respectively. As the analysis is designed to answer specific research questions, it was decided to avoid category three (flake fragments) whenever possible. The absence of a point of applied force in classifications defined by Sullivan *et al*. (1985) might categorise some flakes into category three (flake fragment) that may otherwise be classified as one (complete flake) or two (broken flake). At Moondarra a high proportion of basalt flakes are shattered with only fragmentary striking platforms remaining. When only a portion of the platform is present it is difficult to recognise the point of applied force.

Hiscock (1988:373) suggested that shattered platforms may be the result of excessive force and/or that the blow was located very close to the edge of the core. This result is possibly common when trimming thin flakes from basalt axes. Therefore, if the point of applied force could not be determined on a shattered flake that possessed a positive bulb of percussion, it was classified as type one or two depending on the condition of the margins. It was felt that analysis of data with a high proportion of flakes without striking platforms might contaminate the result if some intact and non-intact flakes were categorised into flake fragments.

According to Odell (2000:313), the typological system of Sullivan *et al*. (1985) has proven less than advantageous and may be difficult to follow in the future. He suggested that the system may be helpful for a researcher who desires information on breakage patterns, but not for other questions. However, with some minor modification this proved a useful typology for this research when used in conjunction with other analyses.

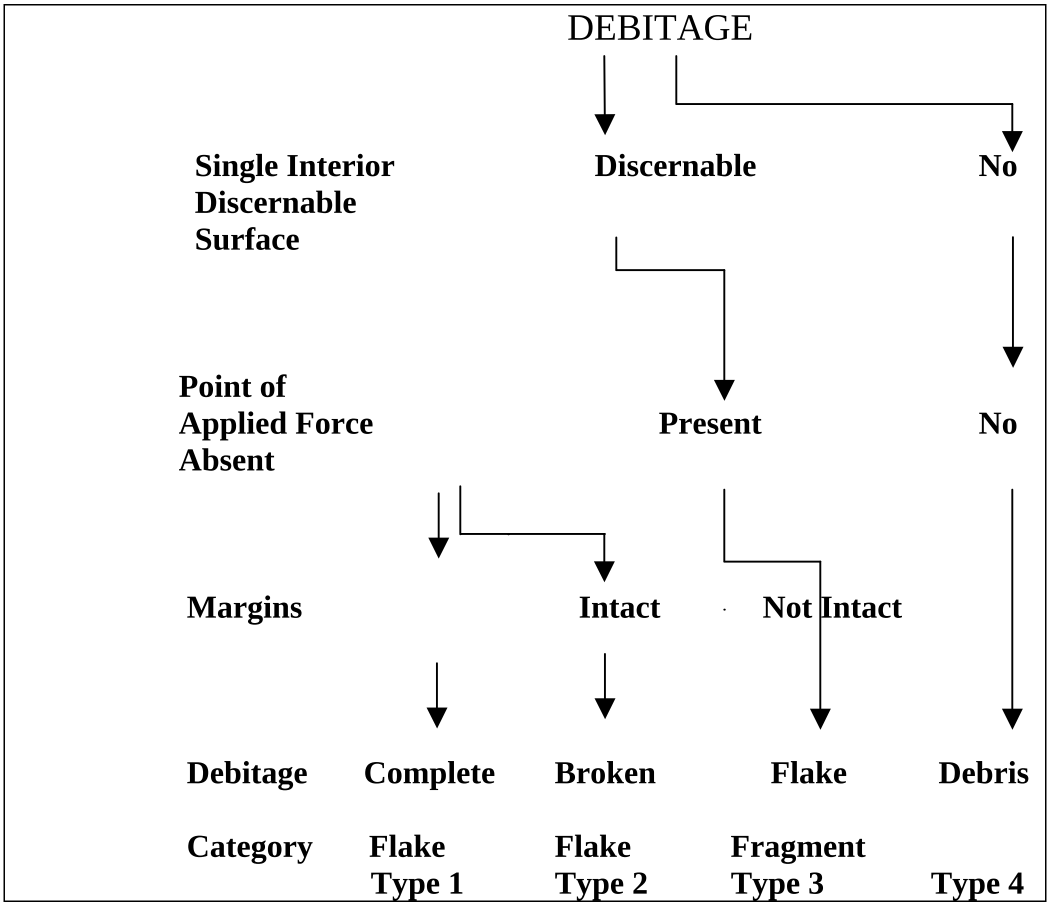


Figure 4.1. Technological attributes to define debitage categories (from Sullivan *et al*. 1985:759).

The second method of recording data was measurement. Flakes were measured to determine artefact length, width, thickness, platform width, platform thickness, edge angle and weight. Once recorded, this data was entered onto a spreadsheet to enable rapid metrical analysis.

4.9 Experimental archaeology

Some experimental edge grinding was conducted on basalt flakes and quartzite blocks using wet sand and quartzite colluvium from Stone Axe Creek and reduction floor two as grinding agents. Large quartzite stones were recorded on the knapping floors at Moondarra and large basalt grindstones were noted at Gunpowder. These grindstones may have been used to edge grind axes. Experimental archaeology tested the feasibility of using a grinding agent and an estimation of the time taken to conduct this action. Roth's (1897) notation that it took 24 hours to grind an axe seemed to be an extraordinary amount of time. The basalt used was gathered from the surface of Q2. This non-cultural material (surrounded by knapped stone) was knapped to form an edge similar in shape, size and angle to the edge of an unground axe.

4.10 Statistical analysis

Various statistical methods were used to analyses data in this thesis. These techniques included:

1. Descriptive and inferential statistics that were used extensively as a technique to describe or characterise data (see chapters 6, 7, 8, 9 and 11). In addition the mean, standard error, median, mode, standard deviation, sample variation, kurtosis, skewedness range minimum, maximum, sum and count are frequently used during these chapters. In the tables showing these results, the number of times an attribute may appear in a debitage category may change from the total number in the sample, for example in Table 7.1, edge angles have an *n* of 19 in a complete flake category of 29. This discrepancy occurs as partial platforms have made edge angle analysis problematic for 10 of the 29 samples. The mean

measurements are presented in bold print to enhance rapid comparative analysis within and between tables. Whenever the artefact count in a table is one, the standard deviation is not displayed, as it becomes irrelevant. These descriptive methods are similar to Hiscock (1988), but are presented in a format made possible by recent computer software.

2. Graphs were generally used to illustrate change of uniformity in variables. A moving analysis is used to combine two or more data sets onto one graph.

3. Inferential statistics were used to examine the relationships between two or more phenomena (see chapters 6 and 7). One important inferential statistics employed was the correlation of variation which was used to measure or gauge how closely one variable is related to another (bivariate statistics). The coefficient of variation (CV) is the Standard Deviation ÷ Mean x 100 and is the principle method to gauge standardisation in axe production. This method indicates highly variable or highly standardised assemblages.

4. Trimmed means were applied in some instances to eliminate outliers (extremely high or low values in a batch) from the samples so that they will not have an undue effect on the result. This approach removes extreme values from both the upper and lower ends of the range.

5. In the interpretative chapters, data for axes provenanced to Moondarra (both quarries and reduction floors), the Mt Isa region generally, Glenormiston, Boulia and the northwest of New South Wales are applied to test for differences in the degree of standardisation for these different axe assemblages. These results were also compared other lithic assemblages (not axes).

4.12 **Conclusion**

This chapter describes the methods used in collection of data in this thesis. The type profiles set by Hiscock and Mitchell (1993) in defining quarries and reduction floors are applied in this thesis. These definitions for quarry and reduction floors provide an unambiguous system that is readily applicable to the Moondarra quarry complex. The site survey resulted in the identification of specific areas of quarrying activity and the identification of specific features. This facilitated an understanding of the possible spatial relationships between particular areas and the development of arguments regarding the behaviour that underpinned this. This work and the identification of boundaries have been important in terms of management where has been a potential threat from mining activities near or on the site.

The request by the Kalkadoon Aboriginal Council that cultural material should not leave the field resulted in some unexpected positive outcomes. Although this regulation required additional planning, organisation and personnel in the field, it resulted in sharply focusing research questions.

Sullivan *et al*.'s (1985) classification system is an appropriate methodology for flake classification when analyses have to be completed in the field. However, the high number of shattered artefacts required a slight modification to debitage types so that specific research questions could be interpreted. Without forecasting excavation results, preliminary analysis detected a high proportion of shattered platforms, which otherwise might have biased the analysis with a high proportion of category three debris using Sullivan's *et al*. (1985) analysis system. Therefore, it was decided to add the criteria of positive bulb of percussion and force line radiation to determine debris classification. The additional recording of flake length, width, thickness, platform width, platform thickness, weight and edge angle allowed statistical computer analysis to be subsequently undertaken. Computer analyses was essential in testing for correlations between various artefact variables, changes in artefact size, determining size differences between different tool types made from the same raw material, changing density, establishing the degree of standardisation and analyzing the difference between axe populations provenanced to different regions.

Chapter 5 Spatial relationships at Moondarra

5.1 Introduction

This chapter examines the nature of sites within the Moondarra complex and their spatial relationships. This includes those that were not directly associated with axe quarrying and production. The immense size of the quarry and associated activity areas required comprehensive mapping and assessment to define the range of activities conducted in the area. This assessment provided a foundation for arguments regarding past quarrying behaviour at the site and the inter-relationship between different activity areas within it.

The survey results for 32 individual sites comprising three types of quarries and axe reduction floors. These sites types included, 23 basalt quarries used to obtain raw material for axe production, one quartz quarry where flakes were knapped and two quartzite quarries used for blade production. In addition, six axe reduction floors which are also habitation sites were recorded. The survey also recorded the area of the quarry, raw material quarried, vegetation types, ground visibility, the effects of cattle grazing upon sites, stock routes passing through them, mining activities, road building, and the impact that Lake Moondarra has had on the site. Table 5.1 shows the area of each site and the stone type of each quarry.

The rough terrain, expansive nature of the site, reduced inter-visibility and limited ground surface visibility were limiting factors in mapping the site. A systematic approach to the ground survey was required to partly overcome these natural constraints. A detailed map of the site enables the quarry to be spatially identified, arguments to be formulated regarding the relationship between different activity areas, identification of significant features within the site and provides a valuable management tool. Determining site boundaries are also important given that the site is in the immediate vicinity of one of the richest copper, silver, lead and zinc mines in the world.

Location	**Area in square metres**	**Stone type**
Q1	600	Quartz
Q2	3579.3	Basalt
Q3	6359.9	Basalt
Q4	5046.9	Basalt
Q5	3353.1	Basalt
Q6	667.5	Basalt
Q7	208.5	Basalt
Q8	1130.9	Basalt
Q9	185.1	Basalt
Q10	2894.4	Basalt
Q11	5422.3	Basalt
Q12	18899.9	Basalt
Q13	5429.9	Basalt
Q14	11025.6	Quartz
Q15	496.6	Basalt
Q16	4971.2	Basalt
Q17	1023.1	Basalt
Q18	7945.1	Basalt
Q19	7796.5	Basalt
Q20	1277.9	Basalt
Q21	3047.7	Basalt
Q22	401.2	Basalt
Q23	Not recorded	Quartzite
Q24	Not recorded	Quartzite, creek bed
Q25	975.1	basalt
Q26	5518.2	basalt
Total Area, Quarries	**98,255.9m²**	
R1	8858.2m²	
R2	51051.8m²	
R3	4937.1m²	
R4	1880.5m²	
R5	677.5m²	
R6	9301.6m²	
Total Area, Reduction Floors	**76,706.7m²**	
Total Area of Moondarra	**174,962.6m²**	

Table 5.1. The spatial dimensions of quarries and reduction floors at Moondarra.

An accurate site map showing the spatial relationship between quarries and reduction floors is crucial in supporting some suggestions advanced in this thesis. The outer boundaries of the quarry complex are 3,705m from north to south and 1,764m from east to west (Figure 5.1). Previously, the perimeters had been documented as 4km by 2km (Bradshaw, 1989, Innes, 1991 and Simmons, 1991). The reduction sites beside Stone Axe Creek and its tributaries form the southwest and northwest boundaries. The Paroo Range defines the eastern margins (Figure 5.1).

Finally, spatial comparisons are made with Gunpowder (perhaps the second largest axe quarry in northwest Queensland) and with other stone axe quarries in the United Kingdom where similar survey methods were applied to establish spatial boundaries. This illustrates the scale of Aboriginal mining activities at Moondarra.

5.2 **Quarry type profiles**

Hiscock and Mitchell (1993) identified two types of quarries in Australia: the excavated hardstone quarry and surficial hardstone quarry. They described the surficial hardstone quarry as ‘sources of stone that were exploited either by simply collecting fragments of rock scattered on the ground surface, or by breaking up lumps of bedrock that were naturally exposed’ (Hiscock and Mitchell (1993:61). To adequately encompass the changes in intensity of quarrying at Moondarra, this term requires a further definition. Large boulders at outcrops or rock-faces are surficial, but the term ‘outcrop hardstone’ enables a distinction between surface rocks and exposed outcrops of extremely dense and large blocks. Claris *et al*. (1989:6) sub-divided surface rock types by defining ‘Type A’ sites as those exhibiting unmistakable evidence of quarrying from outcropping rock rather than screes and blockfields. Outcrop hardstone, is therefore an appropriate addition to Hiscock and Mitchell’s (1993) quarry type profiles at Moondarra. This categorisation also enables one of the quartzite quarries and the quartz quarry to be adequately described.

Similar knapping techniques are noted at basalt outcrop hardstone quarries and surficial basalt quarries, but at the former the materials being worked are enormous blocks of stone. Large anvils, while not restricted to these areas, are more prevalent at hardstone outcrops. Evidence of specialised techniques such as wedging (discussed in Chapter 8) is also present at these quarries. Plate 5.1 shows a hardstone quarry.

Plate 5.1. An outcrop hardstone on Q5 at Moondarra.

5.3 **Spatial relationships**

Quarry 1 is a quartz quarry about 30m by 20m and is the most southerly quarry at Moondarra (Figure 5.1). There is no vegetation within the quartz quarry, but spinifex surrounds the site. The quartz outcrop is up to three metres in height in some areas and consists of a number of large boulders with extensive quantities of scree on the southern, downward slope. The quartz is white and milky and although possessing conchoidal properties (Bishop *et al*. 1999), no evidence of conchoidal fracture was observed on flake debitage at the site.

Geological evidence suggests that greenstone blocks and hammerstones were carried to Q1 as greenstone is a foreign material here, just as is quartz at the reduction floors. Basalt blocks weighing approximately 10-12kgs that were possibly used as anvils or pounders for smashing quartz from the outcrop are located in the centre of the quartz quarry. These blocks had evidence of pounding or crushing on the surface resulting in numerous indentations where chips of stone had been removed. Smaller fist-sized basalt hammer-stones (weighing 700gm to 1500gm) are also present in close proximity to the anvils. These smaller basalt artefacts had distinctive wear patterns where numerous chips of stone had been removed. The basalt appears to have been transported a minimum of 320m from the nearest basalt source at Q25 (see Figure 5.1).

Quarries 2, 3, 4, 5 and 6 are basalt quarries, possibly from the same geological event as they form a ridgeline interconnected by saddles. Q2 covers an area of 3,579.3m², which is considered medium-sized. It is an extensive surficial hardstone quarry. Entrance to Q2 may be obtained from two points. The first and by far the easier path is via the creek-line than transects the southern portion of R2 (see Figure 5.1). The second access route originates just north of R2 and continues in a southeasterly direction towards the quarries. This course is steeper near the quarries. Spinifex is the dominant native pasture and snappy gums are frequent on the quarry itself. A feature at Q2 and other elevated quarries is that the spinifex on the higher slopes is much smaller in height at about 40cm to 50 cm compared with 150cm or higher on the flatter areas. This is immediately apparent when rising from the flatlands onto the higher basalt ridges where most of the quarries are located. It is suggested that the steep slopes of the hills, shallow soils, clear rocky ground and accelerated runoff rather than a change of temperature associated with higher elevation results in immediately decreasing height of the spinifex. The smaller spinifex enables a minimum of 50 percent ground visibility on most of the rocky quarry sites.

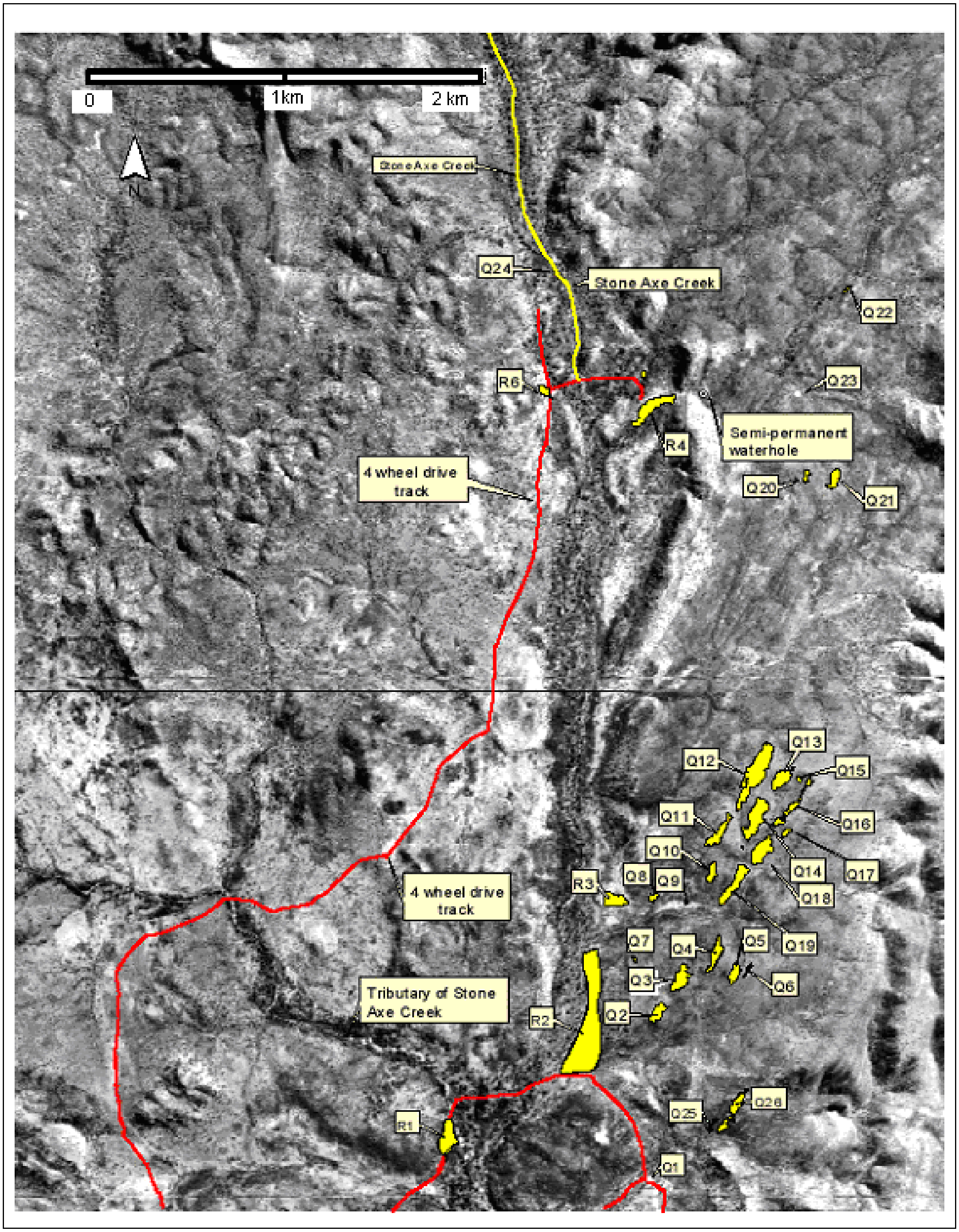


Figure 5.1. Quarries, reduction floors and roads projected over an air-photograph of Moondarra.

With an area of 6,359.9m² Q3 is a significant quarry even by Moondarra standards. Vegetation cover is slightly different to Q2, with native grasses and spinifex providing the majority of groundcover. The native grasses do provide more ground cover and therefore reduce visibility however, the rocky ground still enables an assessment of past quarrying activities. From 200m away, Q3 seems like a rounded grassy hill however, on closed inspection larger boulders are ubiquitous and Aboriginal excavations are readily apparent. It appears that every sizeable rock at Q3 has been knapped.

The large size of Q3, the amount of surficial stone knapped, the evidence of Aboriginal mining and the stockpiles suggest this is a significant axe quarry site within the Moondarra complex. In production terms, it is in the top four axe-producing sites at Moondarra. Q3 is unusual for two reasons. First, it is one of only two quarries at Moondarra that has evidence of Aboriginal excavations and second, the presence and quantity of axe stockpiles (see Plate 5.2).

Q4 is situated across a deep saddle from Q3. At 5046.9m² it is slightly smaller than Q3. The ground is extremely rocky but in some places the basalt is in pebble form that is too small for axe manufacturing. Nevertheless, there is evidence of intensive quarrying at the northern end of the site where numerous blanks and hammer-stones were recorded.

Q5 consists of large uplifted basalt blocks rising about 10 to 12 metres above ground with extensive scree down slope (see Plate 5.3). This is one of three outcrop hardstone quarries at Moondarra, and has an area of 3,353m². Extensive stone-working has been conducted along this exposed outcrop but the southern-most portions have not been quarried. Here, the basalt is characterised by linear cracks within the large stone blocks, which renders it unsuitable for axe production. The scree in the northern section is up to three metres thick and devoid of vegetation. Every piece of stone examined appear to have been extensively knapped. The high rock features at Q5 make it one of the most visible quarries in the Moondarra landscape.

Plate 5.2. Stockpile of axes on Q3 near a burnt tree stump.

At 677.5m², Q6 is one of the smaller quarries at Moondarra. It is a narrow band of basalt, 73m long and eight to 16m wide, immediately to the east of Q5 (see Figure 5.1). A slightly raised quartzite bed forms the eastern boundary. The low density of flakes and small size of this quarry suggest that the quantity of axes produced would have been negligible in comparative terms with the previous basalt quarries.

Q7 is located at the northern end of a high quartzite ridge. It is one of the smallest quarries recorded at Moondarra, with an area of 208.5m². The blocks of basalt flaked here are medium-sized (20kg to 30 kg) and many have rolled down the slope onto level ground. The number of axes removed from this quarry appears to be insignificant compared with the larger quarries due to its small area.

The southernmost basalt quarries in the Moondarra complex are located about 530m southeast of Q2. The smaller quarry is Q25, which has an area of 975m². At 5,518m², Q26 is a medium-sized quarry. Surficial basalt was quarried at both locations and there is no evidence for Aboriginal mining pits. These quarries are in close proximity to the quartz quarry and there is possibly a relationship between these quarries and the large amounts of quartz flakes on the surface of reduction floor one.

Q8 to Q18 have been extensively quarried and are located on steeper slopes and higher hills compared to the previous quarries. Surficial, outcrop and mining pits are present and the majority of stone axes produced at Moondarra can most likely sourced to this central section.

Q8 is a basalt quarry positioned at the southern end of a quartzite ridge 440m long that rises about 40 metres above Stone Axe Creek. The quarry is situated on a low hill and has an area of 1,130.9m². This is a surficial hardstone quarry. Vegetation at Q8 is mostly chisholm wattle or turpentine bush (*Acacia chisholmii*) that grows to about 2.5m tall. It is an open shrub but grows in dense stands, usually with grass beneath the canopy. However, apart from the difficulty in walking through turpentine bush, ground visibility is good at around 60 to 70 %.

Q9 at 185.1m² is the smallest axe quarry at Moondarra. It differs from others in that trimming flakes as well as are numerous blank axes were recorded on the flatter ground immediately to the south. It may be that this was a small reduction site associated with Q9. On the other hand, knappers may have moved away from the steeply sloping ground to a more comfortable location that was flat and sandy to carry out preliminary knapping of axe blanks.

Two saddles connect Q10, Q11 and Q12 and provide an access route to the higher ridges. Medium to large basalt boulders are found at Q10 and Q11, whose respective areas are 2,894.4m² and 5,422.34m². The quarrying technique at both these sites is surficial but the ground is covered with knapped stone. Large numbers of stone axes blanks are present with some extremely large specimens that had been knapped around the margins to form a rounded or discoid shape (see Chapter 8).

The principal source of axe blanks at Moondarra appears to be Q12. At 18,899.9m² it is a massive quarry with maximum dimensions of 385m long and 101m wide at 395m above sea level. It is the highest peak at Moondarra. Three types of quarrying were conducted at this expansive site. Surficial hardstone quarrying is widespread. In addition, 35 Aboriginal mining pits were recorded, 20 pits at the northern end of the ridge and 15 near the centre of the quarry. An archaeological excavation was conducted at one of the Aboriginal pits (see Chapter 8). The third quarry type utilises outcropping hardstone that aligns NNE along the mid-western boundary of Q12. Stone working at this small area (maximum length 50m x 28m) is intensive with an approximate depth of debitage varying between two to three metres thick (see Plate 5.3).

Quarries 13 (5,429.9m²) and 14 (11,025.6m²) are located on separate ridges across the valley, to the east of Q12. Quarrying is on surficial hardstone with dense concentrations of knapped stone across both sites. Q13 has some unusual features for Moondarra in that in the centre of the quarry there two basalt blocks about 110cm in height have almost level tops and are about 1m in diameter. They are slightly concave and have flaking debitage at the centre. Several blank axes were also located around these blocks which appear to have been used as ‘workbenches’ (see Plate 5.4).

Q15 is situated on the connecting saddle between Q13 and Q16. It has dense concentrations of basalt with evidence for intense surficial and outcrop quarrying. There is limited vegetation at this site due to the heavy concentrations of stone on the ground.

Quarry 16 comprises two distinct quarry types. A surficial quarry is located at the northern section (measuring 3,136.2m²) while an outcrop quarry (1,235.0m²) is located in the southern section. Superficial quarrying is sparse in the northern section while the southern outcrop is intensively quarried. Substantial amounts of debitage from the southern section have rolled down the steep slope to the west into the valley separating Q16 from Q14.

Q17 has an area of 1,023.1m² and is one of the smaller surficial quarries in the central section. The basalt is not concentrated here, but where present, it has been extensively knapped. The ridge extends parallel and northwards in alignment with Q16 but basalt is absent along this part of the spine. Less dense vegetation to the east of Q17 is a sign of increasing quartzite underlying the surface. Figure 5.1 shows that this central part of Moondarra is more vegetated in comparison with the area directly to the east.

Q18 is an extremely steep-sided quarry situated on a small plateau. Concentrated mounts of basalt are present and have indications of being intensively knapped. With an area of 7,945.1m², enormous quantities of stone axes have been knapped from the surficial deposits at this site.

Plate 5.3. Roger Sullivan sitting on the outcrop hardstone quarry within Q12.

The final quarry in the central part of Moondarra is Q19. It is situated on a lower ridge than preceding quarries. At 7,796.5m², it is a large quarry but the density of basalt is markedly less than observed at Q18.

Plate 5.4. A stone axe stockpile resting in situ on a rock platform at Q13.

The northern part of Moondarra has fewer quarries in comparison with more southerly sections. Nevertheless, it has greater diversity in the types of artefacts manufactured and provides evidence that the site was not only engaged in axe production.

Q20 (a surficial quarry of 1,277.9m²) is situated 1230m due north of Q12 with Q21 (3,047.7m²) due east. They are both situated on low rolling hills with turpentine bush, higher spinifex and native grasses as groundcover. Basalt is not as ubiquitous as at the larger sites to the south, but where suitable larger stones are present, they have been extensively worked. Within these rolling hills in the north of the complex smaller basalt rocks are extensively pot-lidded. Meticulous inspection of broken stone was required to differentiate between these natural and cultural phenomena. When features such as striking platforms, bulbs of percussion and initiation points are detectable on a flake, percussion or human action can be generally inferred. Potlidding usually results in a circular flake removed from the parent rock by sudden heating and leaves a small saucer-shaped depression in the surface of the stone.

Q22 is a small quarry (1,277.9m²) that is distinguished by the colour of the basalt found here. Under ephemeral light conditions, this changed from a light green to an aqua-blue colour which is unique to this quarry.

Evidence for the production of large quartzite flakes (macroblades or leilira blades) 10 to 15cm long is found at Q23. The raw material had been removed from large quartzite boulders near the site. The quartzite debitage at this quarry covers an area of 10m x 6m (and averages 30cm deep). The black/grey quartzite at Q23 has fine quartz grains compared to the numerous Myally beds of median to coarse-grained material located within the perimeter of the site. No evidence of quartzite quarrying was found on these Myally quartzite protrusions. Vegetation cannot grow through this thick debitage on the reduction floor.

Q24 is unusual in that it comprises a two-kilometre section in the creek-bed of the northwestern tributary of Stone Axe Creek. Evidence such as small blades or knives and large blades or leilira blades were observed along the length of this quarry. A different granular structure is readily apparent to the naked eye between the finer-grained quartzite along the creek-line and the medium-grained quartzite ridges. In the creek, cortex is a yellow/reddish colour that changes that changes to light or dark grey as depth increases. The quartzite at both Q24 and Q23 is similar in colour and grain size except that the creek boulders (cores) have been leached by weathering on the outer layers. The quartzite cores quarried in the creek beds are loose, rounded (tumbled) boulders easily distinguished from the angular pieces from the uplifted Myally beds.

5.4 **Reduction floors**

Six reduction floors were identified, within the Moondarra complex. The density of artefacts changes significantly between reduction sites and this may be due to factors such as public access and pilfering of artefacts, increased erosion caused by road building and cattle trampling. The reduction floors have been adversely affected by some of these factors as they are situated near creeks, which form natural easements through the rough terrain. Cattle grazing and moving to and from water use this relatively level part of the landscape, which also allows access for vehicles. Conversely, the quarries that are situated on high, stony ridges remain in an almost pristine condition. Excavations and analyses of two reduction floors (R3 and R4) are discussed in Chapters 6, 7 and 8.

R1 (Reduction floor 1) is situated at the southwest corner of the Moondarra complex. A tributary of Stone Axe Creek defines the eastern boundary of the site and a low hill designates the western margin. R1 is 8,858.2m² and the closest quarries are Q2 (the basalt quarry) 1.025km away and Q1 (a quartzite quarry), which is 950m from the site. It appears that close proximity to creeks was a major consideration in selecting reduction sites at Moondarra. There is limited grass at Q2 and a profusion of Gidyea or Gidgee (*Acacia cambagei*) which appears to limit other growth (Wilson 2000:114). This site epitomises post-depositional changes caused by cattle trampling, road building, artefact pilfering and increased erosion (see Plate 5.5). Despite archaeological evidence for significant basalt knapping on the site there is an absence of stone axes. This is not the case for reduction floors that are some distance from roadways with higher degrees of vegetation cover.

At 51,051m², R2 is the largest reduction site. Three natural boundaries form a perimeter around the site. To the north a shallow natural drain flows east to west into Stone Axe Creek; to the west there is Stone Axe Creek itself and a high long (505m) quartzite ridge (Myally bed) forms an impassable barrier separating R2 from the southern quarries to the east. Vegetation varies with high spinifex being the prevalent groundcover in the southern regions and spinifex, grass, snappy gums, turpentine bush and some low shrubs in the northern section of the site. There are many patches of open ground across the site that has been adversely impacted by erosion and cattle trampling. The different and heavier vegetation type in some sections reduces ground visibility and appears to have provided some protection against the pilfering of stone axes. Numerous axes in varying stages of reduction are present across this site. Basalt was the most intensively knapped stone at R2 with evidence for lesser quantities of quartzite, and minimal numbers of quartz and chert flakes.

Plate 5.5. A section of Reduction Floor 1 with some grass cover after fencing.

R3 (with an area of 4,937.1m²) is located 200m north of R2. A shallow wash 200m wide forms a natural spillway between the two reduction floors. A small creek has incised into this wash. Spinifex and open gums are the main vegetation types at R3 with large areas of open ground devoid of vegetation. As for previous reduction floors, this site is also a natural easement for cattle moving across twice a day to water at Lake Moondarra. The western and eastern borders are tributaries of Stone Axe Creek and a high quartzite ridge forms the eastern boundary. Quarried material from the southern and central quarries may have been knapped at R3. Excavations were conducted at this reduction floor (see Chapter 7).

R4 is located on the banks of Stone Axe Creek 2,280m north of R3 and 720m northwest of Q22. Basalt debitage is extremely dense across the 9,301.6m² of this site. Basalt from the northern quarries was probably knapped at R4 as the distinctive coloured greenstone from Q22 can be observed there. Tributaries of Stone Axe Creek border the site to the west and the northeast, and a high Myally quartzite ridge forms the eastern boundary. The outer limits of this quartzite ridge extend across the creek flowing north-northeast (NNE) at about 1metre below bankful, forming a natural dam across the creek. This semi-permanent waterhole locally known as the 'Jet', is about 5m wide and 20m long and retained water from December to early June in 2001 and 2002 during the height of *El Nino.* An abandoned copper gouge (mine) is situated about 30m north of the Jet.

Over the previous 120 years the pilfering of artefacts has been prolific at R4 and only a few stone axes remain among the thick carpet of debitage on the surface. High spinifex covers parts of the site and scattered gums are present. An excavation was conducted at R4 and the results are discussed in Chapters 7 and 8. Basalt was the principle material knapped but there is also evidence of considerable quantities of quartzite flakes. Quartz and chert are present, but in much smaller amounts compared with basalt and quartzite. Nonetheless, five different coloured cherts were recorded. R4 is unique at Moondarra for several reasons: 1. R4 is located near the only semi-permanent waterhole within the quarry complex, 2. The densest collections of surface artefacts are at R4, 3. Groups of people moving from the quarries to R5 and R6 would have to move through or bypass near R4, 4. the two shortest passageways through the rough terrain to the central quarries are 1730m and 2030m distant respectively, and 5. in this semi arid landscape, R4 with a semi-permanent waterhole nearby was possibly occupied by Aboriginals after the first heavy summer rains.

Some quartz flakes were noted on the surface of R4. Approximately two kilometres due west of R4 is a high outcrop of quartz with large greenstone anvils that have been transported in and carried about 20m up a rock face. This is possibly where the knappers at R4 obtained their supplies of quartz. The distance from R4 to this quarry is shorter, and perhaps more economical than travelling to Q1 to obtain raw materials.

The smaller reduction sites R5 and R6 are located to the west of Stone Axe Creek. At 677.5m², R5 is the smallest reduction floor at Moondarra and artefact density appears to be lower than for other reduction sites. It is situated on the bank of Stone Axe Creek. R6 has an area of 1,880.5m² and is 135m from Stone Axe Creek. This is extremely unusual as the other five reduction floors are located adjacent to creeks. A road has been built through the centre of R6 and spinifex and snappy gums provide sparse patches of vegetation. Erosion appears to been a major post-depositional process, with increased runoff caused by the roadway channelling water across the site.

5.5 Spatial patterns and interpretation

This chapter examines the spatial relationships of sites at Moondarra. Mapping the complex identified 26 quarries and six reduction floors. In addition to the previously known basalt quarries, quartz and quartzite quarries were located at the site. An overview of the general characteristics of sites, their spatial relationships, and effects of human and animal actions on sites allows for the development of an interpretation of how this large complex was used over time.

An understanding of spatial relationships provides a foundation for understanding how specific sites were accessed and how these might have been controlled. Water availability, those times of the year when the sites were amenable to human habitation, provide clues to when the axes were produced, and the seasonality of axe production. These issues are discussed in Chapter 10. Finally, by providing a spatial understanding of Moondarra, its size and complexity can be compared with other sites.

Two reduction floors were identified to the west of Stone Axe Creek, which is beyond the previously accepted western boundary of the site (MIM site map, Brayshaw 1989). This is possibly because previous surveys were confined to precincts established by the leaseholder.

A quartzite quarry was recorded in the northern section of Moondarra and a major quartzite quarry was identified along a two-kilometre section of Stone Axe Creek. This suggests that in addition to axe production, quartzite leilira blades (identified as macroblades by Roth, 1897) may have been a significant activity at Moondarra (see also Chapter 8).

All the reduction floors were located in close proximity to the creeks with the exception of R6, which is some distance from the creek, but spatial increase maintains a similar height as other reduction floors above the creek. In other words, increased distance from water is associated with maintaining a similar height above bankful. This possibly indicates that stone axes were produced from December to March and that reduction floors were located above the flood line.

An argument for floods removing any cultural material below the flood line is another proposition but this explanation is not supported for the following reasons. First, with the exception of R6, the five other reduction floors abut creek banks which are liner barriers preventing the natural expansion of these reduction floors towards the creek. The expansion of these sites is seems to be restricted to restricted to higher ground away from creeks. Second, the creek beds comprise mainly larger cobbles and boulders that would make habitation sites uncomfortable compared to the higher ground with slightly sloping ground and relatively devoid of large rocks.

The reduction floors share a complex spatial relationship with the quarries. It is probable that the southern quarries are associated with the southernmost reduction sites. R1 is possibly associated with Q1 (quartz quarry), as a significant quantity of quartz debitage is located on the surface. Movement between R1 and the southern basalt quarries (Q2, Q3, Q4, Q5, Q6 Q7, Q25, Q26) would have required either traversing through or adjacent to R2 as the high uplifted Myally beds form impassable natural barriers channelling human movement through natural ‘gateways’ (see Figure 5.2 and 5.3).

The central quarries seem to have a more complex spatial relationship with reduction sites. It is suggested that some central quarries may be associated with R3 and R2, but that most are associated with R4. A significant quantity of debitage at R4 in comparison with the other five reduction floors supports this.

R4 is the only reduction floor that has a semi-permanent water-source, although, R5 and R6 are situated near less reliable water sources. People moving from R5 and R6 to the northern and central quarries would have to pass through R4.

The principal issue of people moving two kilometres northwards from Q12 to R4, R5 or R6 is that these locations increases the distance from a permanent water source five kilometres south of Q12, in the Leichardt River. The shortest passable route between Q12 and R4 is about two kilometres as a massive quartzite ridge prevents a shorter track. This ridge is extremely steep and dangerous for humans to cross. This infers that these reduction floors were also habitation sites occupied during the wet season (see Chapter 7). If the quarries were mined during the dry season, then movement north to these sites increases the distance from the quarry to water from 5 to 9 kilometres. This supports the notion that Moondarra was quarried during the wet season.

There seems to be an association between R1 and the southern quarries. This relationship is illustrated by the increased density of quartz flakes at R1 compared with R2 and R3. This comparative data is illustrated in Chapter 6 where the absence of quartz in the archaeological excavation is noted at R3. While chronological patterns of change cannot be suggested, there are numerous arguments to explain this variation when R2 is closer to the quartz quarry than R1 and the association between R4, R5 and R6. These arguments are:

a. More than one group quarried simultaneously at Moondarra, and each groups had rights to different sections of the complex.

b. More than one group had access to all parts of the complex.

c. More than one group quarried simultaneously at the complex. However, they camped at separate locations.

d. The miners dispersed into smaller groups to quarry the basalt.

e. Water availability fluctuated in two streams with different catchment areas thus changing the preferred location of campsites/reduction floors.

f. Both sites were used by the same group, but at different times of the year or in different years, and

g. The locations of reduction floors changed in order to avoid the over-exploitation of food resources

Figures 5.2 and 5.3 show possible routes between quarries and reduction floors. The green lines on these maps are impassable barriers. The northern reduction floors have a similarly complex relationship as interpreted for the southern parts of Moondarra. Access to R5 and R6 is either through R4 or close to it as it is located immediately behind a pass between two impenetrable quartzite ridges. The southern ridge is approximately 1.5 km long and forms a barrier between the central and northern parts of the complex. R4 has the best water availability so it is unlikely that R5 or R6 would have been preferred reduction sites.

If water availability was instrumental in deciding the location of reduction floors or the same group of miners used different campsites in different times, then access to Q1 might be continuous resulting in similar quantities of quartz flakes at both reduction floors. This concurs with Binford’s (1979) notion of embedded procurement of the subsistence tool kit, as nearby sources of quartz would be expected to be preferentially exploited.

Reduction floor one has an abundance of quartz flakes despite the presence of quartzite boulders in nearby Stone Axe Creek. Although, more difficult to flake (inferred by the presence of basalt anvils and hammerstones at Q1 and the offsite quartz quarry), the quartz may possess better edge holding qualities. The issue of travel to onsite and offsite quarries can still be interpreted as embedded procurement as quartz would be accessible to hunting and gathering groups setting out from the main camp or reduction floor. Conversely, basalt quarrying and axe production are not viewed as embedded behaviour. This inference is based on the size of the quarries, scale of production and the archaeological evidence for regional exchange (see also Chapter 11).

Changing reduction floors or habitation sites to exploit new hunting grounds seems unlikely when distance between R1 and R2 and R4, R5 and R6 are relatively close. A variation in the availability of water is also discounted as embedded procurement in the subsistence tool kit might be unaltered given the proximity of Q1 to R1 and R2. Without pre-empting later examinations of control and access, it appears that two or more groups occupied the reduction floors at Moondarra simultaneously.

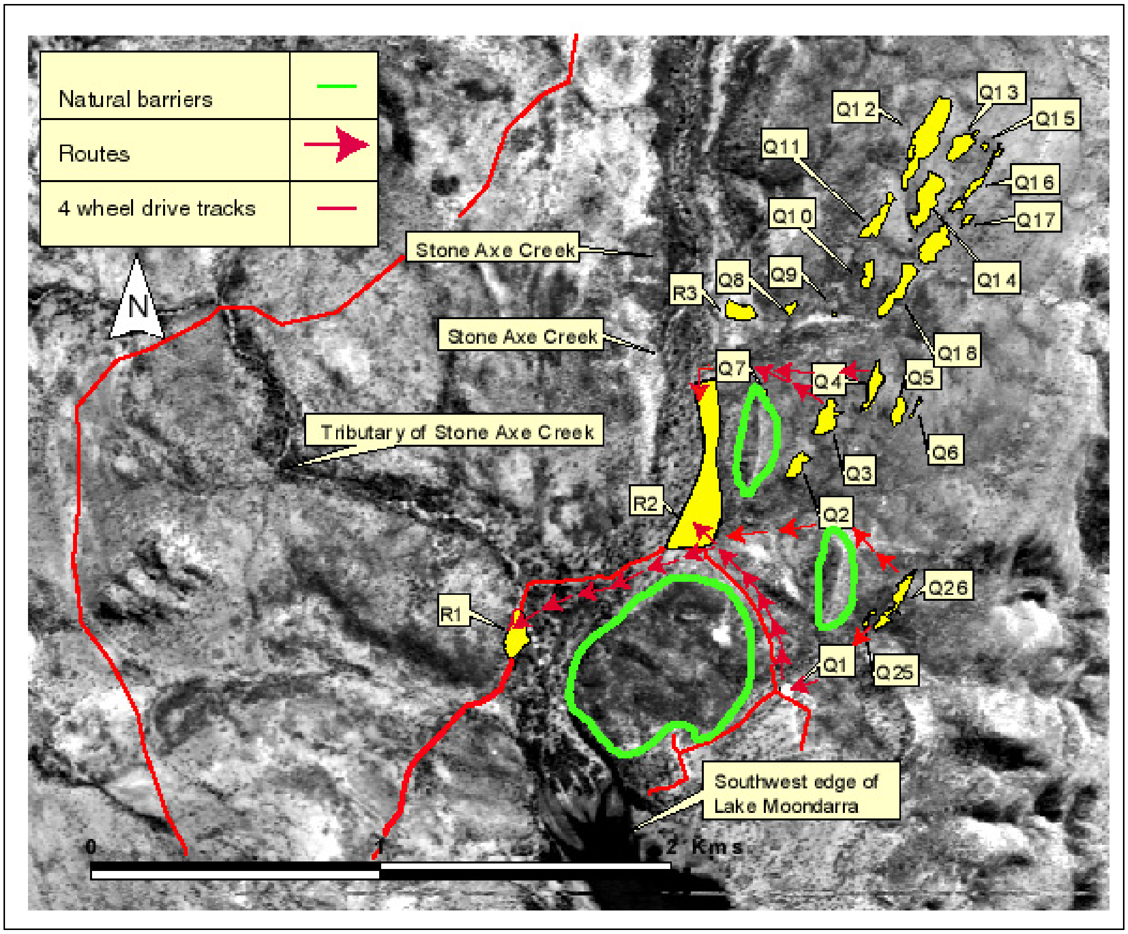


Figure 5.2. Possible routes from the southernmost basalt and quartz quarries to R1 and R2.

Public access to the site, changes in vegetation cover and the close proximity of sites to roadways directly affects the quantity of stone axes remaining on the knapping floors. The two sites that have roadways through them are devoid of stone axes. A four-wheel drive track is close to R5 and R6 and very few stone axes are present at these sites. R4 has good ground visibility and abundant evidence of basalt knapping but few axes. The largest reduction site, R2 has about 90 axes present, however this site is not visible from a nearby track. Measurements of attributes from these axes are analysed in Chapter 8. Trade is not considered a reason for the absence of axes on some sites as they are common in well-vegetated areas away from roads.

Mapping the Moondarra complex and calculating the area off reduction floors and quarries has enabled the site to be measured objectively. Moondarra is probably the most expansive stone axe quarry in Australia.

Accurate measurements of quarries such as Moondarra allow comparative areal analysis with other major quarries. The total quarrying area identified, recorded and mapped at Moondarra was 98,255.9 m^2 incorporating 24 of the 26 quarries. The area of the creek quarry was not recorded apart from suggesting that it is at least two kilometres long. With a quarried area of 98,255.9m^2, Moondarra is 3.16 times larger than the Neolithic stone axe quarry at Great Langdale (31,037 sq m) and 25.4 times larger than Scafell Pike (3,866sq m, Claris *et al*. 1989). Data does not exist for comparative spatial analysis with expansive axe quarries in Australia except for Gunpowder whose quarries are approximately 70% the size of Moondarra. The combined area of the reduction sites at Moondarra is 76,706.7m^2. The total area of the Moondarra's reduction floors and quarries is 174,962.6m^2 or 174.962 hectares. The production relationship between Moondarra and Gunpowder is discussed in Chapter 10.

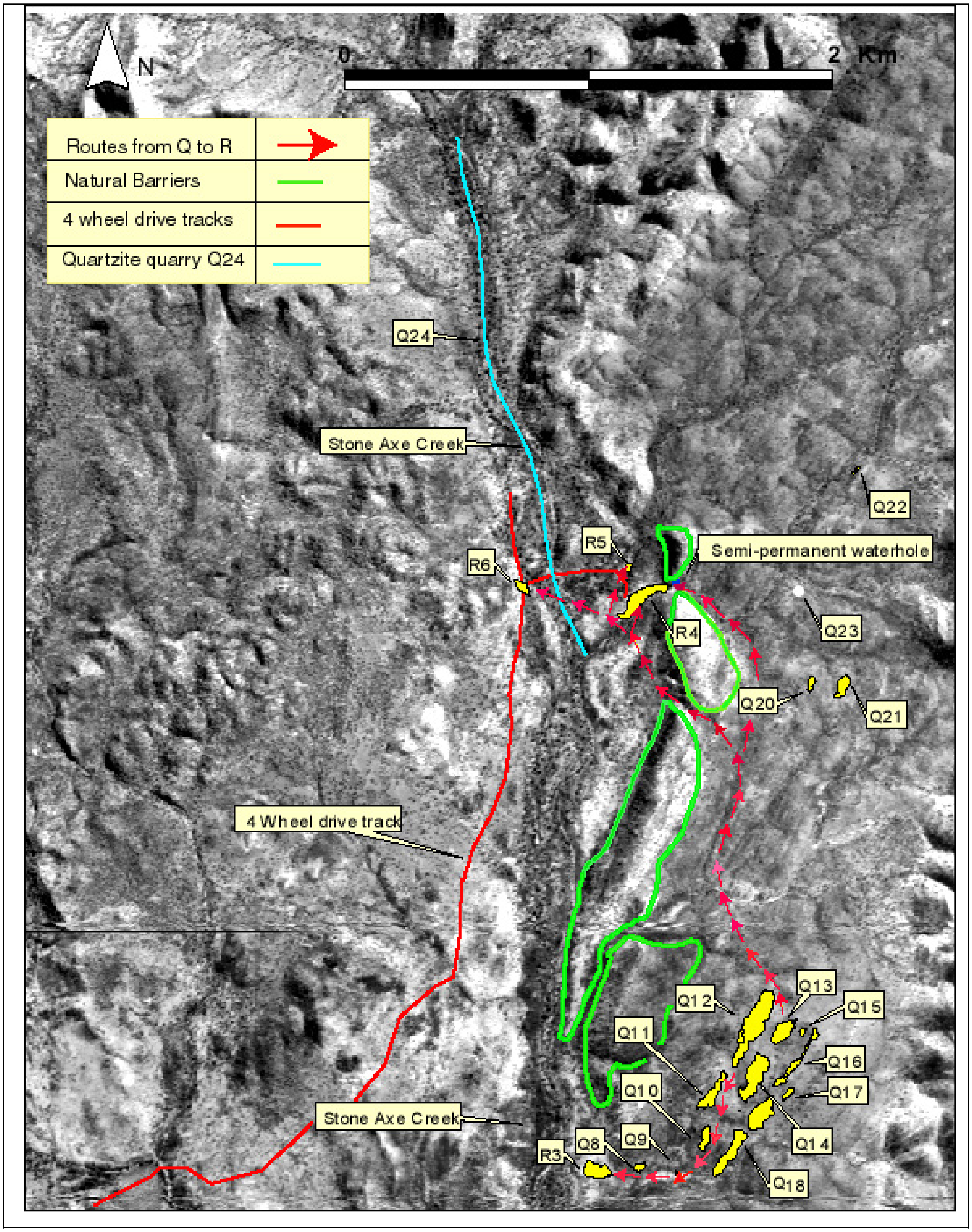


Figure 5.3. Possible tracks between the northerly quarries and reduction floors.

5.6 **Conclusion**

The survey revealed that Moondarra has 23 basalt quarries, two quartzite quarries, one quartz quarry and six axe reduction floors. All of the quarries are on the eastern side of Stone Axe Creek and two reduction floors are on the western side. The survey resulted in the expansion of the western and northern boundaries and the inclusion of two reduction sites and a quartzite quarry. A macroblade quartzite quarry two kilometres long was recorded in the bed of Stone Axe Creek. Lake Moondarra is an expansive site with a total area of almost 175 hectares.

Based on the number and size of the basalt quarries it seems that axe production was undoubtedly the principle activity conducted at Moondarra. The two quartzite quarries provide archaeological evidence for leilira blade production. The quartz quarry possibly reflects the embedded nature of tool-kit reprovisioning in a hunter-gatherer society.
This analysis suggests that a complex relationship might have existed between reduction floors and quarries. The rough terrain at Moondarra certainly channelled Aboriginal tracks through passes. Nevertheless, movement patterns that may reflect differential rights of access seem to be emerging.

Chapter 6 Evidence for techniques of quarrying and production at Moondarra

6.1 Introduction

This chapter examines technological and production sequences used in quarrying basalt to produce stone axes at Moondarra. As described in the Chapter 4, the principle quarrying method applied at Moondarra was surficial hardstone quarrying. At Moondarra, quarrying included shallow mining pits to extract basalt in boulder form from immediately under the ground. There are 34 such mining pits along the northwest of Q12, which is the most expansive quarry within the complex.

Mathematical calculations to estimate the volume of rock contained within the debris or walls surrounding one of these mining pits (MP1) clearly demonstrated that most of the material was not sourced from the miner’s excavation. This information is significant as it provides archaeological evidence to support the notions of specialisation and demarcation in production roles during hunter-gatherer axe production at Moondarra. The presence of specialised knappers at different stages of production at the complex does not automatically demonstrate standardisation in both technology and production, but without craft specialisation these technical standards may have been difficult to achieve.

Subsequent parts of this chapter examine production issues such as whether firing of rocks was used to facilitate breakage, the use of wooden levers to extract stone from the ground, the preparation of boulders for wedging, the use of stone wedges, the positioning of large rocks for percussion breakage, the use of anvils, and hammerstones. A generalised reduction sequences and how these artefact types are linked with different steps in reduction process are described. Archaeological evidence is presented to suggest that both axes and trimming flakes reduce in the size with progressive stages of reduction compared with earlier stages. In addition, grindstones, the use of a grinding agent in the axe grinding process, and the return of old axes to the site are examined.

6.2.1 Aboriginal mining pit MP1

6.2.2 Site location and general description

The mining pit (MP1) is located on Quarry 12 (Q12) and is among a cluster of pits near the hardstone quarry (see Figure 6.1). An archaeological excavation was conducted in the centre of MP1 a near circular shaped stone structure (with a cleared centre). Hiscock (1988a, forthcoming), and Innes (1991:37) have identified similar patterns of debitage at Moondarra as Aboriginal mining pits. Negative percussion scars on some rocks within the walls, the presence of stone axes resting on the walls and a stockpile of 10 axes approximately 10 metres away from the pit suggested that axe making activities had also taken place at this location.

The centre of the mining pit is a grassed area devoid of large basalt blocks. The original mining pit has been infilled during the post-depositional process. Loose earth and small stone particles excavated from the pit would be rapidly transported back into the pit by flowing water during the heavy rainfall this locality experiences during the wet seasons. A depression such as a mining pit would trap water within it and consequently, any sediment carried as suspended load in the water would be deposited on the floor of the depression eventually infilling the pit completely. This process possibly explains why the deepest level within the superimposed pit was only 5cm lower than the surrounding debris.

The most striking feature of MP1 was the quantity of spoil within the surrounding walls. A preliminary investigation was conducted to determine if the estimated volume of material from the mining pit was similar to the volume of basalt contained within the walls of the stone circle.

Preliminary calculations of the volume of stone contained in the walls of debris suggested that if all of the basalt raw material surrounding the cleared centre of the mining pit had been excavated from the mining pit, then it was significantly deeper than those usually found at Moondarra. Although, MP1 has been infilled it provides relevant data on axe reduction at a primary site and comparative data with results from reduction floors R3 and R4.

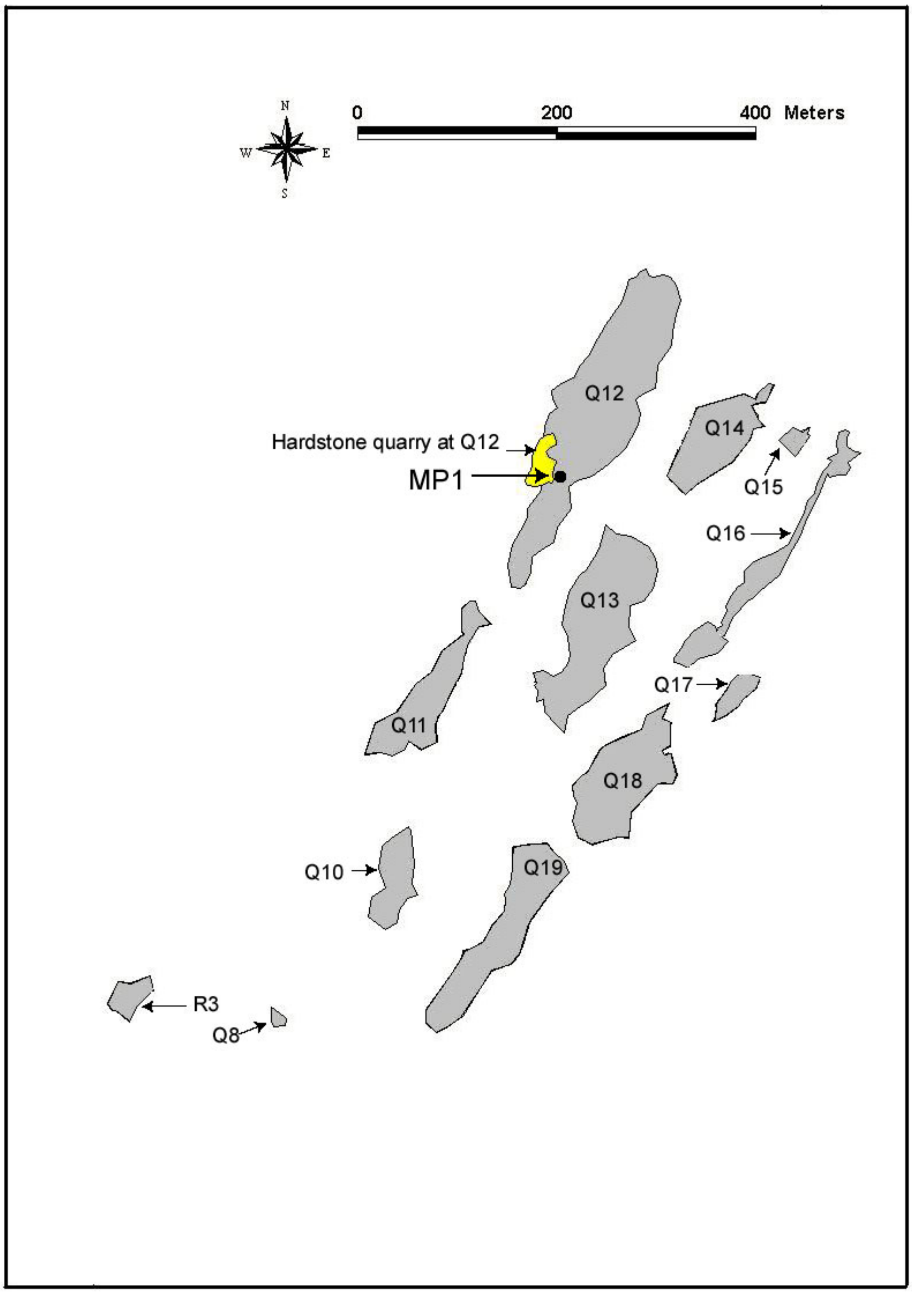


Figure 6.1. Location of MP1 and nearby sites.

MP1 consists of two near parallel stonewalls with semi-circular ends. The elliptical space within these stonewalls was clear and believed to represent the original mining pit. The cross section profile of the debitage contained in the walls surrounding the pit is probably best described as hemispheric rather than rectangular (see Figure 6.2).

A conservative estimate of the volume of excavated stone was based on a formula for a hemispheric profile with consideration of changing dimensions along each section of the walls (see Figure 6.2). The calculation for estimating the volume of debitage within the walls is shown in Table 6.1.

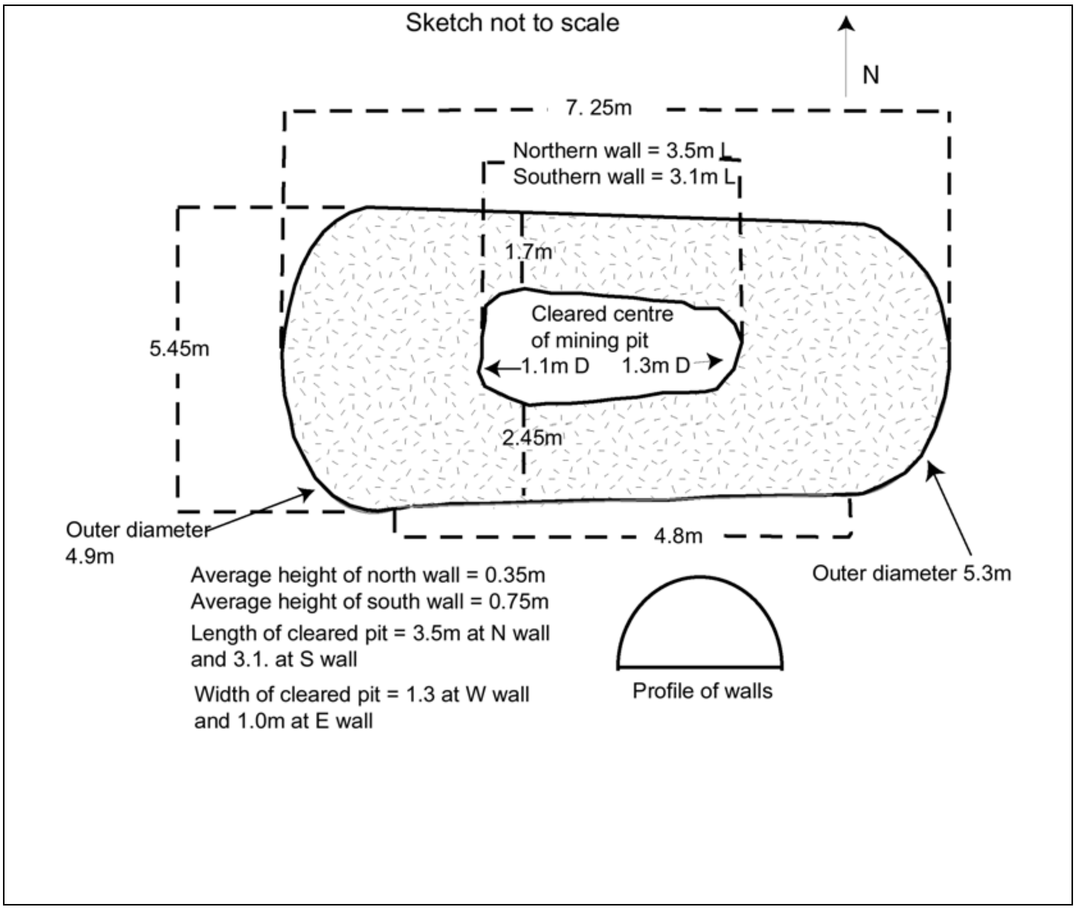


Figure 6.2. Sketch of MP1 located at Q12.

In estimating the volume of stone within the walls of the structure, a formula to provide a reliable estimation of volume in this irregular shaped profile had to be decided upon. The height of the excavated basalt walls varied and the walls could not be described as rectangular, but more rounded near the top. Despite this rounded top the base of the walls were near rectangular. Based on the measurements of the stone arrangement the depth of the Aboriginal mining pit if all the stone within the walls had been excavated from the pit, then the excavation would have been 3.47m deep (see Table 6.1).

A depth of 3.47m seems extraordinary when comparisons were made with similar features at Moondarra and elsewhere in northern Australia (Jones and White, 1988). Based on the amount of debris surrounding the pits most of the other excavations at Moondarra were probably less than one metre in depth. Peter Hiscock (forthcoming) has described one pit at Moondarra as being 8-10 metres across and 60cm deep. MP1 is shown in Plates 6.1 and 6.2. These photograph shows grass growing in the centre where mining presumably took place.

Feature	Dimensions	Calculation of Volume	Volume
North wall	L 4.8m x W1.71 x H0.35m	(Length x Breadth x Height) x 11÷14	**2.26m^3**
South wall	L 4.8m x W2.45m x H0.75	(Length x Breadth x Height) x 11÷14	**6.93m^3**
Eastern wall	Outer Semi-circle Dia.5.3m Inner Semi-circle Dia.1.3m	(Diameter x Pi ÷ 2) x (Height x 11÷14) (Diameter x Pi ÷ 2) x (Height x 11÷14) Outer volume – Inner volume	3.60m^3 - 0.88m^3 **=2.72m^3**
Western wall	Outer Semi-circle Dia. 4.9m Inner Semi-circle Dia. 1.0m	(Diameter x Pi ÷ 2) x (Height x 11÷14) (Diameter x Pi ÷ 2) x (Height x 11÷14) Outer Volume – Inner Volume	2.69m^3 - 0.43m^3 **= 2.26^3**
Volume of walls		Nth wall + South wall +East wall + West wall	**14.17m^3**
Area of the excavation	L3.3m W 1.2m	L x B	**4.08^2**
Estimated depth of the excavation		Depth = Volume of walls ÷ Area of excavation (14.17m^3 ÷4.08m^2)	**3.47m**

Table 6.1. Estimated volume and depth of the Aboriginal mining pit MP1.

6.3 Excavations at MP1

A test excavation was conducted in 5cm spits to gauge the original depth of the mining pit. Within spit 1, a retouched and an unretouched axe blank were recovered. Basalt trimming flakes and debris were excavated to a depth of 32cm. At 35cm the test pit was stopped as at this depth the amount of rock increased noticeably and it was determined that the basal layer had been reached at 32cm. This depth of cultural material suggests that all the raw material surrounding the mining pit may not have been excavated from the pit.

Plate 6.1. Clinton Percy sitting on the southern wall encircling MP1.

To confirm the results of the test excavation, a second more detailed archaeological excavation was implemented at MP1. The excavated material was sieved (1.6mm) and the measurements of all cultural material recovered are recorded in Appendix A. The initial area of this excavation was 100cm x 50cm. However the sheer volume of debris recovered from the surface and spit one necessitated the excavation to be reduced to a 50cm by 50cm square at spit two. The principle aim of confirming the depth of the Aboriginal mining pit was not compromised by this change. The cultural material ceased at 33cm and the excavation was completed at 35cm when an extremely rocky base that was difficult to excavate through was reached.

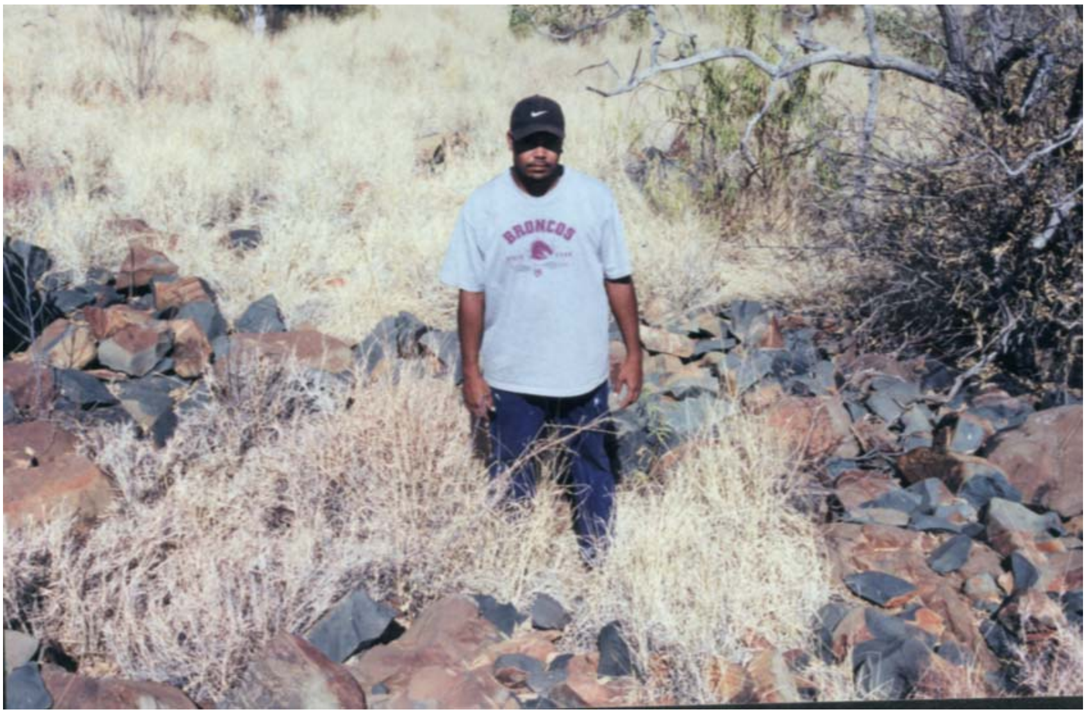


Plate 6.2. Roger Sullivan standing in the centre of MP1.

The second archaeological excavation clearly demonstrated that the volume of basalt contained within the walls surrounding the Aboriginal mining pit exceeded the volume of the pit by 10.5 times. This observation is supported by the results from the test pit excavation with a result of 10.8 times. The basal depths for cultural material from the major excavation and test excavation at 33cm and 32cm respectively are comparable. At each of the excavations, below the basal layers of cultural material the subsurface was comprised of large basalt rocks that would have been excavated if the original mining pit had continued through to this level. The most compelling indication that the basal cultural layer had been reached was the marked decrease in cultural debris immediately above this impenetrable extremely rocky substrate (see Table 6. 2 spits 6 and 7).

Reducing the excavation from 100 cm x 50 cm to 50cm x 50cm in spit 2 resulted in decreased quantities of cultural material being excavated from the Aboriginal mining pit. Therefore, the increase in the weight of cultural material and debitage quantities recovered from in spit 2 as shown in Table 6.2 is considerably greater as shown by the percentages that allow for a reduction in excavation area.

The excavation has provided an insight into Aboriginal mining processes. It is suggested that mining reached a depth of about 20cm (the bottom of spit 4) and that rock below this level was extracted possibly by digging sticks or levers that loosened, but did not remove the soil. Subsequently, as surface water washed down the hill towards the pit, the lighter debris surrounding the mining pit would be more easily transported as suspended load and therefore be washed into the pit in higher proportions than heavier objects. This post-depositional process might explain the maximum quantity and lighter basalt debris being excavated from spit 4 and slightly heavier and markedly fewer quantities of debris from below this level. The pattern of increasing size near the surface is suggested as the result of larger, heavier pieces of stone being less likely to be washed in (see Table 6.2). Spit 1 does not show this trend, but this may be due to water flowing more quickly through a shallower pit and lighter objects being deposited beyond the limits of the original excavation. Long-term subsidence from the excavated stonewalls over the life of the structure may result in heavier objects resting on the surface of the pit.

Some of the smaller debris was possibly the direct result of the original excavation and remained in the loose soil at the bottom of the pit while some may have been sourced from the walls. Size differences in the debris may be explained in that smaller debris may have been washed down-slope and through the northern wall as suspended load in flowing water that filled the pit and then settled on the bottom. Repetition of this post-depositional process over many wet seasons would result in infilling of the mining pit. Larger debris (less prone to movement in flowing water) almost certainly originated from the debris in the walls that have subsided into the pit. This is supported by the presence of larger flakes near the surface and unretouched stone axes found only in spits 1 and 2. The infilling of the pit was possibly rapid in archaeological terms.

Debris surrounding mining pits is a common feature of quarries in northern Australia. The ethnographic observations by Jones and White (1988: Figure 3 and Plate 2) on their 1981 expedition to the legendary spearhead and knife-point quarry at Ngilipitji in Arnhem Land provide an explanation for the shape of mining pits at Moondarra. Their observations show how stonewalls are build up by the miner placing excavated stone outside of the pit. The Ngilipitji pit appears to be about 1.3m in diameter (Jones and White 1987: Figure 3), which is similar in area to MP1.

6.4.1 **Demarcation in lithic production**

The archaeological excavations have demonstrated that the majority of the debitage surrounding MP1 was not excavated from the mining pit. A possible explanation for the presence of excess basalt near the mining pit is that this stone was carried to a central position for more experienced knappers to process. The more experienced artisans could have been situated near the excavation, while less experienced workers quarried the stone and others gathered it from the surface of Q12. MP1 could therefore represent an area where suitable stone was stockpiled and experts worked. The presence of complete and broken trimming flakes within the pit, retouched and unretouched axes on the stonewalls and a nearby stockpile of retouched axes suggest that knapping has occurred at MP1.

Spit number	**Total number of flakes: complete and broken**	**Debitage *n***	**Total Weight of cultural material**	**Weight by rounded percentages based on area**	**Depth**	**Area of spit**
Surface	21	1	7,519gm	18.5%	Surface	100cm x 50cm
1	245	31	3,168gm	7.8%	0-5cm	100cm x 50cm
2	72	197	8,445gm	41.5%	6-10cm	50cm x 50cm
3	130	44	3,776gm	18.5%	11-15cm	50cm x 50c
4	57	472	1,687gm	8.3%	16-20cm	50cm x 50cm
5	10	66	932gm	4.6%	21-25cm	50cm x 50cm
6	2	20	163gm	0.8%	26-30cm	50cm x 50cm
7	1	11	17gm	0.04%	31-33cm	50cm x 50cm

Table 6.2. Weight of cultural material recovered from MP1.

In the northeast of the Lake Eyre Basin, Aiston (1928) described an age, skill delineation in a hunter-gatherer knapping process. This might partly explain the phenomena described above. Aiston (1928) states that:

> Usually the younger blacks got the rough material from quarries… these were usually in some exposed place, so the young men, who had all the wild animal's dread of being caught in the open, would batter off as much stone as they could easily carry and would take it to where the old men waited, in some sheltered place… Here the rough stone was chipped up, all the pieces that were suitable for stone tools were the taken to the main camp to work up, the rough flakes that were of useless shape were left lying on the ground and the cores were also discarded, unless as sometimes happened the cores were suitable stone from which to chip small knives, they were taken into the camp to be used up. (Aiston1928:123)

Based on debitage analysis at the Mauna Kea adze quarry complex in Hawaii, Cleghorn (1986:386) concluded that the labour force was organised in two groups. The first were expert craftsmen working where the raw material was abundant and the second group comprised novices or apprentices working the outwash plain where resources were less abundant. In this scenario, the less and more experienced knappers worked independently.

Pigeot's (1987:113-4) research at Magdalenian Etiolles suggests that social stratification based on technical competence and different qualities of *knapping confidence* are represented as discrete spatial zones. Her 1990 study of this site identified apprentice activities by younger members of the group and she argued that technical confidence is associated with age. Pigeot (1990) believed that the advanced skill acquired by older or more senior knappers bordered on craft specialisation.

Behaviour at MP1 may include the younger members of the group carrying out the more physically demanding, yet less skilful aspects of gathering, excavating, transporting, and centralising heavy blocks of suitable stone. The older more experienced craftsmen may have congregated at this workstation to carry out the less physically demanding, but more skilful aspects of tool making. These actions may explain why basalt excavated from MP1 is significantly less than that in the walls surrounding the site. The observations of Aiston (1928), Cleghorn (1986) and the social interpretations of Pigeot (1990) appear to support the notion that craft specialisation may have occurred at Moondarra.

6.4.2 **AMS Results at MP1**

During the excavation of the Aboriginal mining pit at MP1 a minuscule charcoal sample was recovered from spit 4 in association with cultural material. This sample was probably washed into the pit as previously outlined. This date may represent a minimum age for the mining pit, as it was suggested earlier that the infilling process would have occurred rapidly during the wet-seasons following mining.

The charcoal sample was sent to Waikato University for AMS dating and returned with a date of 414 ± 47 years BP. Aboriginal mining at Moondarra may represent a change in quarrying techniques to acquire additional raw materials, which facilitated increased axe production in an expanding exchange system (see Chapter 8). If it was assumed that this charcoal sample was not associated with infilling but human behaviour at the site then this AMS date becomes more relevant. However, the next section strongly argues against the possibility of firing (and residual charcoal) to break up basalt during the extraction of raw materials at Moondarra.

6.5.1 **Firing and levering at quarries**

Deliberate firing of rock causes it to split into smaller pieces suitable for producing cores, which are then further reduced by percussion. Ethnographic, historical and archaeological evidence for firing at sandstone and quartzite quarries are recorded, but this has not been witnessed at axe quarries. Binford and O’Connell (1984:418) observed Alyawara men near MacDonald Station in Central Australia building fires beneath quartzite boulders to initiate breaks. Other Australian references to firing for this purpose includes Akerman (1979:144), Elkin (1948:110), and Jones and White (1988:62). Binford and O’Connell (1984) noted that in the North American literature there are many references to heating and rapid cooling of stone to produce flakes. However, they cited the studies Ellis (1940), Crabtree and Butler (1964), and Purdy (1981a, 1981b) who demonstrated some scepticism for this method (Binford and O’Connell 1984:418).

By contrast, in 1987 an excavation of the Neolithic axe quarry at Great Langdale (UK) identified a 1.5m lens of freshly broken blocks and charcoal, between deposits of coarse and fine flakes. Claris and Quartermain (1990:7) suggest that this intermediate stratigraphic layer represents fire setting between alternating periods of tool manufacture.

Field observations and experiments by Florek (1989) identified two means of interpreting the use of fire to break rock. At Wangianna Springs, his experimentation suggested that fine silcrete and chert exposed to heat undergoes rapid colour change to a creamy white. It also became ‘soft’ and there was a loss of the glossy lustre from the stone. Hiscock (1988b) also noted that chert changed colour after heating at Lawn Hill.

Roth (1904) described the manufacture of axes in northwest Queensland as:

> The actual manufacture of a celt is now a lost art in Queensland, though the statements of some of the older natives and a careful examination of specimens combine to throw a certain amount of light on the process adopted. The original celt in its simplest form is a water-worn pebble or boulder, an adaptation of the natural form, otherwise it is a portion removed from a rock, etc., *in situ*, either by fire, indiscriminate breakage, or flaking. The employment of fire for such a purpose has thus, on the authority of Kalkadun natives (occupying the ranges N.W. of Cloncurry) been explained to me: after lighting a large fire for some considerable time either upon or up against the rock from which the celt is obtained, it is suddenly extinguished with water, the ashes, etc., removed, and the stone found to be broken and split. On the other hand, I can find no European evidence confirmatory of such a procedure (Roth 1904:19).

Florek (1989) also conducted experiments to determine if firing had been used to split cobbles at Old Woman Quarry, Finniss Springs, and Lake Eyre South. His site inspection revealed that every surface and embedded cobble had been split along several planes (Florek 1989:23). Although hammerstones and flakes were present in low numbers he was reluctant to designate the site as a quarry. He believed that in circumstances where the visible evidence for firing is minimal, then breakage can be attributed to natural forces such as thermoclastis, frost, or pressure unloading.

To assign rock breakage of this type to alternating expansion and contraction due to diurnal temperature changes or thermoclasty maybe problematic. According to Whittow (1984:536), many modern geomorphologists are unconvinced that this weathering process exists, as no experiments to stimulate thermoclasty have been successful. Nevertheless, this argument does not counter the observations that firing increases the temperature of rocks resulting in splitting. In the desert environment of Lake Eyre, haloclasty may cause rock splitting. This process occurs as the result of periodic wetting and crystallisation of salt within the rock leading to stresses created by swelling. This type of chemical weathering is one of the major processes in hot deserts (Whittow 1984:243).

Regardless of the arguments above, Florek (1989) was faced with the problem of how the rocks were broken. Splitting by natural weathering or human action might be similar in appearance as cobbles split along flaw lines. By conducting infra-red light spectrum analysis and density measurements, Florek was able to demonstrate that firing had split the cobbles. The results suggested that flakes from the quarry had been exposed to over 300° C, which is well above the natural temperature range.

Evidence for firing at Moondarra is complicated by a number of factors. Fire-setting as documented by Binford and O’Connell (1989) and hurling rocks onto pavements or anvils and shattering them as noted by Tindale (1965:140) may in some instances leave similar debris in the archaeological record. Charcoal residue from fire setting might be even more difficult to interpret. In the absence of stratified layers of charcoal and debitage as at Great Langdale, the presence of charcoal is ambiguous. If charcoal is collected from near split rocks it may be naturally occurring and not necessarily associated with the cracked rock. If charcoal is not found then the proposition that firing has occurred cannot be substantiated as the post-depositional processes (e.g. flowing water) might have removed the evidence.

In the absence of stratified charcoal layers, the presence of charcoal particles could not be used to definitively determine if firing was used as a quarrying technique. To establish the presence or absence of this practice at Moondarra, a different method was required. Developing the notion that firing might result in fracturing along planes it was reasoned that if splitting by firing had occurred and subsequently flakes had been removed from these planes by percussion then this reduction sequence should be detectable. The test involved finding breaks along planes or breaks not induced by percussion, and counting the number of percussion breaks occurring within these planes. If humans had fired the basalt to split the rocks in an endeavour to obtain cores, then subsequent percussion blows to remove axe blanks would be expected on the broken pieces.

Q5 was the first hardstone quarry selected for a detailed survey to establish if percussion or firing and percussion were used to split basalt. The first 20 by 3m section examined revealed a number of fractured rocks, but no evidence for the removal of axe blanks by percussion. The rock had apparently cracked naturally along flaw lines and was possibly inferior quality stone compared with that used for axe production. This was inferred by the complete absence of quarrying in this section. Moreover, the presence of numerous horizontal fissures on rocks five to six metres high where firing would have been near impossible by human action seems to indicate natural fracturing has occurred.

Two further sections at Q5 and Q12 revealed thousands of percussions blows indicated by the negative bulb of percussion, but none along fractured planes. In conducting this test here and elsewhere at Moondarra all the percussion blows revealed a green colouring where rock has been removed from the core. When resting at ground level, mineralisation by iron oxide changes the fresh breaks in Moondarra basalt to a reddish colour, but rocks higher than flowing water retain the vibrant green colour. This colouring highlights any breakage by human interaction in these hardstone quarries.

Based on these results, an argument that firing was used to split basalt at the hardstone quarries at Moondarra seems unconvincing. In addition, if this technique was not applied to larger boulders in the hardstone quarries, then it is most unlikely to be a reduction method applied to smaller cobbles on the surface quarries. At Mauna Kea adze quarry in Hawaii, McCoy and Gould (1977:241) found archaeological evidence for fires in rockshelters, but they suggested that the ancient Hawaiians used levers to break up slabs of basalt already cracked by thermal expansion and contraction.

Poles were almost certainly used as levers to extract stone from the subsurface at Moondarra. The data in Table 6.2 possibly indicates that levers had been used to extract basalt. Although stone from MP1 was extracted to a depth of 33cm, the majority of debris was located between 15cm to 20 cm below the surface (spit 4). Probing into the ground for suitable stone and then levering it out could explain this pattern. If all the earth within the mining pit had been extracted down to 33cm, the majority of debris would be expected at this level when infilling occurred, which is not the case.

A supporting statement for the use of poles at axe quarries comes from John Green's account of mining at Mt William, Victoria in Smyth (**I**:1878), which states that stone was usually removed with a pole of wood and then flaked into shape. When interviewing former quarrymen who worked the Tuman axe quarries in the Papuan New Guinea Highlands, Burton (1984:241) was told that wooden stakes or wedges were one of the mechanical tools used to extract stone.

6.5.2 **Wedging**

During the survey of quarries in the northern part of the complex, evidence was located and photographed to show that the miners used hammerstones to create cracks in rock, and placed wedges into these fractures to split the rocks into two or more pieces. After splitting, the edges of the split rock would provide a platform on a core, from which flakes (axe blanks) could be knapped (Plate 6.3).

The splitting of rock shown in Plate 6.3 is possibly an attempt to parallel an existing fissure (see Plate 6.3, to the left of the chalk line). The successful removal of the rock between the natural and human induced split would enable a stone wedge to be placed into the wider opening, allowing the two pieces of rock to be completely separated. The fissure shown by the chalk line in Plate 6.3 lies along a row of percussion blows, as indicated by the ringcracks and natural green colour of the basalt exposed by the removal of the cortex. The mass of percussion blows in the left-hand bottom of the picture is possibly an unsuccessful attempt to split the rock on the left hand side of the natural fissure.

The stone wedge in Plate 6.4 shows an attempt to prise open an existing split in a basalt boulder. The presence of cortex in the fissure of Plate 6.4 suggests that this is a natural fissure in the stone. Percussion blows were noted on the end of the wedge and it was stuck fast in the rock. The purposeful creation of fissures and the use of wedges on these and natural fissures is certainly a quarrying technique that could take full advantage of fracturing rocks by firing. However, at present the use of this as a reduction method cannot be supported by evidence from Moondarra.

The quartzite rock used as a spacer in Plate 6.5 is not naturally positioned, as quartzite is not present in the immediate vicinity of this basalt outcrop. This site is located in the northern section of the complex, but is not technically recorded as a quarry as it is an isolated feature with less than 10^2 m of quarried stone surrounding it. Positioning a rock in preparation for breakage like this results in any force to the rock acting as tension, which unlike compression cannot be absorbed over the base of the rock. This principle of tension and compression can be likened to a house brick, which can withstand enormous amounts of compression, but breaks easily when only the ends are supported and force is applied to the centre of the brick.

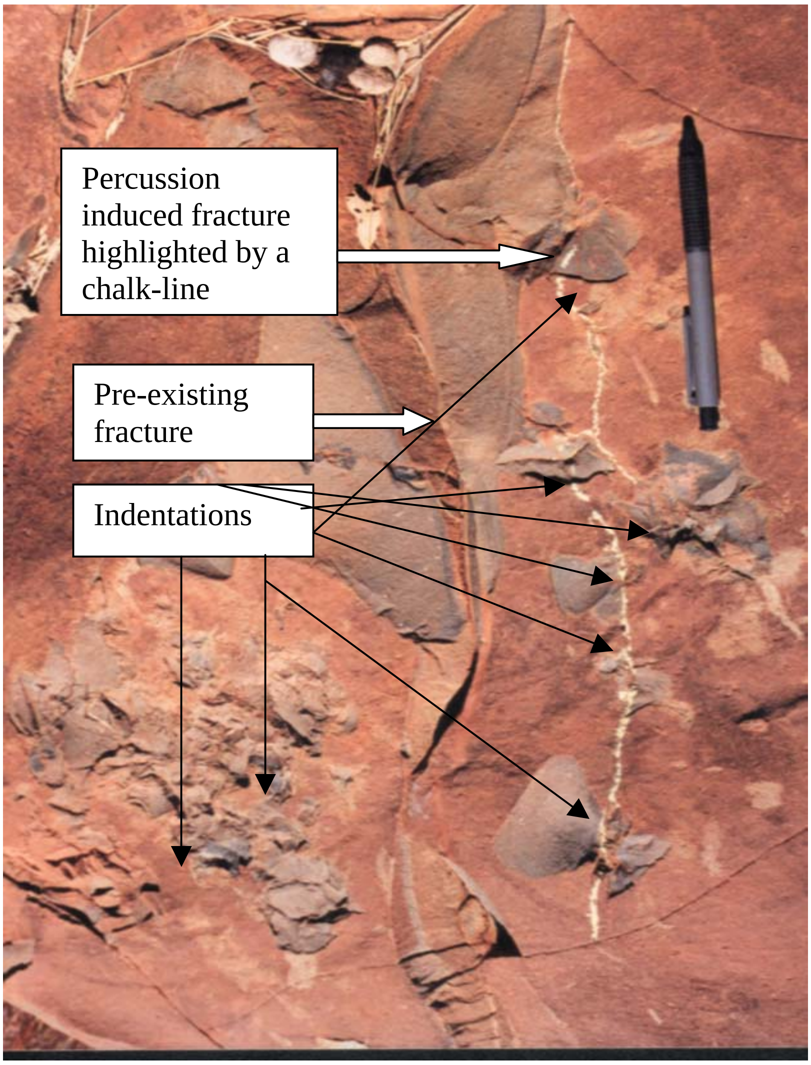


Plate 6.3. Chalk line showing a fissure created by a line of percussion blows with a fracture to the left.

6.5.3 **Anvils**

Anvils were used at Moondarra and the one shown in Plate 6.6 was located in an area of intensively worked boulder outcrop on the western boundary of Q12. Stone anvils have also been documented at Mt William:

> Many of the circular mining pits are several meters in diameter and now over a metre deep. Most have associated flaking floors, and often in the centre an undisturbed slab of outcrop, left to serve as an anvil stone for rough shaping of the mined material. (McBryde 1984:273)

Plate 6.4. A stone wedge inserted into a natural fissure.

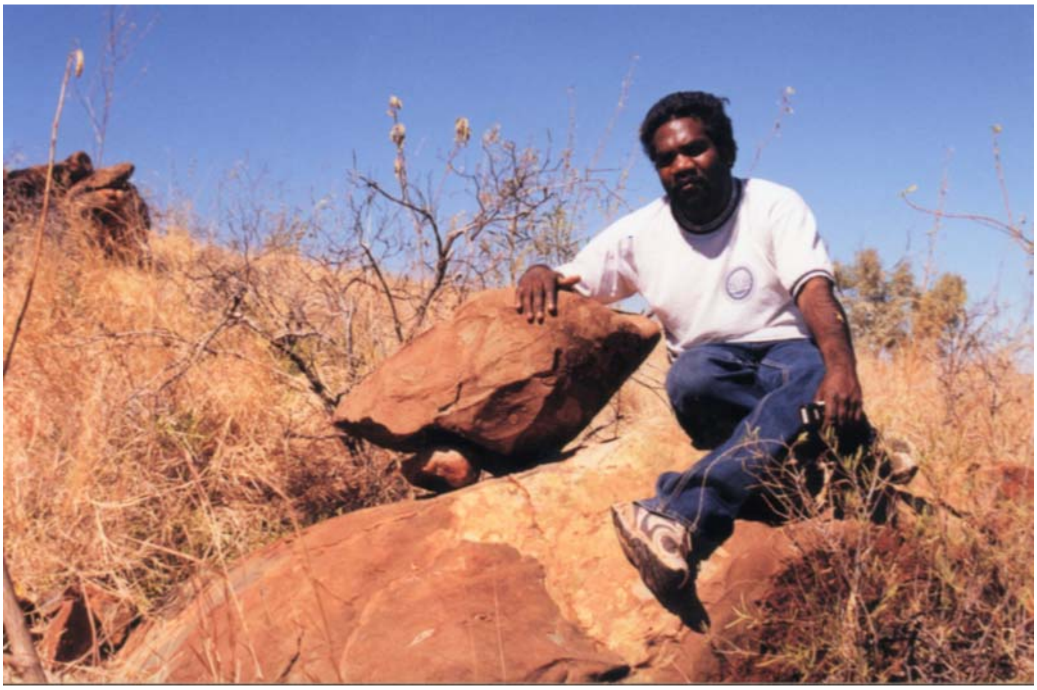


Plate 6.5. Clinton Percy with his hand resting on a basalt boulder positioned for splitting.

This type of block (Plate 6.6) appears to have been used as a traditional anvil with objects being placed upon it and then hammered, resulting in some breakage on top. A second type was also used where rocks were hurled onto the anvil and indiscriminate breakage would probably occur to both the anvil and the stone thrown at it (see Plate 6.7). These anvils are subjected to greater force when heavy stones are hurled down on them, which result in flakes being removed from the edges as in Plate 6.7.

6.5.4 **Hammerstones**

Spherical basalt hammerstones with numerous indentations on the area used for hammering are readily found on the quarries at Moondarra, but they are conspicuous by their absence at reduction floors. This may be attributed to quartzite blocks and recycled quartzite grindstones being used to trim the axes in these locations. These quartzite tools are found with chip marks on the surface suggesting that they were hard enough to facilitate the rigours of knapping. Support for this is suggested by the transport of basalt blocks and hammerstones to the quartz quarry at Q1. This quarry is about 500m from the nearest basalt quarry, and this evidence supports the idea that stone material was transported around Moondarra for specific needs.

A second explanation for the absence of basalt hammerstones at reduction floors may be that these have been removed as a result of pilfering, but this does not apply in relation to stone axes. As hammerstones are usually less attractive to collectors, this explanation is not strongly supported. A third possibility is that hammerstones are highly valuable and have been transported away from reduction floors. However, the archaeological experiments of Dibble and Pelcin (1995) may partly explain the absence of hammerstones from reduction floors.

Dibble and Pelcin (1995) suggest that the mass of flakes is almost entirely determined by the exterior platform angle and platform thickness and that velocity and mass of the indentor, as well as the combination of the two, exert minimal influence on flake mass (Dibble and Pelcin 1995:435). Based on Dibble and Pelcin (1995) proposition, it is reasonable to suggest that smaller objects were sufficient (albeit in producing smaller flakes) and that an opportunistic approach to using suitable materials to hand can explain the absence of basalt hammerstones from the reduction floors.

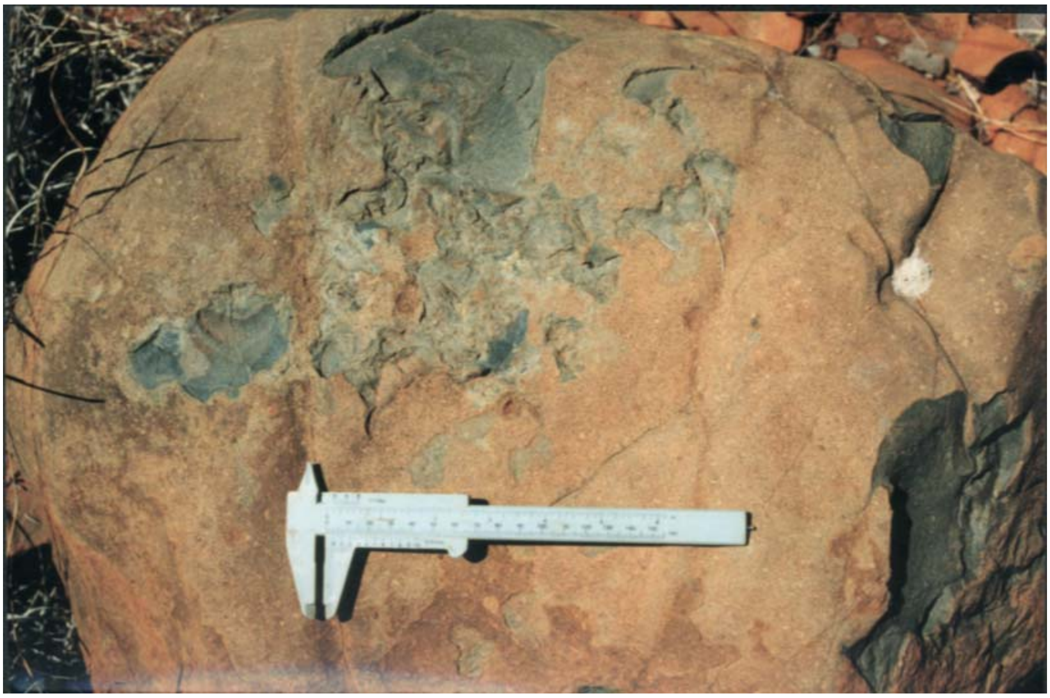


Plate 6.6. A basalt anvil on Q12 with indentations caused from bruising.

Plate 6.7. An anvil at Q12 showing breakage around the edges from rocks being hurled at it.

A graph of 16 hammerstones measured from Q4 is shown in Figure 6.3. The measuring convention for linear measurements was that length was the longest measurement, width the next longest and thickness the minimum measurement on the near spherical shaped tools.

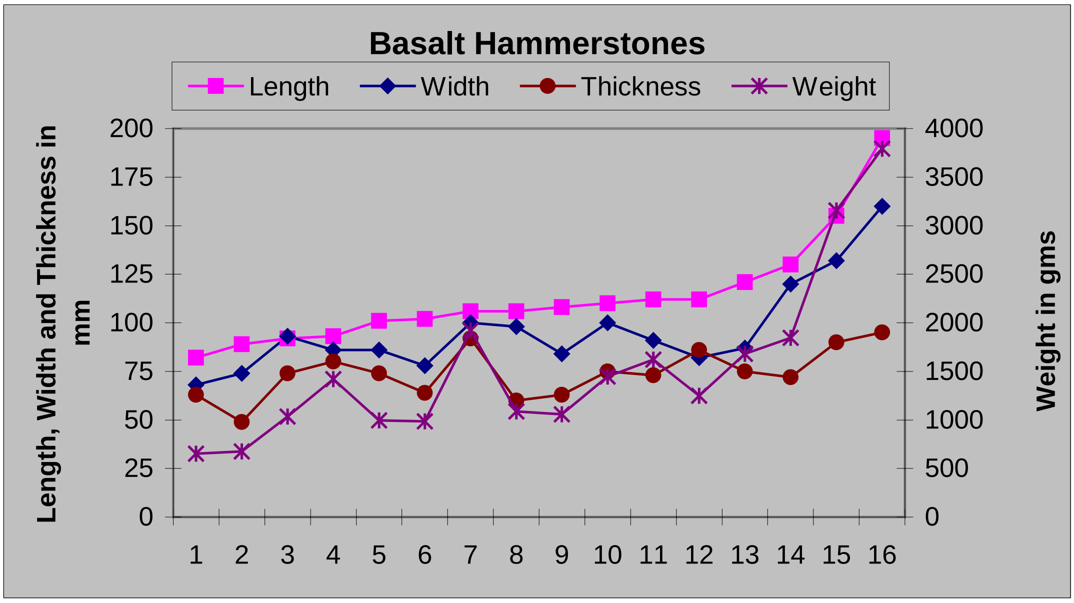


Figure 6.3. Length, width, thickness and weight of 16 hammerstones measured from Q4.

Figure 6.3 indicates that the majority of hammerstones are between one and two kilograms in weight and thickness is remarkably uniform. A photograph of a hammerstone is shown at Plate 6.8.

Plate 6.8. A basalt hammerstone resting upon a basalt block.

6.6 Axe general reduction sequence

The general reduction sequence for axes produced at Moondarra align with five stages of production, which are:

a. Stage 1: Flake blank
b. Stage 2: Edged blank
c. Stage 3: Thinned blank (larger flakes removed)
d. Stage 4: Final trimming (smaller flakes removed)
e. Stage 5: edge ground axe

From stages one to four of the reduction sequence the axe may be discarded, if the axe does not meet the minimum measurements of length, width and thickness.

Stage one blanks are not retouched. In knapping the axe blank from the core, it appears that every attempt was made to remove a flake of suitable size and thickness. Although most of the axes are extremely thick during this initial stage of reduction, in cases where minimum thickness was below about 34mm, these axes remain on the quarries as stage one artefacts. This suggests an immediate rejection of the axe blank as no further reduction is attempted.

The minimum thickness required to extend across almost the entire flake is about 34mm. This can be tested by three data sets. First, reject preforms on the quarries with a thickness less than this are common. Second, an examination of 90 axes that were located on the reduction floors have a median thickness of 41mm. Third, the median thickness for stone axes traded into the Lake Eyre Basin from Moondarra is 31mm (Tibbett 2000). The decreased axe thickness of the Lake Eyre Basin axes can be explained by subsequent hammer dressing that further reduces axe thickness (see Tibbett 2003).

Stage two axes have been retouched on the margins to form an outline that exceeds the parameters required for a stage three axe. A retouched flake has one or more edges modified by the deliberate removal of secondary flakes. Extremely thick flakes in the range of 60mm and over are sometimes discarded at the first stage of production. Significantly increased amounts of knapping are required to reduce thickness to an acceptable level on these axes by proportionally increasing the amount of knapping required to reduce the axe.

This proposition is partly supported by the methods used to produce the larger axes. These are manufactured from naturally formed boulders of a suitable size. These extremely large, thick stage two flakes sometimes usually have a thickness of 60-70mm. They are completely knapped around the margins to form a discoid shape and then left on the quarries. The resulting profile resembles the shape of a turtle’s shell. It is unlikely that these blanks were discarded. A considerable amount of reduction has been conducted without any attempt to reduce thickness. Rather, it would appear that they have been stored for further reduction. Essentially they have been reduced to a desired length and width similar to the reductive process for the stage two smaller axes. However, no attempt has been made to reduce thickness and this type of blank is only noted on the quarries. Completed ‘ceremonial’ axes in museum collections can weigh over three kilograms.

Stage three axes are usually extensively reduced on the dorsal side to reduce thickness. These axes are found on all quarries with heavier concentrations near mining pits where extensive axe production has occurred. They are considerably larger and heavier than stage four axes. Occasionally, stage four axes are also located on the quarries. This situation may occur when the dimensions of the stage one flake was near that required for a stage three axe, therefore requiring minimal reduction. Stage three axes are retouched flakes that exceed the dimensions required for a stage four and stage five axe.

A comparison between the trimming flakes removed at the quarries with those removed at the reduction floors is shown in Tables 6.3 and 6.4. Except for edge angles, all other variables are significantly higher on the flakes removed at the quarries. The difference between stage three and stage four stages of reduction is accentuated in the measurement of weight (Tables 6.3 and 6.4), which has a direct association with flake length, width and thickness.

The stage four axes located on the reduction floors have mean length of 114mm and are on average slightly larger than those produced to stage five. They have certainly been carried from the quarries and retouched on the reduction floors, but comparative analyses with axes used more broadly in the Mt Isa region and beyond suggest that these axes are below the median length of those exchanged from Moondarra.

	Length mm	Width mm	T/ness mm	P Length mm	P Width mm	Weight gm	P Angle deg.
Mean	45	37	11	21	8	47	79
Standard Error	2.438	2.25	1.00	1.42	0.71	12.41	2.24
Median	37	29	8	19	6	8	77
Mode	37	51	4	12	3	1	70
Standard Dev.	26	24	11	12	6	131	18
Sample Var.	657.29	564.53	111.65	155.25	40.37	17120.49	338.67
Kurtosis	1.09	1.83	28.73	2.85	7.60	59.15	0.75
Skewness	1.11	1.40	4.34	1.58	2.22	7.018	0.13
Range	134	115	89	58	39	1214	106
Minimum	10	9	1	6	1	1	26
Maximum	144	124	90	64	40	1215	132
Sum	5010	4117	1179	1625	619	5237	5298
Count	111	111	111	76	78	111	67

Table 6.3. Dimensions of complete basalt trimming flakes recovered from R3 and R4

	Length mm	Width mm	T/ness mm	P Length mm	P Width mm	Weight gm	P Angle deg.
Mean	34	27	7	16	5	15	80
Standard Error	1.36	1.02	0.371	0.745	0.45	1.79	1.17
Median	31	24.5	7	14	4	7	81
Mode	30	22	7	11	3	1	86
Standard Dev.	19	14	5	9	5	25	12
Sample Var.	368.39	206.11	27.17	76.01	28.20	637.88	142.06
Kurtosis	1.31	2.38	16.10	3.11	56.93	26.45	2.37
Skewness	1.072	1.05	2.97	1.52	6.40	4.44	0.23
Range	100	90	40	47	54	215	81
Minimum	3	2	1	4	1	1	40
Maximum	103	92	41	51	55	216	121
Sum	6776	5313	1472	2138	709	3014	8239
Count	198	198	198	136	138	197	103

Table 6.4. Dimensions of complete basalt trimming flakes recovered from Q12.

For example, axes exchanged to Glenormiston, 220km from the quarry have a median length of 134mm and those generally from the Mount Isa district have a median length of 118mm (Tibbett 2000). It is doubtful that this type of artefact remaining on the reduction floors axes are actually rejected or discarded axes, as processing to this stage of reduction requires additional time and effort that would be wasted if the knapper knew that the final product was near or below the minimum size required for exchange. Despite the majority of these axes being marginally smaller in comparative terms with exchanged axes, they may represent a hoard or surplus produced to meet future consumer demand.

Stage five axes can have minor retouching on the dorsal side and occasionally the distal side to minimize the amount of edge grinding required to form a cutting edge. This retouching is in addition to the knapping required to form the margins on stage two axes. The edge ground cutting edge may only extend about 5-10mm from the margin. Rarely, are stage five axes ground completely on the dorsal side in the Mt Isa district, but this characteristic becomes widespread in the Glenormiston district.

The presence of cortex on trimming flakes at both the quarries and reduction floors was to some extent an ineffective method in determining the sequence of reduction. The reason for this is the extremely low percentage of axes that have cortex on the dorsal side, resulting in minimal numbers of trimming flakes having cortex on the surface. This is possibly the result of numerous flakes (axes) being struck from the same core. Nevertheless, a trend for decreasing percentages of cortex on axes during reduction stages is perceptible, but this archaeological evidence is based on low numbers (Table 6.5).

Reduction sequence	**Location**	**Number of axes**	**Number with cortex**	**Percentage of cortex on each axe**
3	Quarries	n141	n8 = 5.7 percent of the assemblage	4 at 100% 1 at 75% 3 at 25%
4	Reduction Floor	n91	n6 = 6.6 percent of the assemblage	1 at 75% 5 at 25%

Table 6.5. Cortex percentages on axes during stages of reduction.

On the surface of Kalkadoon campsites to the north of Moondarra there is a lack of empirical evidence for distinctive green flakes despite the presence of numerous broken axe particles. Often, the broken axes could be conjoined which suggests that after breakage, the axe has not been used as a core to produce another artefact type. This supports the belief that the thousands of greenstone flakes located at Moondarra are waste from trimming axes and not artefact types.

Stockpiles of stage four and stage five (edge ground) axes represent a considerable investment in time, energy and raw materials and their storage onsite (in the open) suggests that factors such as ownership and control existed over sections of the quarry. In other words, these axes were not merely left there, they were *kept* there. Therefore, distinct access and associated ownership rights may diminish the possibility of misappropriation by other Aboriginal groups in the absence of formal transactions.

Attempts to achieve a degree of standardisation may have influenced the decision to continue a reduction sequence on a particular artefact. An example of possible attempts at standardisation (resulting in discard) are archaeologically detectable in stage three of the reduction sequence at the quarries when the size of the artefact is reduced to below the minimum size for any of the major variables of length, width and thickness. When this result happens, discard can occur.

6.7 **Axe production stages**

To enable comparable analyses with previous researchers at Moondarra Hiscock (forthcoming) and Innes (1991), the data are analysed by four stages of production. The four axe types identified by Hiscock (forthcoming) and Innes (1991) are not directly associated with the general reduction sequence. The essential divergence is that stage two of their classification, combines both stage two (edging) and stage three (initial thinning) of the general reduction sequence (see Table 6.6). Axes can be discarded after edging, therefore it seems that reducing thickness is a separate stage of production.

Hiscock (forthcoming) and Innes (1991) described axe types at Moondarra as:

1. Unretouched flakes on the crests of ridges with quarry pits,
2. Retouched flakes on ridge with quarries,
3. Retouched flakes on the reduction floors, and
4. Retouched flakes on the reduction floors that have been ground.

The axe blanks themselves are large flakes (stage 1) and thus as secondary flakes or chips are increasingly removed from an axe, its changes to a higher level of reduction.

Stage one is never found at the reduction floors and stage four is not found at the quarries. The majority of retouched flakes on the quarries are appreciably larger than the retouched flakes on the reduction floors (see Table 6.7) and, this size difference is largely due to increased reduction at different workstations. Occasionally, flakes are reduced to stage three on the quarries and this type of behaviour is sometimes noted near the numerous stockpiles of blanks sited on several of the quarries. The largest stockpiles were 23 axes at Q4, 16 at Q12 while there were numerous hoards of about 10 axes (see Plate 6.9).

Stage three axes from the reduction floors are significantly smaller than in length, breadth and thickness compared with stage two axes found at the quarries. This decrease in size is noticeable in the markedly lower weights of stage three axes compared with stage two axes (Table 6.7).

General Reduction Sequence	**Stages of Production**	**Comments**
1 Flake Blank	**1** Unretouched Flake	
2 Edged blank		Hiscock (forthcoming) and Innes (1991) do include edge trimming in their stages of production.
3 Thinned blank (larger flakes removed)	**2*** Retouched flake at the quarry	
4 Final trimming (smaller flakes removed)	**3** Retouched flake at the reduction floor	
5 Edge ground axe	**4** Retouched flake that has been edge ground	

Table 6.6. Reduction sequence compared with stages of production.

After Innes (1991), Hiscock (forthcoming) has also sustained the progression of reduction hypothesis at various workstations at Moondarra with archaeological statistics providing linear dimensions for stages 2, 3, and 4 for each stage (Table 6.8). In addition, he supported this notion of progressive reduction by measuring the frequency of fracturing for the first three stages of flake production (see Table 6.9).

The data used in Tables 6.7 and 6.8 are different assemblages. The reduction floor collection was *n*90 (Table 6.7) compared with *n*47 (Table 6.8) and the flakes from the quarries in Table 6.9 is a random sample from six quarries. Despite these differences, the perception of each stage of axes being more extensively reduced than the previous stage at subsequent workstations is clearly supported in both data sets.

Flakes with hinge terminations can be more rapidly reduced to stage three axes as until the edge is prepared prior to grinding, the ventral side provides a symmetrical profile suitable for the completed artefact (see Figure 6.6). Therefore, only minimal knapping is required on the ventral side to prepare a cutting edge prior to edge grinding. Hinge terminations would increase production efficiency by minimizing the amount of knapping required to produce an axe to stage three.

Plate 6.9. A stockpile of axes on Q12.

Reduction floors				
Stage 3 axes	**Length mm**	**Width mm**	**Thickness mm**	**Weight gm**
Mean	114	112	42	830
Median	111	109	41	696
Count	90	89	90	85
Quarries				
Stage 2 axes	**Length mm**	**Width mm**	**Thickness mm**	**Weight gm**
Mean	142	137	52	1396
Median	140	135	50	1269
Count	147	134	42	791
	141	141	141	141

Table 6.7. Comparative analysis between axe blanks from reduction floors and quarries.

Reduction stage	**Sample**	**Length (mm)**	**Width (mm)**	**Thickness (mm)**	**% bifacially flaked**
2	Flakes on ridges with quarry pits (*n*=138)	131	140	54	33
3	Flakes on reduction floors (*n*=47)	119	111	47	71
4	Flakes with grinding (*n*=20)	97	93	41	82

Table 6.8. Dimensions and extent of shaping on retouched flakes from different parts of the quarry (from Hiscock forthcoming).

Reduction stage	**Sample**	**Feather**	**Hinge**	**Step**
1	Unretouched flakes on ridges (*n*=102)	82	15	2
2	Retouched flakes on ridges (*n*=119)	65	35	0
3	Retouched flakes on reduction floors (*n*=27)	48	52	0

Table 6.9. Frequency of fracture terminations on flakes at Moondarra (from Hiscock forthcoming).

6.8 Axe flake terminations

After Cotterell and Kamminga (1986, 1987), Pelcin (1996:250) suggested that platform thickness influences the type of flake termination. Feathering may be considered a normal type of termination, but hinge terminations characterise axe blanks at Moondarra. A longitudinal profile of a hinge and featured termination are shown in Figure 6.4.

Most of the axes produced at Moondarra have hinge terminations. A hinge termination maximises thickness near the distal end or intended cutting edge. Axe thickness is extremely important as, if the axe thickness reduces abruptly near the cutting edge, which in the case of Moondarra axes is generally the distal end of the flake, the axe would be less unable to absorb the rigour of physical forces applied during use without breaking. By creating a hinge termination, with increased thickness on the distal edge, the Moondarra knappers also created a flake that maximised the length of the blank that could be used. This reduction procedure maximises the length of the flake that can be effectively used as an axe blank.

Although, a hinge termination may seemingly decrease the length of a flake compared with a feathered termination, with a hinge termination the full length of the flake is useable with minor trimming to create an edge suitable edge for grinding. On the other hand, a feathered termination requires considerable retouching on the distal end to obtain the required thickness. Therefore, the increased length of a feathered blank actually reduces the potential useable length of the flake (see Figure 6.4). In addition, the advantage of a hinged termination for knappers producing stone axes is that the profile of the ventral surface becomes the symmetrical outline, with the dorsal side only requiring trimming to create a balanced or symmetrical profile on the axe. The majority of stone axes at Moondarra, used in the Mt Isa district and in museum collections are mostly reduced on the dorsal side.

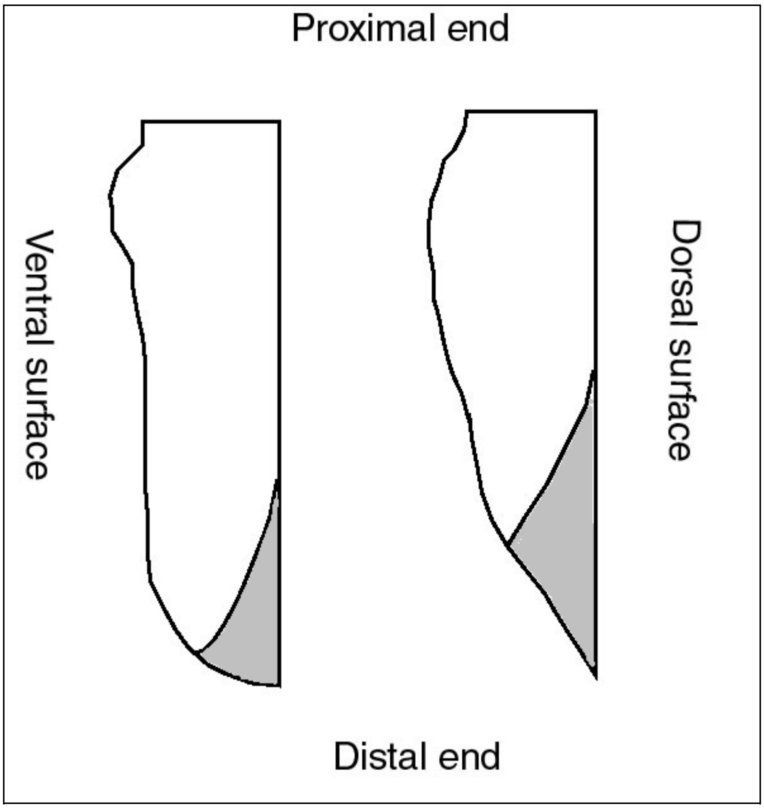


Figure 6.4. Longitudinal profile of a hinged termination on the left and a feathered termination to the right (after Hiscock forthcoming Figure 2).

6.9 **Grindstones and grinding grooves**

The association between grindstones and axe production at Moondarra is circumstantial, but the weight of evidence seems to support the view that grindstones were used for both food processing and axe production at Moondarra. Roth (1904: 25) documented the exchange of sandstone grindstones from Pituri Creek on the western tributaries of the Georgina River and the nearby Toko Ranges to the Kalkadoons near Carandotta Station, southwest of Moondarra.

Sandstone is extremely rare rock type in the northwest Highlands as it mostly originates in underwater deposits and this region has never been submerged below sea level. Sandstone can also form in lakes or infrequently along stream courses (Lapidus and Winstanley 1990:450), but geological maps of the Mt Isa district show very few sandstone formations.

In contrast to Roth’s notes, sandstone grindstones were not observed at Moondarra possibly because local siltstone and quartzite were used instead. The siltstone may be sourced to an outcrop on R2. Quartzite grindstones, which are found on all six-reduction floors can be sourced to Stone Axe Creek. This is because the distinctive yellow mineralisation of the cortex and more rounded edges on creek cobbles differs from the whiter quartzite rock with angular profiles on the ridge formations.

Grindstones were undoubtedly essential for food processing for the Kalkadoons and Roth (1904:25) documented that in the northwest district grain constituted the main source of the vegetable component of the diet. However, it does seem unusual that flat siltstone grindstones with very smooth fine-grained surfaces may have been used to grind seeds. The use of this type of grindstone may represent a scarcity of trade goods from the Toko Ranges. However, it is possible that Aboriginal visits to Moondarra occurred in early summer after the first heavy summer rains that herald the end of the dry season. Seed grinding may have been less important during early summer, as after a prolonged dry season broken by summer rains, native grasses require some time to grow and seed.

The archaeological evidence for edge grinding as part of the production process at Moondarra is principally based on the presence of numerous quartzite stones on the reduction floors. These objects may have been used to grind axes in the final stage of production. Axes with ground bevels can still be located along the watercourses at Moondarra and Simmons (1991:65) in describing the Jet waterhole (a semi-permanent waterhole near R4) noted that: “In the area surrounding the water hole six axes with varying degrees of grinding … were found”. The presence of quartzite grindstones at Moondarra has a parallel at the Gunpowder axe quarry to the north where basalt blocks on the reduction floors show wear patterns similar to grindstones.

Aboriginal informants described a grinding technique to Roth (1897) in which basalt was ground on basalt:

> From descriptions given to me by older blackfellows I found that the stone-head itself used to be cut as follows: A lump about the required size was first

> of all broken away, and parts chipped off here and there with another piece of rock until the necessary shape would be roughly obtained. A whole day perhaps would be occupied in doing this, while another twenty-four hours would be required for grinding down, with water, along another smooth piece of the same material until such time as the edge would be sharpened enough for use. (Roth 1897:151)

Roth’s (1897) account of the time taken to edge grind a stone axe is partly supported by Dickson (1981) who experimented with grinding basalt on basalt. He suggested that this process would be long, drawn out and provide a poor result. Campsites on May Downs and Yelvertoft Stations to the north of Moondarra had basalt axes that had only the cutting edges ground. An exception was a basalt axe in pristine condition completely ground with no obvious wear marks or indentations on the bevel. This axe was completely smooth on all surfaces and the negative scars from knapping had been completely ground down. Nevertheless, this axe was found some distance from a major campsite and was possibly cached, intended for further use. The amount of edge grinding on the ground axes found at Moondarra are similar to most of the edge ground axes discarded to the north of Kalkadoon country and possibly in other locations (Tibbett 2004a, 2004b).

It is possible that axes were exchanged with only the edges ground as preference for ground or hammer dressed axes changes with increasing distance from the source. As distance from Moondarra increases, the thickness of the axes are more intensively reduced by hammer dressing, which makes them easier to resharpen as the edge ingresses towards the original thicker centre of the axe (Tibbett 2002b:37). In essence, the bulge in the centre of the axe is removed by hammer dressing, enabling the edge to be maintained with minimal resharpening.

The northern regions of the Lake Eyre Basin have significantly lower percentages of hammer dressed stone hatchets compared with the southern regions (Tibbett 2000:35). This assumption seems to be partly supported by the observations of Roth (1904) in northwest Queensland who noted:

> Where indiscriminately broken from the surface of the rock, the weathered external surface can be recognised in Figs 68a, 69: in the latter example, the

> flat side shows no trace of further workmanship save the edges. (Roth 1904:19)

Roth’s description of stone axes is similar to those remaining at Moondarra and most of the axes found in the Mt Isa region. More polished axes, comparable to the one located at May Downs, are similar to those provenanced to the northern regions of the Lake Eyre Basin. However, when axes are made for exchange the eventual owners preference is unlikely to be known and therefore, preparation of an implement by polishing or hammer dressing (other than producing a ground edge), may constitute an effort that does not markedly increase the value of the item.

6.10 **Axe grinding grooves in northwest Queensland**

There is a paucity of recorded axe grinding sites in the Environmental Protection Agencies’ records for northwest Queensland. Only three documented axe-grinding sites occur within a 150km radius of Moondarra and these are all located on watercourses. The Waterfall and Upper Waverly Creek grinding sites are located along or near the Kalkadoon trade routes to the south (Figure 6.5). McBryde (1997) documented this southwest exchange trail based upon ethnographic interpretations and Tibbett (2000) has supported her suggested trade route principally on metrical and geological evidence for axes in the Glenormiston region. The limited number of axe grinding grooves recorded in the Mt Isa region seems to support the assessment that axe edge grinding might have occurred on portable grindstones during the production process at Moondarra.

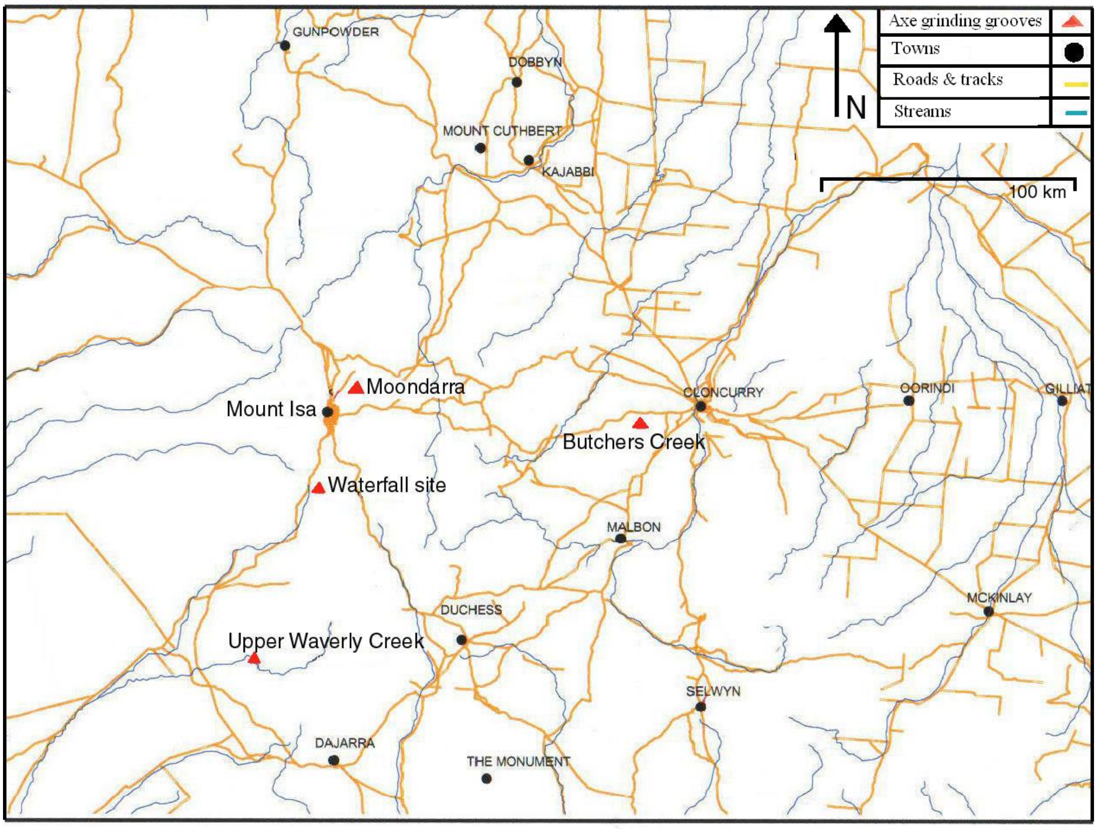


Figure 6.5. Axe grinding groove sites in northwest Queensland and the location of Moondarra.

6.11 **Grinding agents**

The grindstones on Moondarra exhibit shallow depressions on the surface where grinding has worn down the stone. Within these hollows, striations are visible to the naked eye. These grindstones are different from seed processors noted in the Boulia district in that they do not have grooves cut into the surface to facilitate seed grinding.

The use of siltstone and quartzite grindstones for grinding basalt axes at Moondarra would be a tedious and slow method of grinding as this process results in minimal abrasion to the surface of the axe. However, some experimental archaeology was undertaken using colluvium and sand as grinding agents mixed with water to grind edges on knapped basalt to represent the cutting edge of axes. This method rapidly formed smooth edge angles of 90 degrees on a bevel to about one and one half centimeters back from the cutting edge on both sides to represent a ground cutting edge.

The regional average edge angle of Mt Isa axes in the Lake Eyre Basin is 87.20º based on a sample size of 410 edge ground axes (Tibbett 2000:30). Using a smooth siltstone grindstone with a mixture of water and the substrate from R2 (a fine-grained colluvium), a smooth cutting edge could be ground in about 100 to 120 minutes. When a coarser sand substrate from the creeks was used, the edges were ground in 40 to 50 minutes.

Sand is an effective grinding agent and only small striations were left on an otherwise smooth finish. When a grinding agent such as sand is used between the axe and grindstone then the sand becomes the major grinding agent, largely replacing the abrasive textures of the grindstone and the implement being ground. Although, the archaeological evidence is not conclusive, this method of grinding is possibly the reason that some edge ground axes are found near streams (Simmons 1991). Roth (1897) has documented that water was used during the grinding process in northwest Queensland, but he did not mention any material being used as a grinding agent. Plate 6.10 shows a siltstone grindstone from R2.

Kim Akerman has conducted experimental axe edge grinding with sand using both wet and dry methods. In 2003 he produced four or five edge-ground axes for the National Science Museum, Tokyo and observed that wet grinding may hasten the creation of edges, but it resulted in heavy wear on the grindstone (Akerman pers. comm. 2004).

Akerman believes that if grindstones were imported, which presupposes an increased value for the grindstone, then it may be practical to use dry grinding to better preserve the grindstones. However, archaeological evidence for the importation of grindstones is not apparent at Moondarra.

Plate 6.10. A large siltstone grindstone from reduction floor 2.

In the Kimberleys, northwest Western Australia, Akerman has also observed that most axes were ground on suitably flat bedrock with sand and that the same location may not be used again (pers. comm.). At Hidden Valley near Kununurra, he observed axe-grinding grooves around dips in the bedrock where puddles of water would form in the wet season or water could be easily carried from adjacent streams. This method of edge grinding axes may be more common in Australia, but the notion of using a grinding agent to accelerate the edge grinding process at Moondarra can be supported by Akerman's archaeological interpretations from the Kimberley. Also, his experimental results using wet sand are similar to grinding experiments conducted during fieldwork. The absence of suitable sandstone formations at Moondarra for grinding, may have necessitated strategies to collect sand or quartzite colluvium and water to grind axes on portable grindstones. This technique would explain the presence of siltstone and quartzite grindstones on the reduction floors at Moondarra and basalt grindstones at Gunpowder.

Baldwin Spencer (1928) observed Warramunga men in Central Australia grinding axes on blocks of sandstone commonly known as nardoo-stone, which are generally used for grinding seeds, nardoo and ochre:

> ...he took a small quantity of fine sand, strewed it over the surface of the grindstone and then, sprinkling a little water over it, began to rub the axe backwards and forwards and now and then he added more and more water, holding the axe very carefully, so as to fashion two surfaces, meeting at and forming the cutting edge. (Baldwin Spencer 1928:498)

Baldwin Spencer (1928:497-8) also noted that this method of edge grinding took two days to complete but he was describing the process of grinding the complete surface of the axe. He documented that after pecking, the axe is ground and polished over more or less the whole surface.

6.12 **Foreign and discarded axes**

During the field survey an exotic stone axe made from brown/red shale was found on the surface of R2. This axe was larger than most Moondarra axes with measurements of length 171mm, width 150mm and thickness 39mm. One side of the axe had been knapped to form a hafting groove and the edge was bifacially knapped but not edge ground. The axe appeared to be a natural formation apart from a knapped hafting groove and the cutting edge.

At a habitation site near a prehistoric quarry in New Hampshire, Gramley (1980) has noted ‘dumping’ behaviour. It seems that in the process of retooling at the quarry a group traveling from an outlying location have discarded formal tools. Discarding old or tools made of inferior quality stone might explain the presence of the shale axe at Moondarra.

To the north of Moondarra, comparative analysis between axes broken and discarded at and away from habitation sites with axes found at Moondarra revealed considerable differences in form. The association between Moondarra and these axes is inferred through their proximity to the quarry and their distinctive green colouring. Axes discarded away from habitation sites are usually shattered into two or more pieces, have the ground edges broken off, and sometimes have show signs of irregular retouching to create an unground cutting edge. This latter form is probably an expedient response to a job at hand without the possibility of obtaining another axe. The axes recorded from the reduction floors at Moondarra did not possess these qualities. Perhaps axes broken in the field when away from Moondarra are not returned to camp for retouching and regrinding. However, the shale axe previously mentioned probably represents a shortfall in basalt axes and the expedient manufacture of an implement that is speedily discarded when a quality axe becomes available.

Discarded broken axes occur at habitation sites away from Moondarra, but quite often those discarded away from campsites have been expediently retouched before abandonment. At some campsites it appears that trimming possibly to enhance resharpening has reduced axe thickness. This is evidenced by the presence of basalt thinning flakes about two to three millimetres thick. This type of behaviour would be undetectable given the volume of basalt debitage on the reduction floors at Moondarra, but is highly visible away from the axe quarry where the distinctive green basalt is conspicuous (Tibbett 2004a, Tibbett 2004b).

At a number of sites in the Simpson Desert, Hercus and Clarke (1986) noted that green flakes had been trimmed from basalt axes. They suggested that the paucity of suitable stone for tools necessitated the recycling of edge-ground axes into smaller flaked implements (Hercus and Clarke 1986:60-1). Reducing axes to obtain smaller flakes is not accepted as an explanation for the presence of trimming flakes at campsites in the northwest Highlands. However, basalt flakes have been noted near large silcrete quarries where an abundance of high quality flaking material was readily available. Maintenance of axes, rather than recycling seems the probable grounds for trimming flakes off axes at campsites some distance from the axe quarry.

An offsite survey was conducted at a small andesite axe quarry near Lagoon Creek about 20 kilometres southwest from Moondarra. At this site, axe production possibly represents embedded procurement. Although, this axe quarry is also in Kalkadoon country it seems that axes were obtained from this small quarry in preference to travelling to Moondarra. The extremely small size of the Lagoon Creek andesite quarry in comparison with Moondarra may have limited the scale of production required to meet the demands of exchange. Over 93 percent of axes exchanged into the Lake Eyre Basin were basalt (Tibbett 2000). Within 200m of this andesite quarry there are several outcrops of fine-grained quartzite that have been extensively quarried for flakes with debitage in some places being two to three metres deep. These flakes are smaller than the macroblades at Moondarra being mostly under six to seven centimetres in length with extremely sharp edges.

There are no dates available for quarrying at Lagoon Creek to suggest that axe production is contemporary with Moondarra. Nonetheless, it is probable that this important source of quartzite has been quarried for at least as long as Moondarra. High quality sources of raw material such as the quartzite at Lagoon Creek, as suggested by the extremely sharp edges and points on flakes remaining onsite, might have been valuable additions to the tool kit.

In New Guinea, Hughes (cited in Strathern 1969:311) suggested that: "local material was used for axe manufacture more commonly than has so far been recognised in areas distant from quarries". In the same region, Chappell (1966:113) documented that on a limited basis local stone was used to make rough substitutes in locations some distance from the axe quarries. It would have been impossible for hunter-gatherers to carry an inexhaustible supply of stone axes, and in cases when axes were broken beyond repair substitute tools would have to be improvised.

6.13 **Conclusion**

This chapter examined a range of technologies used in producing stone axes at the Moondarra complex. Aboriginal mining to obtain raw materials was examined as were methods used to extract suitable stone and archaeological evidence for firing, preparation of boulders for wedging, evidence for wedging, the use of grindstones and perhaps a grinding agents to complete the production process at Moondarra.

The archaeological excavations at MP1 suggest that most of the spoil in the surrounding walls did not originate from the mining pit. Demarcation based on skill levels may have occurred with the younger, stronger miners completing the physically demanding, but somewhat less skilful work and the older men filling the role of artisan.

Analysis of the axe reduction sequence at Moondarra identified five stages of reduction. Stage two axes are an addition to the four stages of production suggested by earlier studies (Hiscock forthcoming and Innes 1991). However, stage two axes enable the production method used for ceremonial axes to be clearly defined. The five stages of reduction of utilitarian axes are supported by analyses that illustrate the decreasing dimensions for the axes as they are reduced to required forms and sizes (Tables 6.3, 6.4 and 6.6). These distinctive reduction strategies at subsequent workstations reflect continuing uniformity in the reduction sequence and therefore, a high degree of homogeneity can be perceived in the production of axes at Moondarra.

The general reduction sequence was compared with the stages of production by other researchers (Hiscock forthcoming and Innes 1991). This analysis is used in Chapter 10 when discussing standardisation in production. The discussion of axe production concluded with a discussion on the discard of old and foreign axes on the site.

Chapter 7 Archaeological excavations and results at R3 and R4

7.1 Introduction

This chapter is a general examination of the surface and subsurface cultural material from the excavations at Reduction Floors 3 (R3) and 4 (R4). Fluctuations in flake discard rates may demonstrate variation in intensity of site use, changing composition in artefact raw material may reflect changes in site use and variation in flake size may possibly suggest changes in artefact reduction technology. The chapter is structured in three sections. First, a comprehensive geomorphic assessment of R3 and R4 is detailed so that the integrity of the sites can be assessed. Second, the setting and raw materials found at both sites are summarized to provide an understanding of the relationships between these reduction floors and basalt quarries. Third, a descriptive analysis of surface and sub-surface artefacts from the excavation of three squares at both sites is outlined in order to establish whether there are temporal changes in discard rates, the percentages of artefact types and any variation in flake size.

7.2 Establishing the integrity of R3 and R4

Despite the presence of cattle trails across the site and limited vegetation the surface of R3 shows limited evidence of erosion caused by cattle trampling. R4 showed very little visible evidence of trampling, even though water is present for six months of the year in the nearby creek. This suggests that the surface and near surface material at these reduction floors have been less disturbed in comparison to other reduction floors as a result of stock movement. However, the major challenge was to establish geomorphological processes that operate on the complex. This is because Innes (1991:49) claimed that alluvial processes are at work on reduction floors at Moondarra.

The eastern border of R4 is a massive quartzite ridge (see Figure 3.3). Dr Jon Luly, a geomorphologist from James Cook University has examined surface, excavation, and creek bank photographs of R4 and suggested that this site is a colluvial formation. Dr Luly based this argument on several underlying principles:

a) The presence of large quantities of angular rocks on the surface of the site appeared to be a talus apron that is moving down slope from the quartzite scree (Figure 7.1).

b) The soil at the site appears to be a build-up of quartzite grains eroded from the ridges.

c) Stone observed in the excavation walls (excavated but unknapped material) was too angular in comparison with what would be expected from more rounded water-borne material.

d) The rocks in the creek bank that borders R4 are highly angular, which suggested that the creek was in fact incising towards the site (see Plate 7.1).

The angular surface rocks at R4 and a cattle track leading to the adjacent Jet waterhole remain visible despite the vegetation cover (Plate 7.2). The green coloured materials in the centre foreground of Plate 7.2 are basalt trimming flakes knapped from the axes during the reduction process.

The geomorphology of R4 does not conform to expectations regarding locations that border a stream. Colluvium from the quartzite ridge to the east of R4 has and is still depositing top soil onto the surface of R4, and Stone Axe Creek is incising into the colluvial fan and not depositing alluvium onto the surface of R4. The banks of Stone Axe Creek and its tributary, which border R4 to the northwest and northeast are not raised levee banks.

The angular rocks positioned within the creek bank, and on the surface and subsurface of R4 suggest that this stone has not been rounded by abrasion in streams. Quartzite boulders in the bed of Stone Axe Creek are rounded and have different coloured cortex whereas the stone from the ridges is white in colour and more angular. Iron particles are not embedded in the cortex of the talus material. These particles change the outer cortex to a reddish/brown colour, which transforms to a pink and then a grey inner core in parts of the rock unaffected by the chemical weathering of iron minerals. In addition, colluvial formations may be less erosive compared with alluvial systems and therefore be less prone to forming secondary depositional cultural sites, which might contaminate data and subsequent archaeological interpretation.

Plate 7.1. Angular quartzite rocks embedded in the bank of Stone Axe Creek beside R4.

R3 and R4 have similar geomorphic processes affecting site formation. Each site has a massive quartzite ridge to the east, which is the source of colluvium. Stone Axe creek incises to the west of each site and a watercourse flows from the Paroo Range (to the east), which flow past the southern boundary of the quartzite ridges. These east-west creeks are tributaries of Stone Axe Creek.

There certainly is an association between waterways and reduction floors as five of the six reduction floors are located close to waterways. However, a geomorphic assessment suggests that alluvial formations are not part of the depositional process at these two sites. In contrast, the colluvial process from the massive quartzite ridges is the major soil formation process.

Plate 7.2. Quartzite rocks and green basalt flakes on the surface of R4 with a cattle pad leading to the semi-permanent waterhole. The glistening objects in the foreground are leaves.

The difference between alluvial and colluvial site formation processes has notable implications for archaeological excavations. An alluvial formation transports material down-valley by surface water action, periodic aggradation and corrasion (Dalrymple *et al*. 1968). A colluvial formation has the potential to build up a depth of soil that may envelop cultural material at a particular site by mass movement and some surface wash fan formation. The semi-arid conditions at Moondarra may be evaluated in relation to Schiffer (1996:250) who cited Sellers and Hill (1974) to suggest the formation of colluvial formations in the dry Arizona region, which has a rainfall of less than 5 inches (12.5cm) per year. A hypothetical nine-unit land-surface model that illustrates the formation of a colluvial foot-slope is shown in Figure 7.1.

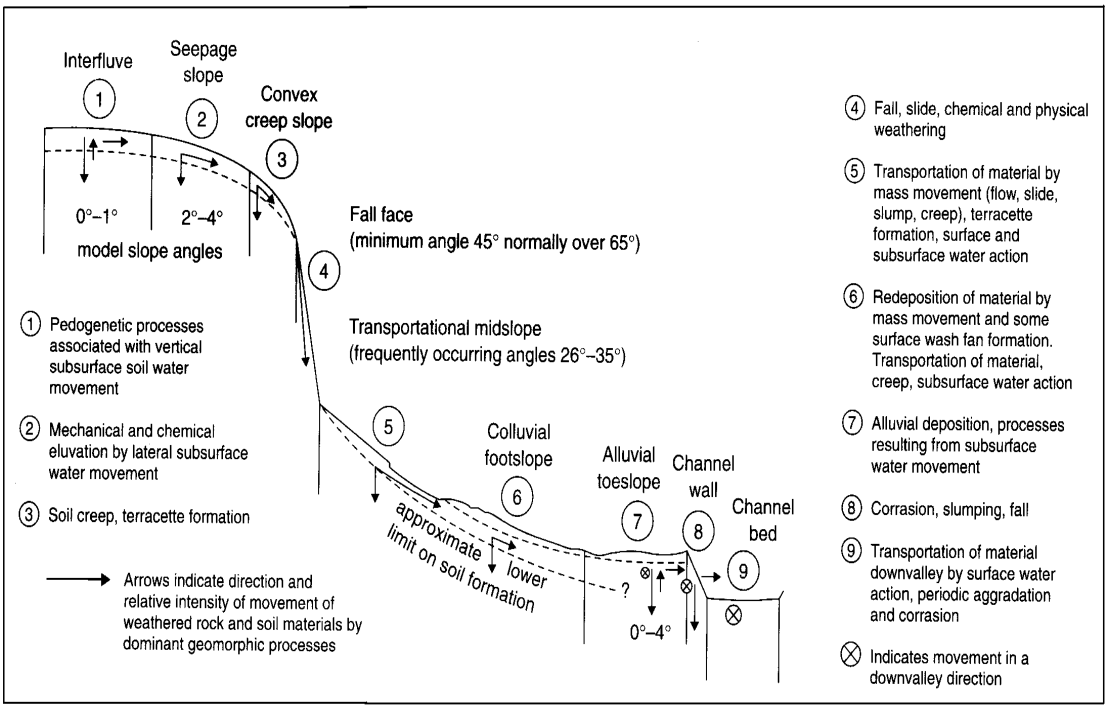


Figure 7.1. The colluvial formation process (from Dalrymple *et al.* 1968: Figure 13.19).

Dr Luly drew attention to another critical archaeological issue to be considered when interpreting cultural material excavated from a quartzite colluvial formation. Clay particles would not be present in the subsurface of a colluvium formation. At an open site such as this, the absence of clay particles would prevent the soil from expanding and contracting as soil water content varied.

Hofman (1986) examined artefacts in alluvial deposits at Cave Springs, Tennessee and attributed the repeatably shrinking and swelling action of clay particles in the deposits as a factor in post-depositional artefact vertical movement. He suggested that the contraction of soils in the wet season when the clays swelled may force larger artefacts towards the surface with smaller artefacts being deposited to lower depths during the dry period (Hofman 1986).

The absence of clay in the soil at R3 and R4 therefore suggests that vertical movement of artefacts in the subsoil is limited and provides further chronological reliability for the cultural material from the excavations. In Figure 7.1 (see also Dalrymple *et al*. 1968) the surface of these reduction sites equates to stages 6 and 7, which represent the approximate lower limit of the soil formation at the site. The bank wall as shown in Plate 7.1 relates to stage 8 in the colluvium process. The high quartzite ridge to the immediate east of the reduction floor represents stages 1 to 5, which are the dominant geomorphic process impacting on the site formation process (see Figure 7.1).

7.3.1 **Setting and raw materials for R3 and R4**

R3 is located 200 metres north of R2 with a shallow drainage system 203m wide separating the two (see Figure 7.2). This wash has two deeper creeks within it. The most northern of these creeks forms the southern boundary of R3, while Stone Axe Creek forms the western boundary. R3 is situated on a colluvial fan, which forms an easement (that generally runs parallel to Stone Axe creek) that is used by cattle moving to and from the water in Lake Moondarra. The cattle trail running through R3 is delimited by Stone Axe Creek to the west and the high quartzite ridge to the east.

Basalt knapped at R3 appears to have been brought from the central group of quarries, as a ridgeline to the east of the quartzite ridge provides relatively easy access to numerous quarries within this central part of the complex. The closest semi-permanent waterhole to R3 is 2.2 kilometres away near R4. Surface water remains for only a few weeks after the creek stop flowing, although digging wells may have extended the timing of water availability. The small catchment area of Stone Axe Creek, the steep hills and rocky ground result in the creek flooding almost immediately after heavy rain and it stops flowing within two or three days after rain.

Figure 7.2 shows the quartzite ridge to the east of R3 and the features surrounding the site. The routes marked between the quarries reduction floors (Figures 7.2 and 7.3) are possible pathways between quarries and reduction floors. In this hilly terrain, the narrow spaces between the long high quartzite ridges probably served as corridors that restricted the number of possible routes between the northern reduction floors and the basalt quarries. Similarly, Figure 7.3 illustrates the location of R4 with high quartzite ridges to the east, the waterhole between the two ridges, and Stone Axe Creek flowing to the west, with a tributary flowing down from an easterly direction, joining the main creek just south of the site. Sketches of the excavation sites at R3 and R4 and nearby features are shown in Figures 7.4 and 7.5 respectively.

R3 contained broken quartzite grindstones that had been used as hammerstones. These hammerstones had indentations over much of the flatter surfaces that were probably caused by particles disintegrating after striking hard objects. It is uncertain if these grindstones had been utilised for food processing or edge grinding axes or used for both functions prior to being utilised as hammerstones. These grindstones had shallow depressions and striations visible to the naked eye on the grinding surface.

The surface of R4 has numerous quartzite rocks with a high density of basalt readily apparent, with quantities of quartzite, chert and quartz flakes also recovered. In addition to the degree of angulation, quartzite river pebbles can be distinguished from quartzite talus by the amount of mineralisation in the cortex. The quartzite from creeks has a yellow-coloured cortex (possibly caused by the ingression of iron oxide into the outer layers of stone) whereas quartzite from the ridges has a lighter surface colour. Both types of quartzite are evident on the surface of R4.

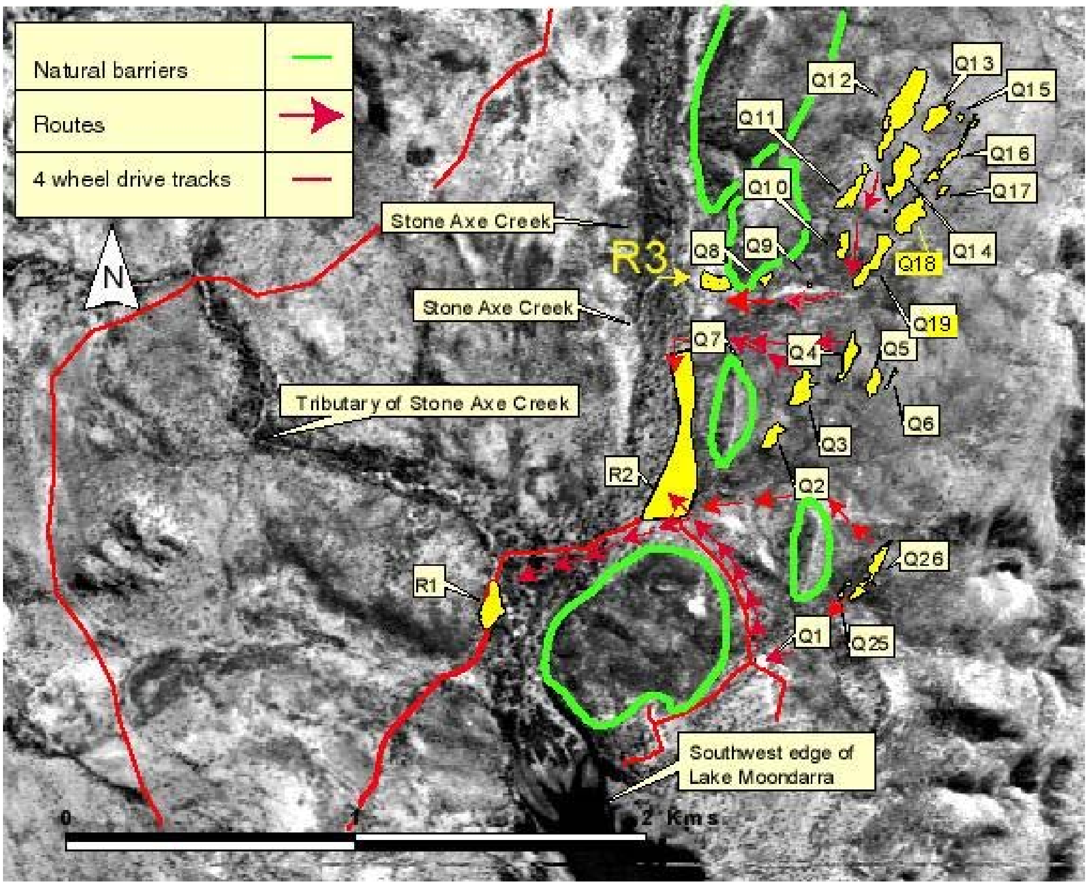


Figure 7.2. Map of R3 illustrating high quartzite ridges that are the source of colluvium, possible pathways and natural barriers.

R4 is situated near the only semi-permanent waterhole at Moondarra and is bordered by two creeks. People camping at adjacent reductions floors at R5 and R6 would most likely have to walk through or pass near R4 to gain entry to the basalt quarries (see Figure 7.3). The timing of visits to the quarries was probably after the first summer rains when the creeks first run. This rainfall would have filled the Jet waterhole and made digging wells for water possible. Wells would have been necessary to obtain water at the reduction floors other than R4 as surface water remains for only a week or so after the streams cease flowing. However natural stone barriers that cross the streams below the bed of the creeks would dam water upstream in the subsurface. Roth (1904) documented that local Aboriginals dug wells to obtain water.

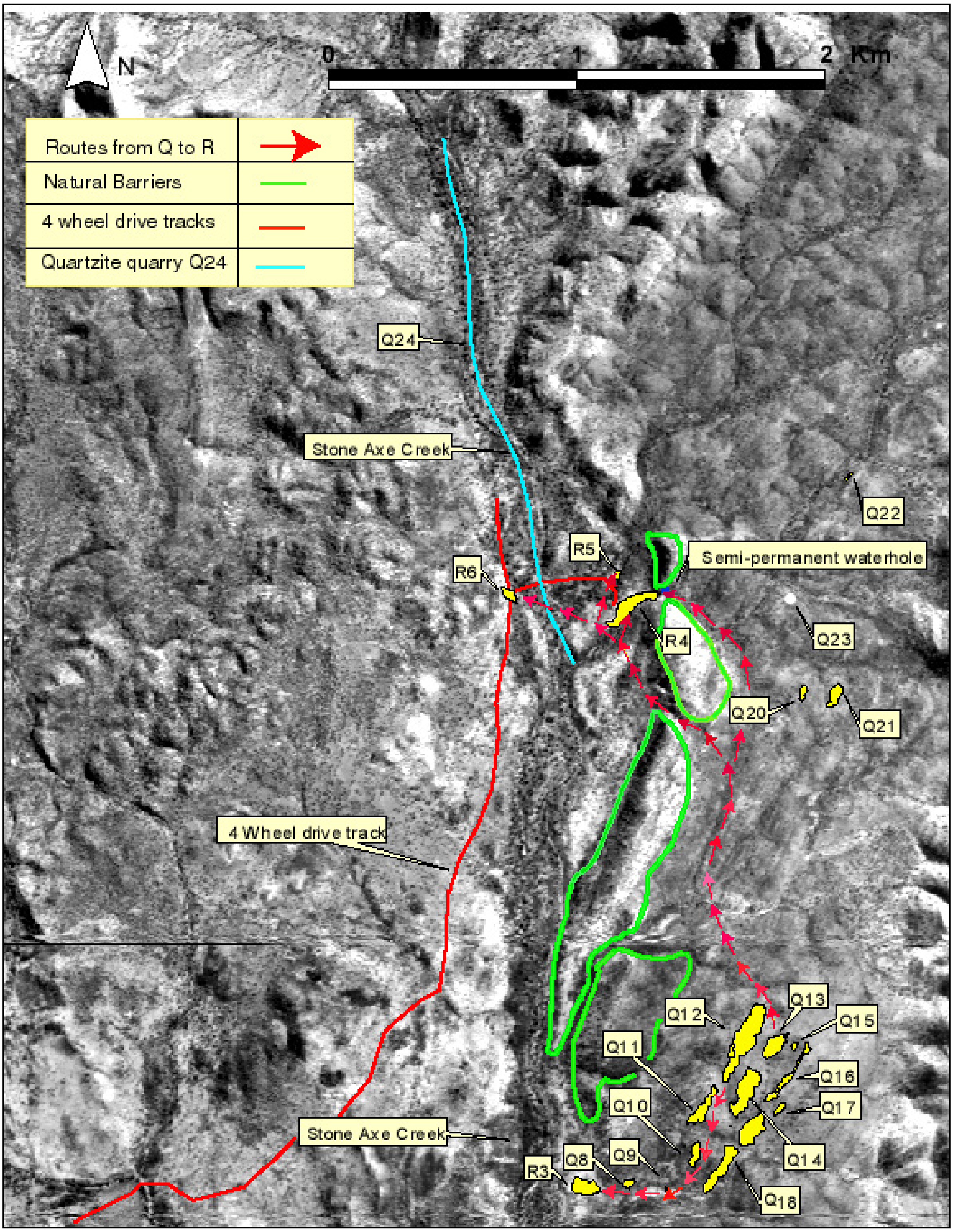


Figure 7.3. Locations of R4 showing high quartzite ridges that are the source of colluvium, possible pathways and natural barriers.

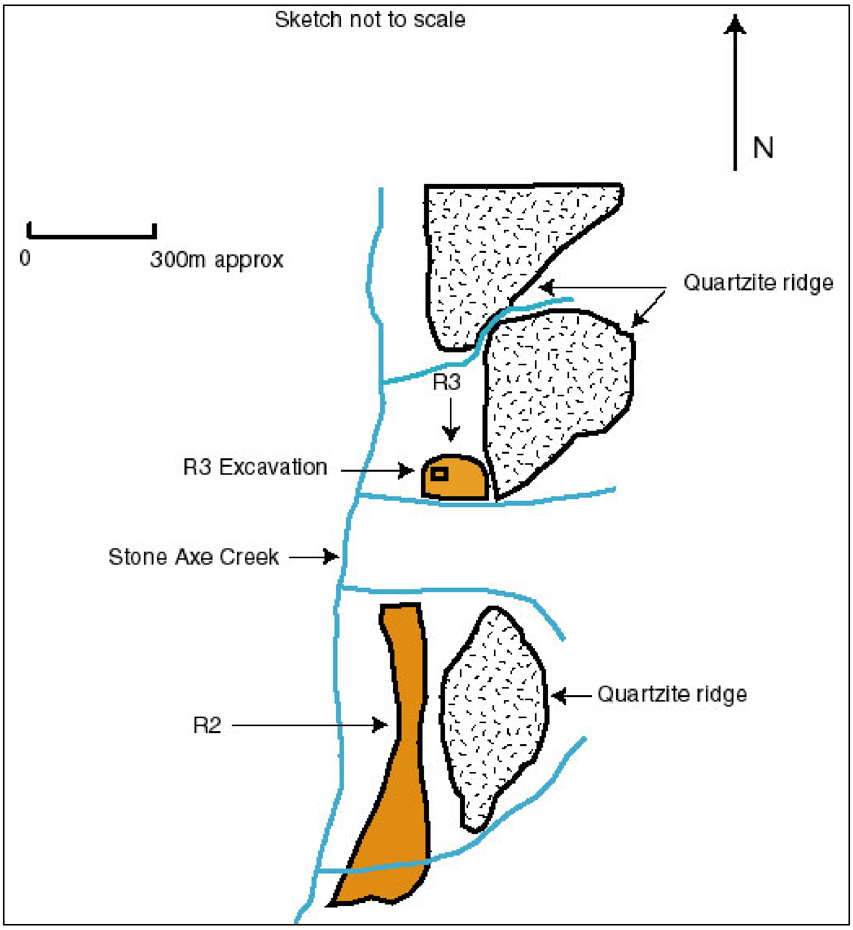


Figure 7.4. Sketch map of excavation at R3 and nearby features.
* Note. Sketch not to scale.

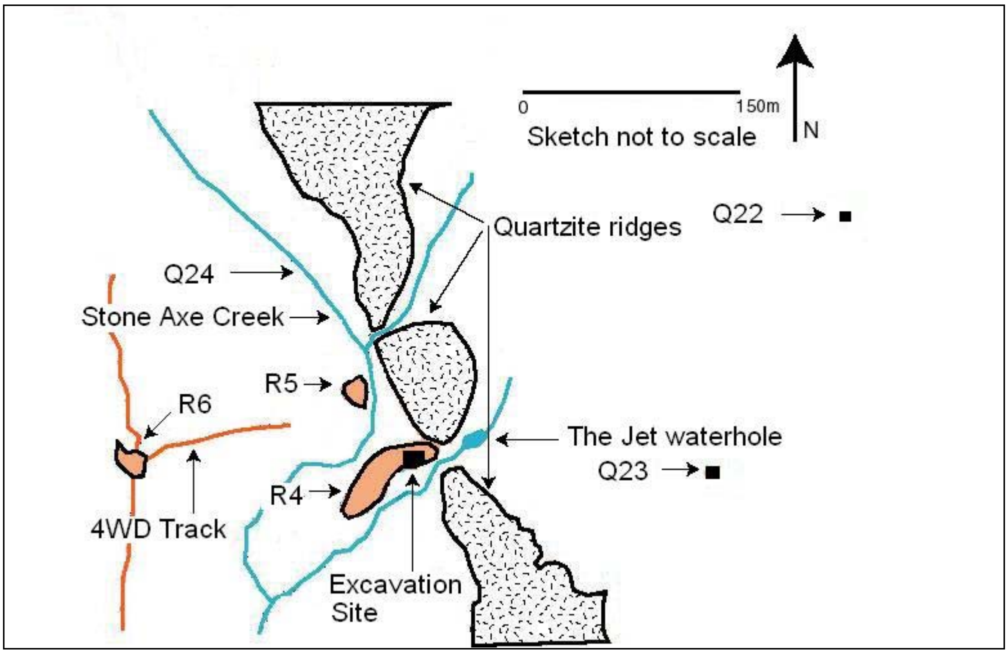


Figure 7.5. Sketch map of excavation site at R4 and nearby locations.
* Note. Sketch not to scale.

7.3.2 **Surface collection at R3**

A descriptive analysis of surface artefacts from R3 is provided to establish the percentages of artefact types and flake size. Comparative analyses can be subsequently made between surface and excavated data to note changes in raw material percentages and flake size at R3. At this stage of the analysis there is no attempt to eliminate outliers as all artefacts are analysed and consequently the data may be skewed during this descriptive stage. Nonetheless, the standard deviation provides a calculation of the variation from the mean. The mean measurements within Tables are in bold print to enhance rapid comparative analysis. As mentioned in Chapter 4, the debitage categories used are similar to those used by Sullivan *et al*. (1985).

Two large quartzite hammerstones were recorded on the surface of A1. The first was 138mm in length x 117mm wide x 81mm thick and weighed 1,447gm and the second was 106mm in length x 86mm wide x 64mm thick and weighed 1,044gm. No basalt hammerstones were observed at R3 and no bone was recovered from either the surface or during excavations.

The few artefacts recovered from the surface of E row (Appendix A) are possibly due to the effects of cattle scuffing the surface of R3 and moving surface artefacts away from their trail. Quartz and chert were not found on the surface or excavations, however observations outside of the excavation area revealed some quartzite and chert flakes.

Table 7.1 is a descriptive analysis of the artefacts recovered from the surface of the excavation showing significant standard deviations from the 1. The analysis of edge angles in Table 7.1 has a relatively low standard deviation of 11 for complete flakes and 13 for broken flakes. Flake counts by type from the surface and sub-surface collections are summarised in tabular form at the completion of the descriptive analyses.

The standard deviation of edge angles in Table 7.1 appears numerically similar to platform thickness and platform width. However, the deviations are calculated on much smaller means than for edge angles and therefore reflect a marked increase in proportional terms from the mean. There are slight variations in the measurement for platform width and platform thickness for complete and broken flakes recovered from the surface (Table 7.1).

Length, width and thickness of broken basalt flakes are smaller than for complete flakes (Table 7.1). Broken flake thickness is also reduced from a mean of 7mm to 5mm. This decrease is not attributed to transverse or longitudinal breaks, as most of these flakes were broken at the margins.

Within the surface material, there is a large proportion of debitage compared with complete and broken flakes (Table 7.2). This increase is possibly due to cattle trampling on flakes and breaking of margins. All artefacts analyses in the following tables were measured to the nearest millimetre, gram and degree. The standard deviations in each table are rounded to the nearest unit of measurement.

Complete Basalt Flakes	Length mm	Width mm	T/ness mm	P Width mm	P T/ness mm	Weight gm	E Angle deg.
Mean	**38**	**36**	**7**	**17**	**5**	**467**	**80**
Std. Dev.	29	6	5.9	11	11	68	11
Count	29	29	29	22	22	22	19
Broken Basalt Flakes	Length	Width	T/ness	P Width	P T/ness	Weight	E Angle
Mean	**26**	**26**	**5**	**14**	**5**	**12**	**83**
Std. Dev.	21	20	6	7	4	26	13
Count	82	82	82	24	24	82	82
Basalt Debitage	Length	Width	T/ness	Weight			
Mean	13	10	3	10			
Std. Dev.	14	12	5	77			
Count	271	271	271	270			

Table 7.1. Descriptive analysis of the debitage recovered from the surface of R3.

R3	**Complete Flakes**	**Broken Flakes**	**Debitage**	**Total**
Surface R3	29	82	271	382
Percentage of Total	7.59%	21.46%	70.94%	100%

Table 7.2. Percentage of surface basalt flakes by type at R3 (total percentage rounded).

The standard deviation of quartzite grindstones or hammerstones shown in Table 7.3 is indicative of a high size range. This may illustrate the opportunistic nature of reusing broken grindstone particles. A stone axe 98mm long, 54mm wide and 16mm thick was recovered from the surface of R3.

Quartzite	Length mm	Width mm	Thickness mm	Weight gm
Mean	**1234**	**90**	**52**	**923**
Std. Dev.	24	18	20	47
Count	14	14	14	14

Table 7.3. Dimensions of quartzite grindstone particles/hammerstones, from the surface of R3.

7.3.3 **Excavation at R3**

Table 7.4 lists the artefacts recovered from the surface of square R3B4. The excavation of B4 revealed a shallow cultural layer with only debitage recovered from spits one and two, while Spit 3 (six cm) was the basal cultural layer (Table 7.5). Nonetheless, the excavation continued for a further 10cm, which was culturally sterile.

Complete Flakes	Length mm	Width mm	T/ness mm	P Width mm	P T/ness mm	Weight gm	E Angle deg.
Mean	**6**	**7**	**1**	**6**	**1**	**1**	n/a
Sum	6	7	1	6	1	1	
Count	1	1	1	1	1	1	
Broken Flakes	Length	Width	Thickness	P Width	P T/ness	Weight	E angle
Mean	**9**	**12**	**2**	**7**	**2**	**1**	**66**
Std. Dev.	1	5	1	3	1	0	
Count	2	2	2	2	2	2	1
Debitage	Length	Width	Thickness	Weight			
Mean	**9**	**6**	**2**	**1**			
Std. Dev.	3	2	1	0			
Count	24	24	24	24			

Table 7.4. Basalt debitage collected from the surface of R3B4.

	Length	Width	Thickness	P Width	P T/ness	Weight	E Angle
Complete Flakes	mm	mm	mm	mm	mm	gm	deg.
Mean	**38**	**31**	**3**	**28**	**4**	**14**	**65**
Count	1	1	1	1	1	1	1
Spit 1							
Broken Flakes	Length	Width	Thickness	Weight			
Mean	**38**	**18**	**2**	**3**			
Count	1	1	1	1			
Spit 1							
Debitage	Length	Width	Thickness	Weight			
Mean	**13**	**9**	**3**	**4**			
Std. Dev.	11	10	4	10			
Count	15	15	15	15			
Spit 2							
Debitage	Length	Width	Thickness	Weight			
Mean	**18**	**10**	**3**	**3**			
Std. Dev.	10	7	2	1			
Count	2	2	2	2			
Spit 3							
Debitage	Length	Width	Thickness	Weight			
Mean	**12**	**9**	**2**	**3**			
Count	1	1	1	1			

Table 7.5. Attributes of basalt debitage recovered from excavation R3B4.

R3C2 had a 10cm of cultural material deposit with large broken flakes in spits four and five. A small charcoal sample (under 1gram) in weight was recovered from Spit 3 returned an AMS date 402 ± 47 BP (Waikato University for AMS analysis).

The number of broken flakes excavated from Spit 1 is relatively low in comparison with the surface (Tables 7.6 and 7.7). However, the complete flakes from spits 2 and 3 (at 40mm and 34mm in length respectively) and the broken flake from spit 3 (length 34mm) are significantly longer than the broken flakes from the surface and spit 1 (Table 7.7).

Twenty-five complete and broken flakes were recovered from the surface of R3C2 compared with 10 from the excavation. This suggests that deflation may have occurred as a result of increased erosion, caused by livestock passing over the site.

Complete Flakes	Length mm	Width mm	Thickness mm	P Width mm	P T/ness mm	Weight gm	E Angle Deg.
Mean	**19**	**20**	**3**	**10**	**1**	**78**	**70**
Std. Dev.	13	18	3	6	1	12	9
Count	7	7	7	5	5	7	6
Broken Flakes	Length	Width	Thickness	P Width	P T/ness	Weight	E Angle
Mean	**22**	**18**	**3**	**10**	**1**	**7**	**76**
Std. Dev.	20	9	3			11	11
Count	18	18	18	1	1	18	3
Debitage	Length	Width	Thickness	Weight			
Mean	**11**	**7**	**2**	**2**			
Std. Dev.	10	7	1	3			
Count	38	38	38	38			

Table 7.6. Attributes of basalt surface debitage recovered from R3C2.

Cultural material was excavated to a depth of eight to 10 centimetres at R3C2, which is a significant depth for an open site in a semi-arid environment with limited soil formation processes (Table 7.7). No charcoal samples were recovered from below spit 3, but two broken flakes were recovered from spit 5 in association with basalt debitage.

As previously mentioned, cattle scuffing had cleared a trail through R3D5 and only two broken basalt flakes and two pieces of basalt debitage were recovered from the surface (Table 7.8). Cultural material was excavated to a depth of 6 centimetres (see Table 7.9).

Spit 1 Broken Flakes	Length mm	Width mm	Thickness mm	Weight gm
Mean	**16**	**17**	**4**	**5**
Std. Dev.	6	9	2	3
Count	4	4	4	4

Spit 1 Debitage	Length	Width	Thickness	Weight
Mean	**14**	**9**	**2**	**3**
Std. Dev.	13	8	2	4
Count	13	13	13	13

Spit 2 Broken Flake	Length	Width	Thickness	Weight
Mean	**40**	**30**	**5**	**9**
Count	1	1	1	1

Spit 2 Debitage	Length	Width	Thickness	Weight
Mean	**12**	**9**	**1**	**2**
Std. Dev.	2	6	0	1
Count	7	7	7	7

Spit 3 Complete Flake	Length mm	Width mm	Thickness mm	P T/ness mm	P Width mm	Weight gm	E Angle deg
Mean	**30**	**25**	**7**	**18**	**8**	**11**	**105**
Count	1	1	1	1	1	1	1

Spit 3 Broken Flake	Length	Width	Thickness	P T/ness	P Width	Weight	E Angle
Mean	**34**	**34**	**4**	**20**	**4**	**16**	**104**
Count	1	1	1	1	1	1	1

Spit 3 Debitage	Length	Width	Thickness	Weight
Mean	**11**	**5**	**1**	**1**
Count	1	1	1	1

Spit 4 Broken Flakes	Length	Width	Thickness	Weight
Mean	**8**	**20**	**1**	**3**
Count	1	1	1	1

Spit 4 Debitage	Length	Width mm	Thickness	Weight
Mean	**12**	**8**	**3**	**3**
Std. Dev	14	8	4	5
Count	6	6	6	6

Spit 5 Broken Flakes	Length	Width mm	Thickness	Weight
Mean	**17**	**21**	**2**	**5**
Std. Dev.	8	11	1	3
Count	2	2	2	2

Spit 5 Debitage	Length	Width	Thickness	Weight
Mean	**9**	**3**	**1**	**1**
Std. Dev.	7	2	0	0
Count	6	6	5	6

Table 7.7. Attributes of debitage recovered from excavation R3C2.

Surface Broken Flakes	Length mm	Width mm	Thickness mm	Weight gm
Mean	**56**	**65**	**17**	**14**
Std. Deviation	57	64	20	16
Count	2	2	2	2
Surface Debitage	Length	Width	Thickness	Weight
Mean	**8**	**7**	**1**	**1**
Std. Deviation	8	8	0	0
Count	2	2	2	2

Table 7.8. Attributes of basalt surface debitage recovered from R3D5.

Spit 1 Broken Flakes	Length mm	Width mm	Thickness mm	Weight gm		
Mean	**16**	**17**	**4**	**5**		
Std. Dev.	6	9	2	3		
Count	4	4	4	4		
Spit 1 Debitage	Length	Width	Thickness	Weight		
Mean	**14**	**9**	**2**	**3**		
Std. Dev.	13	8	2	4		
Count	13	13	13	13		
Spit 2 Broken Flakes	Length	Width	Thickness	Weight		
Mean	**40**	**30**	**5**	**9**		
Count	1	1	1	1		
Spit 2 Debitage	Length	Width	Thickness	Weight		
Mean	**12**	**9**	**1**	**2**		
Std. Dev.	2	6	0	1		
Count	7	7	7	7		
Spit 3 Complete Flake	Length mm	Width mm	Thickness mm	P Width mm	P T/ness mm	Weight gm
Mean	**30**	**25**	**7**	**18**	**8**	**11**
Count	1	1	1	1	1	1
Spit 3 Broken Flake	Length mm	Width mm	Thickness mm	P Width mm	P T/ness mm	Weight gm
Mean	**34**	**34**	**4**	**20**	**4**	**16**
Count	1	1	1	1	1	1
Spit 3 Debitage	Length mm	Width mm	Thickness mm	Weight gm		
Mean	**11**	**5**	**1**	**1**		
Count	1	1	1	1		

Table 7.9. Attributes of basalt debitage recovered from excavation R3D5.

7.4 **Preliminary results from R3**

A review of evidence from of R3, weight of soil and rock can be found in Table 7.10. The excavations at R3 revealed a shallow depth of cultural material. A trend for decreasing numbers of artefact in the lower spits is apparent. This pattern supports an argument that axe production at R3 has increased incrementally until abruptly ceasing in the late nineteenth century. This increasing trend is also reflected in the total weight of cultural material reducing as depth increases (Table 7.10).

The proportion of soil to rock recovered from R3 was relatively low with insignificant variation between spits (Table 7.10). The parent material in the soil was fine-grained quartzite (colluvium) that had eroded from the quartzite ridges. These fine grains are noticeably smaller than the coarser sand within the creek beds. Soil weight by spit varied slightly with weight appearing to increase slightly with increasing depth, but this change is not associated with changes in the weight of rock excavated. Deeper soils may be compacted more than those in the upper levels resulting in slight increases of weight per volume or spit. The excavations at R3 contained relatively small quantities of rock with no marked increases in the amount recovered from the lower spits.

The sub-surface soil was well compacted at R3, but the minimal amounts of rock contained within it enabled the excavation to proceed without difficulty. The soil in all pits was of a similar colour and stratigraphic layers were not visible either during or subsequent to excavation.

This apparent lack of stratigraphic delineation is consistent with colluvium formations. According to Lapidus and Winstanley (1987:113), colluvium soils lack stratification, are usually unsorted and fragments range greatly in size. These characteristics are in accordance with assessment of the colluvial formation at R4 (Jon Luly pers. comm.).

A noteworthy variation at R3C2 in comparison with R3B4 and R3C2 was that complete and broken flakes were recovered down to spit 5 (Table 7.9). Larger basalt flakes were recovered from the lower spits, but not on the surface or in Spit 1. There appeared to be a consistent trend from the three excavations for broken flakes in the lower spits being larger than those in spit 1 (Tables 7.6 and 7.7). This is further addressed in Chapter 8.

A summary of the number of complete and broken flakes by spit number, debitage, the percentage of debitage compared with complete and broken flakes for the three spits excavated at R3 is shown in Table 7.10, which illustrates a pattern for decreasing flake quantities with increasing depth. A moving analysis of the percentage of type 4 flakes compared with complete and broken flakes suggested higher percentages of type 4 flakes in the upper spits compared with the lower spits.

Excavation no.	**Spit**	**Total number of complete Flakes (type 1)**	**Total number of broken Flakes (type 2)**	**Total number of debitage (type 4)**	**Percentage of type 4 flakes at each level**	**Moving percentage of debitage at each level (from three excavations)**
Square B4	B4 Surface	1	2	24	88.88%	Surface. 68.1%
	B4 Spit 1	1	1	15	88.23%	Spit 1. 75%
	B4 Spit 2	nil	nil	2	100%	Spit 2. 88.88%
	B4 Spit 3	nil	nil	1	100%	Spit 3. 42.85%
Square C2	C2 Surface	7	18	38	60.31%	Spit 4 50%
	C2 Spit 1	nil	4	13	76.47%	Spit 5 75%
	C2 Spit 2	nil	1	7	87.5%	
	C2 Spit 3	1	1	1	33.33%	
	C2 Spit 4	nil	1	1	50%	
	C2 Spit 5	nil	2	6	75%	
Square D5	C5 Surface	nil	2	2	50%	
	D5 Spit 1	nil	4	13	76.47%	
	D5 Spit 2	nil	1	7	87.5%	
	D5 Spit 3	1	1	1	33.33%	

Table 7.10. Summary of surface and sub-surface debitage excavated from R3.

Table 7.11 shows that complete and broken basalt flakes are more numerous in the higher spits compared with the lower spits. Fewer debitage in the lower spits can also be noted by the trend for increased weight of cultural material near the surface of R3 (Table 7.11).

Excavation	Spit	No of Type 1 debitage	No of type 4 debitage	Total Wt of cultural material	Weight of soil	Weight of rocks
Ex. B4	S	3	24	27gm	n/a	n/a
	Spit 1	nil	15	15gm	38.105kg	0.617kg
	Spit 2	nil	2	2gm	44.007kg	0.876kg
	Spit 3	nil	2	2gm	41.462kg	0.302kg
Ex. C2	S	25	38	221gm	n/a	n/a
	Spit 1	4	13	33gm	38.048kg	1.256kg
	Spit 2	1	7	21gm	38.552kg	0.404kg
	Spit 3	2	1	28gm	40.819kg	1.402kg
	Spit 4	1	6	23gm	33.550kg	1.190kg
	Spit 5	2	6	17gm	40.721kg	1.309kg
Ex. D5	S	2	2	30gm	n/a	n/a
	Spit 1	4	13	64gm	34.336kg	1.533kg
	Spit 2	1	7	21gm	32.929kg	0.856kg
	Spit 3	2	1	28gm	42.481kg	1.311kg

Table 7.11. Summary of debitage, weight of cultural material, soil and rocks recovered from R3.

Surprisingly, the mean measurements of flake thicknesses, platform thickness and platform width of broken flakes are all larger than complete flakes (Tables 7.12 and 7.14). Generally, smaller flakes in an assemblage may be more prone to breakage by trampling than larger flakes. Possibly, increased penetrability (the introduction of cattle) results in the larger flakes being more prone to breakage. The broken flakes from R3 have higher platform thickness, platform widths and flake thickness that possibly indicates that these flakes were larger than the complete flakes before the impact of post-depositional processes. If this were the case, then the increased measurements for these variables as noted in Tables 7.12 and 7.13 are probable.

	Length mm	Width mm	Thickness mm	P T/ness mm	P Width mm	Weight gm	E Angle deg.
Mean	**31**	**25**	**4**	**15**	**4**	**13**	**79**
Standard Error	4.4578	3.616045	0.628373	1.626846	0.722836	3.712483	2.604283
Median	**30**	**24**	**3**	**11**	**3**	**7**	**80**
Mode	6	20	1	18	1	1	80
Standard Dev.	22	18	3	7	3	18	10
Sample Variance	476.92	313.81	9.47	44.99	8.88	330.78	108.57
Kurtosis	1.94	0.13	-1.45	-0.86	-0.38	5.98	-0.37
Skewness	1.29	0.82	0.488	0.52	0.903	2.333	0.33
Range	84	66	8	22	9	76	36
Minimum	5	3	1	6	1	1	64
Maximum	89	69	9	28	10	77	100
Sum	736	610	101	249	61	317	1258
Count	24	24	24	17	17	24	16

Table 7.12. Complete descriptive analysis of basalt flakes from R3.

	Length mm	Width mm	Thickness mm	P T/ness mm	P Width mm	Weight gm	E Angle deg.
Mean	**24**	**23**	**4**	**15**	**4**	**9**	**83**
Standard Error	1.653694	1.27988	0.359003	1.135312	0.527636	1.394631	2.227241
Median	**22**	**20**	**4**	**15**	**4**	**4**	**86**
Mode	9	15	1	20	4	1	90
Standard Dev.	15	12	3	6	3	13	10
Sample Var.	226.9803	135.9618	10.69733	32.22333	6.96	161.4346	94.25146
Kurtosis	1.216356	2.353434	3.549546	-1.39132	-0.33392	13.14722	-0.18875
Skewness	1.22187	1.266462	1.64464	-0.0137	0.690969	3.333735	-0.79738
Range	65	60	17	18	9	75	34
Minimum	8	8	1	6	1	1	64
Maximum	73	68	18	24	10	76	98
Sum	2028	1938	352	379	107	733	1580
Count	83	83	83	25	25	83	19

Table 7.13. Broken basalt flakes from R3.

Two AMS dates were obtained from charcoal samples in association with cultural material at R3 and submitted to the Waikato University for laboratory analysis. The first calibrated date was 402 ± 47 BP from R3C2 spit 3. The second date was 127 ±47 BP for a charcoal sample from R3D5 spit 3.

A geomorphic estimate (based on a consistent soil formation process) for the basal age of R3C2, based on the older date is 670 BP. The two charcoal samples chosen for testing by AMS were minuscule and recovered from a 1.6mm sieve. The high cost of AMS dating resulted in lower spit carbon samples being preferentially selected for analysis. These charcoal samples were too small for less expensive C14 dating methods and dating two samples from the same excavation was not prudent when resources were limited.

7.5 **Surface collection at R4**

The descriptive analysis commences with the surface flakes from rows A and D and then progresses to the excavated material**.** Tables 7.14 and 7.15 illustrate descriptive analysis of the surface artefacts recovered from the two rows A and D. At R4, surface collections were conducted on two rows due to the quantity of surface material and the constraints set on analysis.

The surface data in Table 7.14 and 7.15 indicates a remarkable consistency in the variables least affected by breakage. Flake thickness, platform width, and thickness and edge angles for complete and broken flakes have similar median measurements. Similar dimensions for platform width, platform thickness and edge angle between complete and broken flakes may be explained as probable outcomes when these attributes are unlikely to be affected by flake breakage. Nonetheless, the consistency of broken flakes having similar flake thickness with complete flakes requires some explanation. The most brittle part of the flake is possibly at the thinner margins and this is where most of the breakage occurs. Consequently, thickness is not affected on the majority of flakes and therefore similar mean measurements are recorded for complete and broken debitage (Tables 7.14 and 7.15).

A descriptive analysis of surface quartzite flakes is shown at Table 7.15 and these are significantly smaller in comparison with complete basalt flakes (Table 7.14) but mean edge angles are similar.

Complete Flakes	Length mm	Width mm	T/ness mm	P Width mm	P T/ness mm	Weight gm	E Angle deg.
Mean	**42**	**32**	**8**	**18**	**6**	**21**	**80**
Std. Dev.	20	12	7	9	3	25	8
Count	70	70	70	49	51	69	35
Broken Flakes	Length	Width	T/ness	P Width	P T/ness	Weight	E Angle
Mean	**33**	**30**	**9**	**18**	**6**	**16**	**82**
Std. Dev.	15	11	6	10	4	24	5
Count	107	107	107	61	57	104	44
Debris	**N 415**	**Weight 178**					

Table 7.14. Basalt flakes collected from the surface of R4.

Complete Flakes	Length mm	Width mm	T/ness mm	P Width mm	P T/ness mm	Weight gm	E Angle deg.
Mean	**27**	**19**	**8**	**16**	**6**	**7**	**81**
Std. Dev.	11	11	4	7	4	14	12
Count	11	11	11	8	8	11	8
Broken Flakes	Length	Width	T/ness	P Width	P T/ness	Weight	E Angle
Mean	**27**	**20**	**7**	**17**	**6**	**9**	**80**
Std. Dev.	12	9	4	10	4	25	5
Count	29	29	29	15	15	29	11
Debris	***n* 96**	**Weight 163.5**					

Table 7.15. Quartzite flakes collected from the surface of R4.

There appears to be some connection between the quantities of type 4 debris in relation to complete flakes from the surface of R4. The ratio of broken flakes to debitage is comparable for both basalt and quartzite from the surface of R4. The ratio for basalt is 1:3.88 and for quartzite 1:3.31. This slight difference may suggest that post-formation processes, which have resulted in breakage might apply equally to both basalt and quartzite flakes on the surface. A possible explanation for this comparative relationship is that both basalt and quartzite are rated at seven on the Mohs hardness scale (Bishop *et al*. 1999). While hard stone can have different rates of brittle failure or plasticity (Briggs *et al*. 1997), post-depositional impacts in this instance seem to be consistent.

The data for stone axes in Table 7.16 indicate that the standard deviation for length is 5, width 11, and thickness is 16. There is a clear difference between the standard deviation for length, compared to width and thickness. The axe reduction process may to some extent explain this increased difference of axe thickness. Axe lengths and widths are extensively trimmed at the quarries in the initial stages of axe production and reduction of thickness is a major practice on the reduction floors when axes are thinned into symmetrical profiles of suitable thickness (see also Chapter 10).

The only axe knapped from a river cobble recovered at Moondarra was found at R4. It measured 110mm in length, 96mm wide and 31mm thick and weighed 471gms. However, along Stone Axe Creek there are numerous examples where broken basalt cobbles have negative scars where large flakes or axe blanks have been removed. As discussed in Chapter 5, at Moondarra basalt seems to have been assayed for axe making properties wherever it was found.

Axes	**Length mm**	**Width mm**	**T/ness mm**	**Weight gm**
Mean	**108**	**101**	**42**	**655**
Std. Dev.	5	11	16	233
Count	5	5	5	4

Table 7.16. The measurement of stone axes recovered from the surface of R4.

An unusual basalt flake recovered from the surface of R4 square A4 had been completely ground on the dorsal side. This flake appeared to be purposely knapped from an edge ground axe. Two scars, located just below the flake platform, suggested unsuccessful attempts to initiate termination. This flake was broken at the margins and measured 35mm x 34mm x 5mm. The removal of this polished flake from the axe may represent an attempt to further reduce axe thickness after initial grinding or maintenance on an existing edge-ground axe in the subsistence tool kit. In such cases, maintenance and production would result in similar debitage, but edge grinding probably commences after the completion of the reduction process. The position of the flake platform in relation to the concave profile suggests that the point of force was 35mm away from the edge ground bevel. It is likely that maintenance rather than reduction explains the presence of this polished flake.

7.6 Excavation at R4

7.6.1 Excavation at R4A3

The length, width and thickness of basalt flakes recovered from R4A3 were generally uniform with increasing depth. There are peaks and troughs in the data but these variations tend to be outliers rather than patterns of changing flake dimensions (Figures 7.6 and 7.7). The analysis of artefacts suggests that when flake thickness varies an incremental change occurs in flake width. This pattern is noticeable by examining peaks and troughs in Figure 7.7. Edge angles range from 40º to 121º, but the majority are between 70º and 101º. An increase in platform thickness seems to correspond with a change in platform width (Figure 7.7). This relationship is further explored in Chapter 8.

Broken basalt flakes were recovered down to Spit 11 in R4A3, however the total number of flakes below Spit 3 decreased markedly (Figure 7.8). There appears to be an unambiguous trend for artefact density to decrease from Spit 5 as only five of the 69 broken flakes were recorded below Spit 4. Where peaks in platform width occur (see Figure 7.7) there seems to be corresponding increase in platform thickness. In general, broken flakes cannot accurately reveal information on relative temporal size variation, but in conjunction with data for complete flakes provides important information on relative flake density.

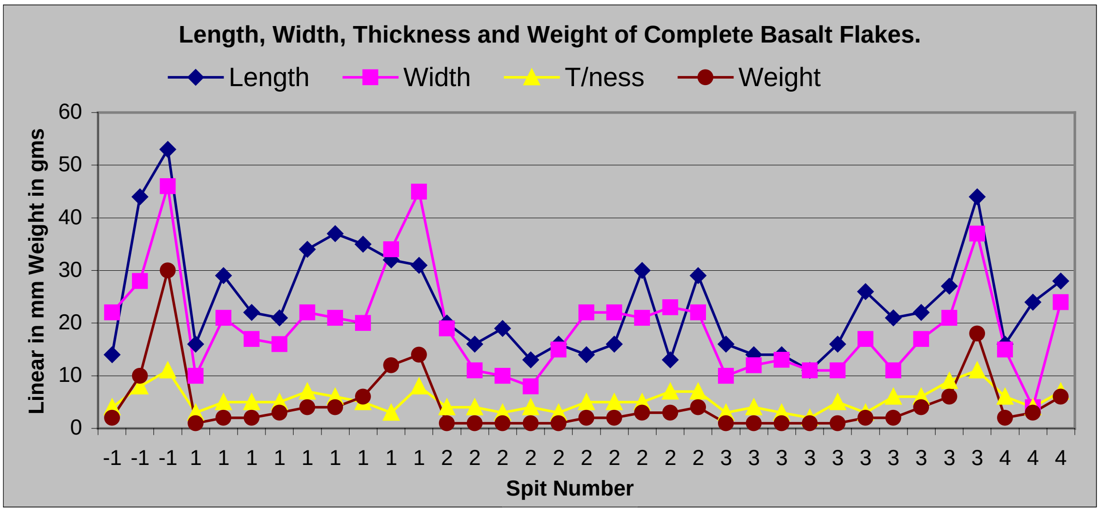


Figure 7.6. Length, width, thickness and weight of complete basalt flakes recovered from R4A3 (*n*35).

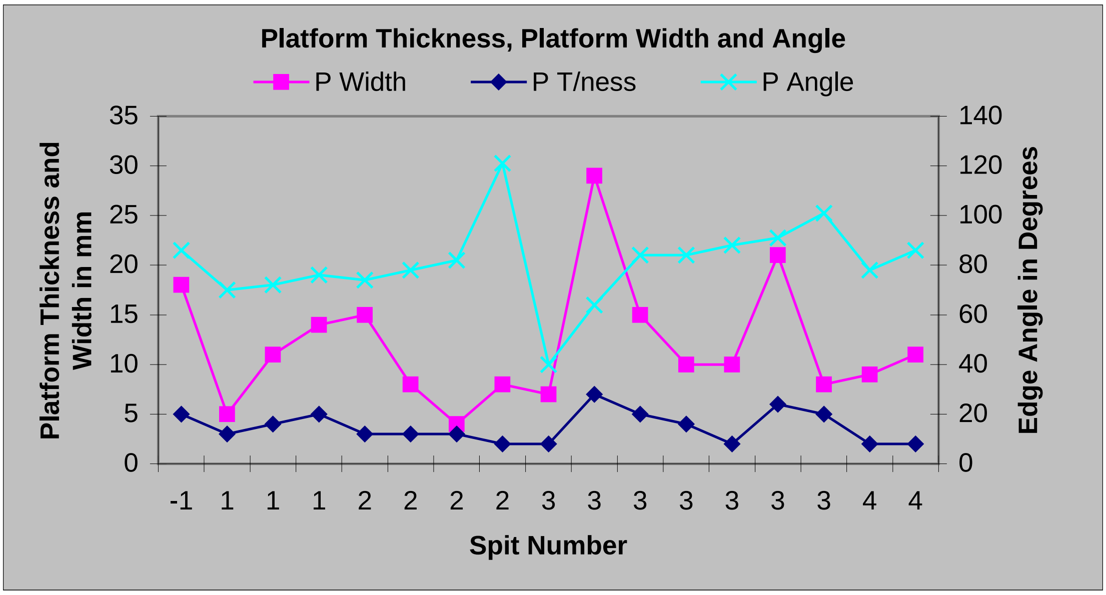


Figure 7.7. Platform thickness, platform width and platform angle for complete basalt flakes recovered from R4A3 (*n*17).

Quartzite flakes form a considerable proportion of the flake assemblage at R4. The data for quartzite flakes (Figures 7.9, 7.10, 7.11 and 7.12) are comparable with the trend observed for basalt flakes (Figures 7.6, 7.7 and 7.8) in that most flakes are within the top four spits. Similar to basalt flakes, attributes measured for quartzite flakes appear to be consistent over time.

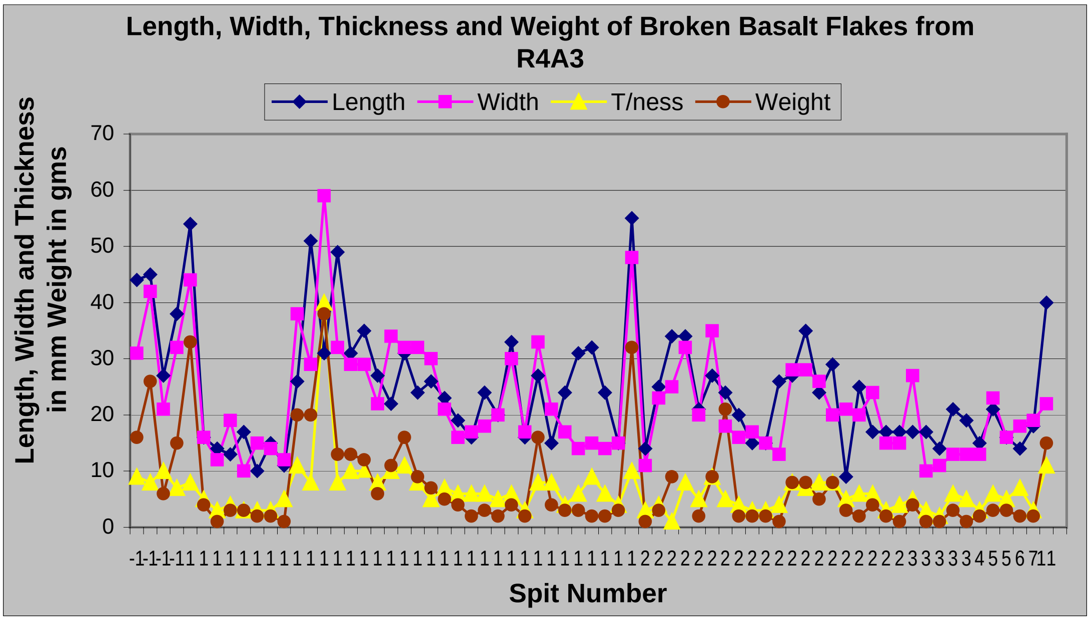


Figure 7.8. Length, width, thickness and weight of broken basalt flakes from R4A3 (*n*69). * Note –1 represents surface material.

Figure 7.10 shows that the length and width of complete quartzite flakes varies in relation to depth however, Figure 7.11 shows that platform thickness, platform width and edge angles for complete quartzite flakes are unusually uniform with minimal deviation over depth.

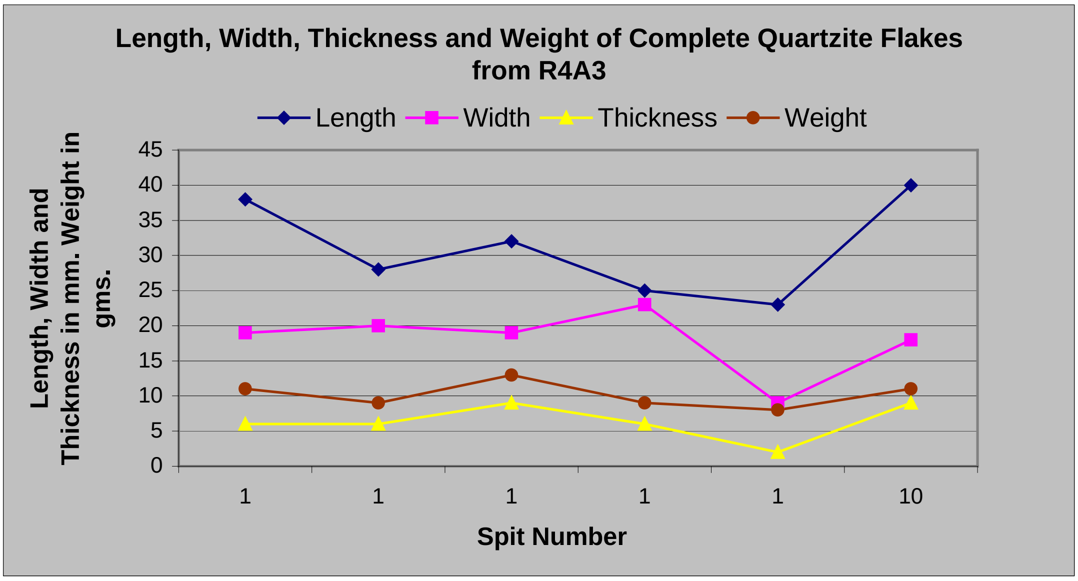


Figure 7.9. Length, width, thickness and weight of complete quartzite flakes from R4A3 (*n*6).

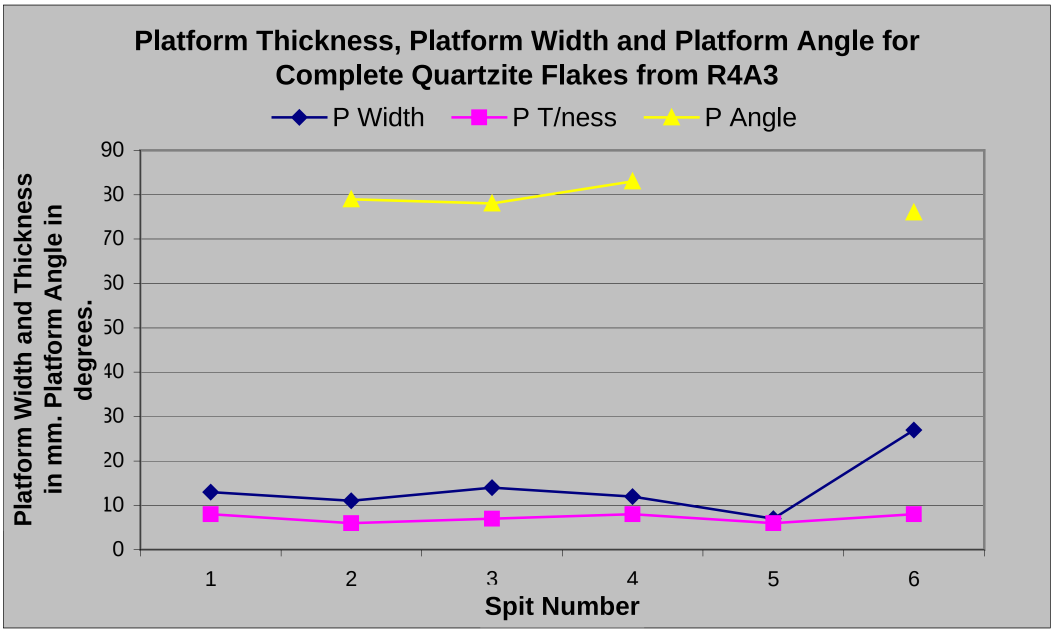


Figure 7.10. Platform thickness, platform width and platform angle from complete quartzite flakes recovered from R4A3 (*n*6).

The measurements for the length, width and weight of complete quartzite flakes are significantly larger than those for broken quartzite flakes, however thickness is similar for both categories (Figures 7.9 and 7.11).

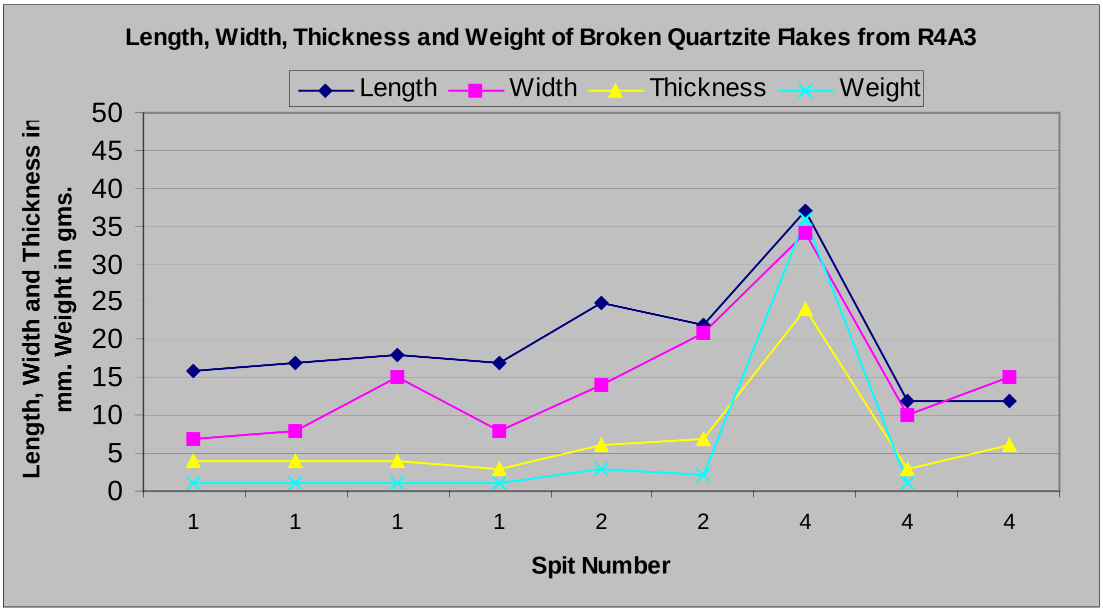


Figure 7.11. Length, width, thickness and weight of broken quartzite flakes recovered from R4A3 (*n*9).

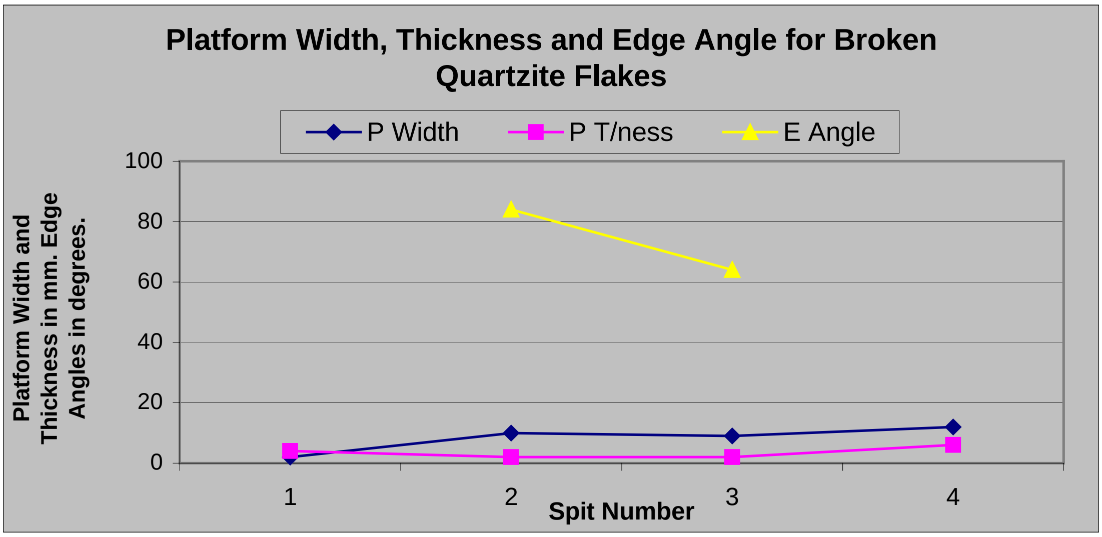


Figure 7.12. Platform thickness, width, and angle for broken quartzite flakes from R4A3. * Note. Data for 2 edge angles not obtainable.

The descriptive summary of complete flakes from R4A3 indicates that quartzite flakes are on average eight mm longer than basalt flakes (Tables 7.17 and 7.18). Although flake width is similar for both quartzite flakes at 10.16mm are almost twice as thick as basalt (5.31mm). Consequently, the increased mean length and thickness of quartzite flakes parallels this increase in weight (Tables 7.17 and 7.18). The mean average of edge angles for basalt and quartzite flakes are similar with measurements of 81 degrees and 79 degrees respectively weight (Tables 7.17 and 7.18).

	Length mm	Width mm	T/ness mm	P Width mm	P T/ness mm	Weight gm	E Angle deg.
Mean	**24**	**19**	**54**	**11**	**36**	**4**	**81**
Standard Error	1.73535	1.61822	0.37298	1.20639	0.31161	1.00868	4.0592
Median	21	19	5	9.5	3	2	82
Mode	16	22	5	6	2	1	86
Standard Dev.	10	10	2	6	2	6	17
Sample Var.	105.4	91.65	4.86	37.84	2.52	35.61	280.11
Kurtosis	0.649	1.74	0.78	1.50	-0.43	9.76	2.92
Skewness	1.03	1.22	0.98	1.26	0.62	2.92	-0.01
Range	42	42	9	25	6	29	81
Minimum	11	4	2	4	1	1	40
Maximum	53	46	11	29	7	30	121
Sum	833	678	186	286	85	157	1375
Count	35	35	35	26	26	35	17

Table 7.17. Descriptive summary of complete basalt flakes recovered from R4A3.

	Length mm	Width mm	T/ness mm	P Width mm	P T/ness mm	Weight gm	E Angle deg.
Mean	**31**	**18**	**10**	**14**	**77**	**6**	**79**
Standard Error	2.82	1.93	0.74	2.78	0.40	1.059	1.47
Median	30	19	10	12.5	7.5	6	78.5
Mode	#N/A	19	11	#N/A	8	6	#N/A
Standard Dev.	7	5	2	7	1	3	3
Sample Var.	48	22.4	3.36	46.4	0.967	6.66	8.66
Kurtosis	-1.86	3.80	-0.62	3.84	-2.39	0.89	1.5
Skewness	0.28	-1.68	0.51	1.72	-0.45	0.7591	0.94
Range	17	14	5	20	2	7	7
Minimum	23	9	8	7	6	2	76
Maximum	40	23	13	27	8	9	83
Sum	186	108	61	84	43	38	316
Count	6	6	6	6	6	6	4

Table 7.18. Descriptive summary for complete quartzite flakes recovered from R4A3.

No cultural material was found it Spits 8 and 9 of R4A3 (see Table 7.19) and apart from two large flakes recovered from Spits 10 and 11 only three pieces of debris were recorded below Spit 7 at R4A3. The tendency for decreasing artefact density with increasing depth is evident at R4A3 (Table 7.19).

The weight of soil excavated from R4A3 was relatively consistent, but the weight of stone increased significantly at Spit 4 (see Table 7.20). The total weight of cultural material from each spit decreased rapidly with increasing depth.

The amount of chert compared with other stone types is negligible, however this is the only non-locally raw material observed on the site (Table 7.19). The presence of quartz on the reduction floors may be attributed to human actions. Quartz outcrops are a few kilometres offsite and small nodules can be found in some nearby creeks.

Spit Number	**Basalt Debris**	**Quartzite Debris**	**Quartz Debris**	**Chert Debris**
Surface	*n* 124 wt 146gm	*n* 14 wt 12.5gm	*n* 9 wt 13gm	*n* 15 wt 12gm
1	*n* 269 wt 315gm	*n* 73 wt 51gm	nil	nil
2	*n* 194 wt 112gm	*n* 67 wt 51gm	*n* 4 wt 2gm	nil
3	*n* 141 wt 67gm	*n 20* *wt 17gm*	nil	nil
4	*n* 86 wt 23gm	*n* 17 wt 31gm	nil	*n* 1 wt 2gm
5	*n* 37 wt 16gm	nil	*n* 26 wt 3	nil
6	*n* 25 wt 9gm	*n* 1 wt 4gm	*n* 16 wt 4gm	nil
7	*n* 6 wt 2gm	nil	*n* 4 wt 2gm	nil
8	nil	nil	nil	nil
9	nil	nil	nil	nil
10	nil	*n* 3 wt 2gm	nil	nil
11	nil	*n*1 wt 2gm	nil	nil
12-16	nil	nil	nil	nil

Table 7.19. Weight of debitage excavated from R4A3.

Basalt and quartzite flakes were the predominant raw material types recorded in R4A3, but additional artefacts and raw material types are present (see Figure 7.13).

The minimum number of each raw material by percentages is, basalt 86.6%, quartzite 12.5% and quartz 0.8%. The presence of chert debitage suggests that tools made from this raw material were used on site.

Despite standard controls (see Chapter 4) only one charcoal sample associated with cultural materials was excavated from Spit 8, R4A3. This sample was forwarded to Waikato University for AMS dating. The calibrated radiocarbon determination was 465 ± 57BP (WK11581). The significance of this is discussed later.

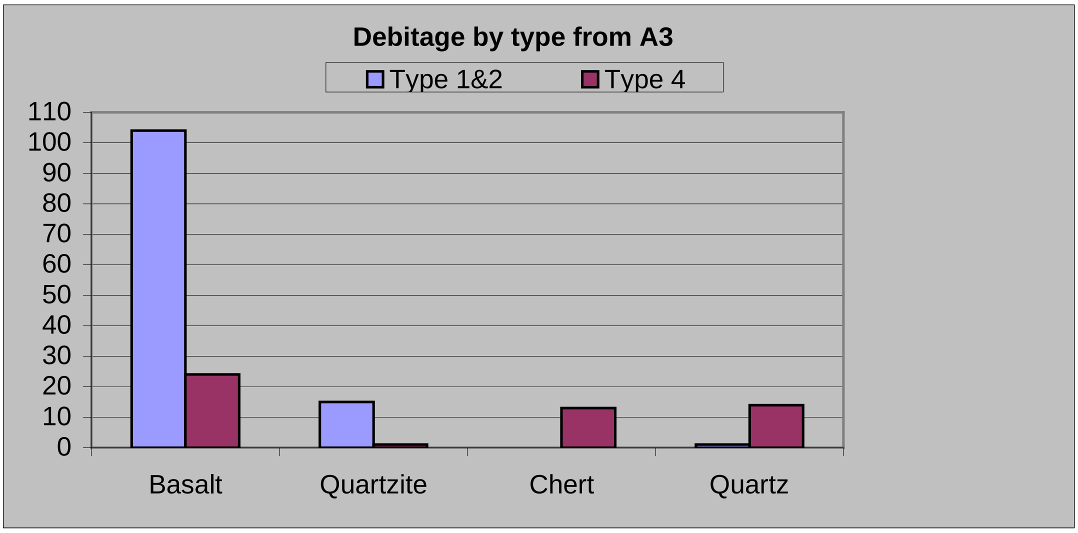


Figure 7.13. Debitage by quantity, type and raw material excavated from R4A3.

Spit No	**Depth**	**Soil Excavated**	**Rock Excavated**	**Total Weight of Cultural Material**
S	n/a	n/a	4kg	759.5gm (1axe = 471gms)
1	0-2cm	21kg	9kg	768gm
2	2-4cm	22.5kg	2.5kg	282gm
3	6-8cm	23kg	3.5kg	131gm
4	8-10cm	22kg	25kg	112gm
5	10-12cm	25kg	22kg	25gm
6	12-14cm	29kg	16.5kg	19gm
7	14-16cm	24.5kg	16.5kg	6gm
8	16-18cm	24.25	22.75kg	nil
9	28-20cm	22.5kg	25.5kg	nil
10	20-22cm	26kg	19kg	10gm
11	22-24cm	25kg	22kg	17gm
12	24-26cm	25kg	26kg	nil
13	26-28cm	23.5kg	11.5kg	nil
14	28-30cm	26.5kg	13kg	nil
15	30-32cm	18kg	20kg	nil
16	32-40cm (8cm spit)	93kg	54kg	nil

Table 7.20. Soil and rock excavated from R4A3 by spit.

7.6.2 **Excavation at R4D2**

The excavation at R4D2 revealed similar trends to the results from R4A3. The relative density of complete and broken flakes decreased noticeably from Spit 4 to Spit 10 (Figures 7.14, to 7.17). Both basalt and quartzite flakes remained relatively similar in size throughout the excavation and the surface had fewer flakes compared with Spit 1.

A bifacial basalt axe and two quartz flakes were recovered from the surface. Chert and quartz debitage were found throughout the excavated material and a complete chert flake (weighing four grams) was recovered in Spit 9.

Thirty-three percent of basalt flakes and 19 percent of quartzite flakes were excavated from below Spit 4. Comparative analysis between basalt and quartzite flakes suggested that despite reduced density below Spit 4, the percentage of the assemblage for each raw material type remains relatively constant with the percentage of basalt in the assemblage from the surface to Spit 4 at 63%, and below Spit 4, at 57%.

As mentioned previously, on the basalt flakes, facetted platforms were often shattered and immeasurable. This resulted in instances where all the variables on an artefact could not be measured resulting in some data sets having different sample counts for the same assemblage. A particularly large basalt trimming flake was collected from Spit 1 of R4D2. Apart from this diversion, the measurements for flake length, width and thickness are generally consistent (Figure 7.14).

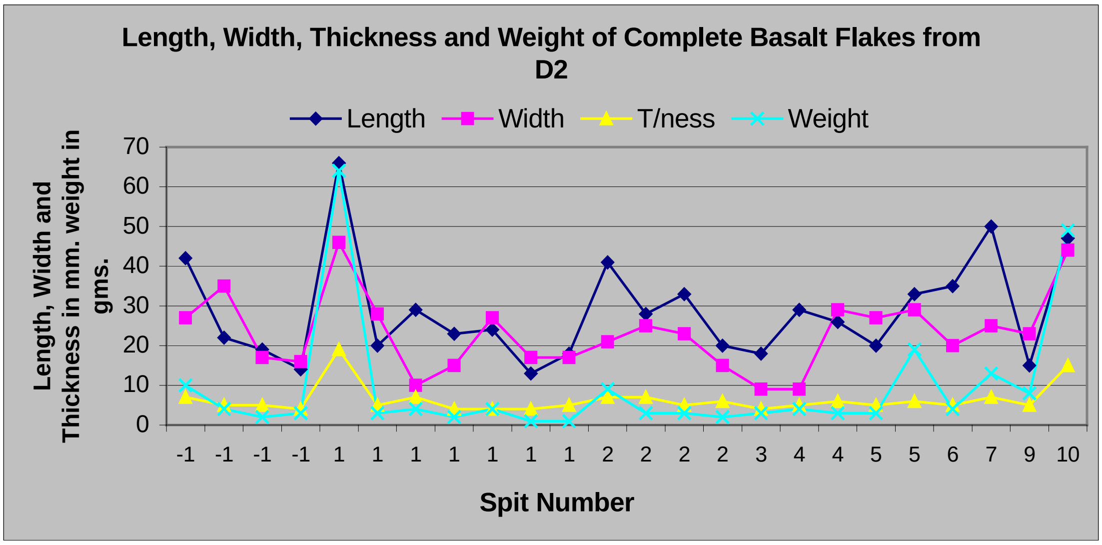


Figure 7.14. Length, width, thickness and weight of complete basalt flakes recovered from R4D2 (*n*24).

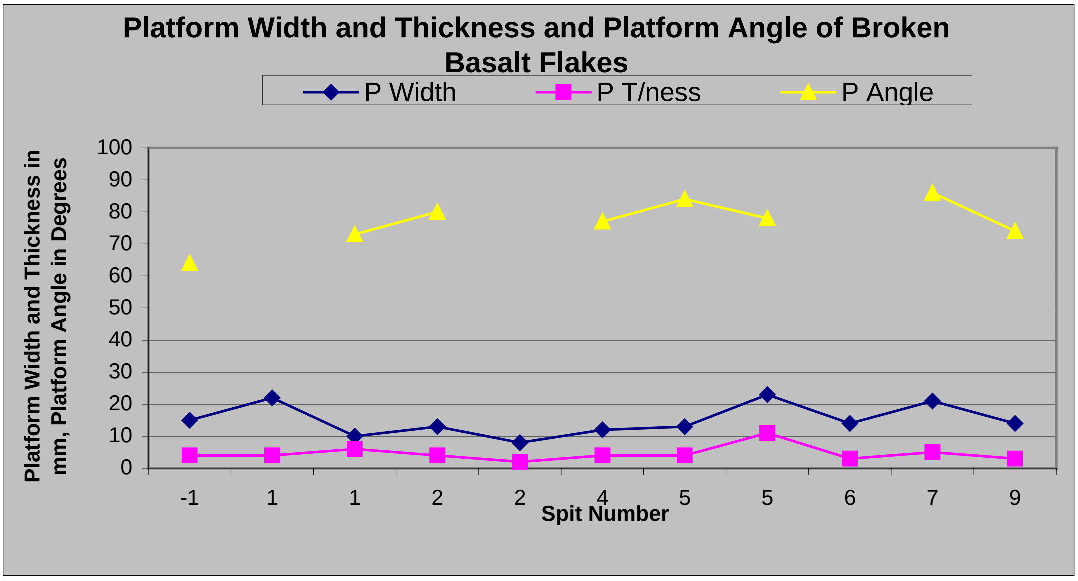


Figure 7.15. Platform width, platform thickness and platform angles from broken basalt flakes recovered from R4D2 (*n*12). Note* length and thickness for one flake in Spit 1 is not available.

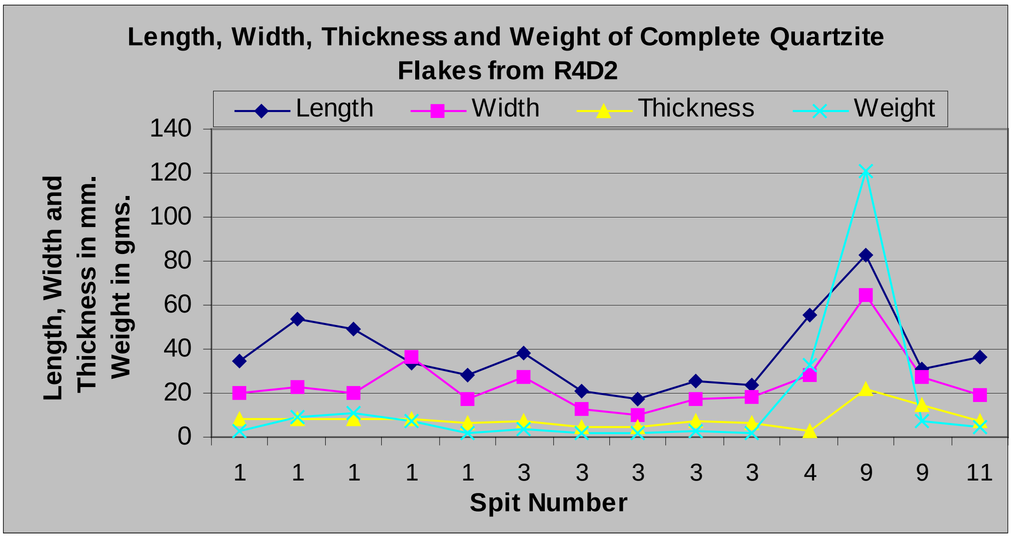


Figure 7.16. Length, width, thickness and weight of complete quartzite flakes from R2 D2 (n14).

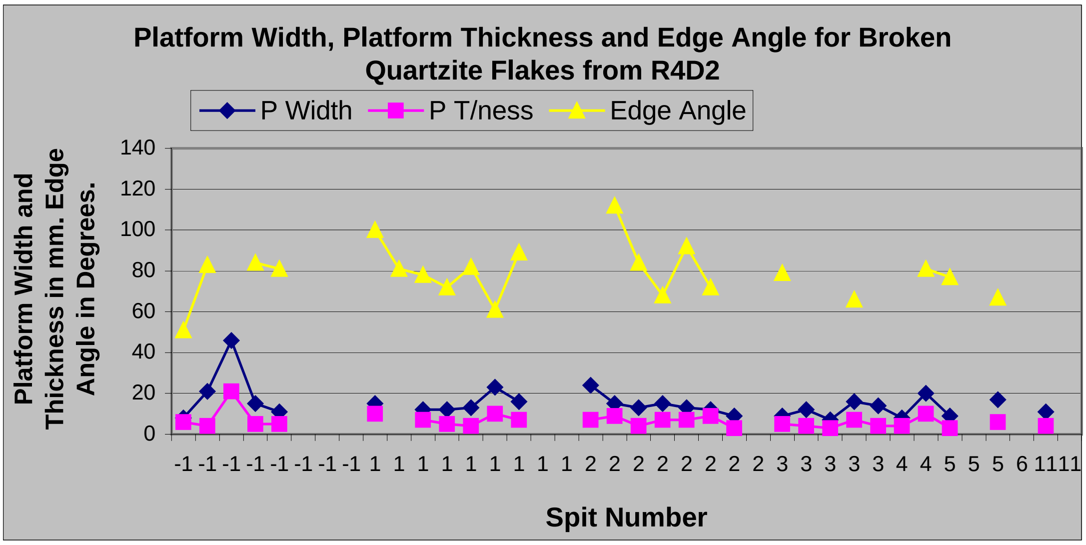


Figure 7.17. Platform length, width, thickness and edge angle of broken quartzite flakes from R4D2 (*n*38). Note* -1 equates to surface.

In descending order, raw material types excavated from R4D2 were, basalt trimming flakes 73.4%, quartzite flakes 23.7%, quartz flakes 2.2% and chert flakes 0.7% (see Figure 7.18). In addition, one retouched axe on the surface of R4D2. Type 4 debitage is not counted in Figure 7.18 as they do not represent knapped flakes (see Andrefsky 2002).

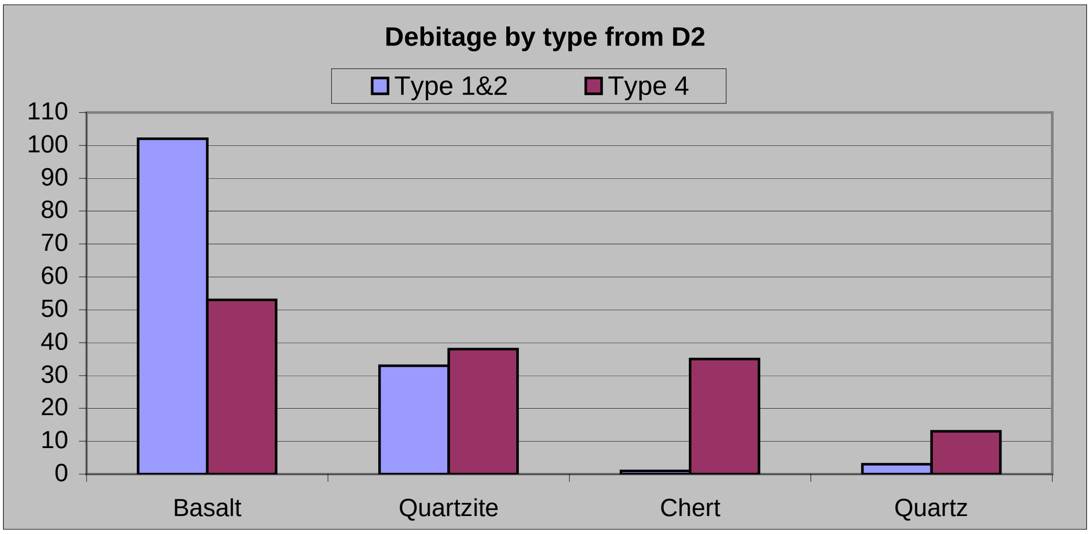


Figure 7.18. Debitage types and raw material quantities excavated from R4D2.

A descriptive analysis of complete basalt and quartzite flakes excavated from R4D2 are shown in Tables 7.21 and 7.22 respectively. These tables show that quartzite flakes are slightly larger than basalt flakes.

	Length mm	Width mm	T/ness mm	P Width mm	P T/ness mm	Weight gm	P. Angle deg.
Mean	**29**	**23**	**6**	**17**	**5**	**9**	**77**
Standard Error	2.6	1.96	0.71	2.27	1.02	3.12	2.14
Median	25	23	5	14	4	4	78
Mode	20	27	5	13	4	3	73
Standard Dev.	13	10	3	7	4	15	7
Sample Var.	169.22	92.43	12.23	62.33	12.60	234.52	45.82
Kurtosis	1.58	0.62	8.47	3.15	2.78	8.433	0.22
Skewness	1.26	0.72	2.88	1.63	1.84	2.95	-0.55
Range	53	37	15	29	12	63	22
Minimum	13	9	4	8	2	1	64
Maximum	66	46	19	37	14	64	86
Sum	685	554	152	202	64	221	774
Count	24	24	24	12	12	24	10

Table 7.21. Descriptive analysis of complete basalt flakes recovered from R4D2.

	Length mm	Width mm	T/ness mm	P Width mm	P T/ness mm	Weight gm	P Angle deg.
Mean	**36**	**25**	**8**	**13**	**6**	**17**	**79**
Standard Error	5.65	4.59	1.64	1.28	0.90	10.73	6.56
Median	31	19	7	13	5	4	82
Mode	#N/A	17	7	12	4	2	#N/A
Standard Dev.	19	15	5	4	3	36	11
Sample Var.	351.65	231.96	29.81	14.77	7.44	1268.09	129.33
Kurtosis	3.801	4.745	3.79	1.65	3.12	9.16	#DIV/0!
Skewness	1.864	1.98	1.98	0.46	1.62	2.98	-1.20
Range	66	55	19	14	9	119	22
Minimum	17	10	3	7	3	2	66
Maximum	83	65	22	21	12	121	88
Sum	392	277	91	121	52	188	236
Count	11	11	11	9	9	11	3

Table 7.22. Descriptive analysis of complete quartzite flakes recovered from R4D2.

There is a clear difference in the amount of debris recorded for the surface and Spit 1 in terms of each of the four raw materials shown in Table 7.23. Below Spit 1 there appears to be a general trend for decreasing amounts of debitage by weight.

As for R4A3, the volume of rock in the excavation and the absence of clay particles may have limited the vertical movement of cultural material in the subsurface (Table 7.24). Stone was excavated from all spits of R4D2 with increasing volumes from Spit 8 and below. The variations in the weight of soil excavated may be attributed to slight differences in spit depth as this was difficult to control when rock occurred at the base of the spits.

Spit Number	**Basalt**	**Quartzite**	**Quartz**	**Chert**
S	*n* 86 wt 154gm	*n* 3 wt 14 gm	*n* 54 wt 27 gm	*n* 8 wt 3 gm
1	*n* 183 wt 89 gm	*n* 68 wt 104 gm	*n* 100 wt 202 gm	*n* 19 wt 22 gm
2	*n* 40 wt 64 gm	*n* 11 wt 39	*n* 52 wt 93 gm	*n* 1 wt 2 gm
3	*n* 31 wt 40 gm	*n* 29 wt 53 gm	*n* 13 wt 23 gm	*n* 12 wt 5 gm
4	*n* 26 wt 40 gm	*n* 8 wt 11 gm	*n* 52 wt 109 gm	*n* 14 wt 7 gm
5	*n* 14 wt 3 gm	*n* 3 wt 7 gm	*n* 21 wt 21 gm	*n* 2 wt 2 gm
6	*n* 15 wt 10 gm	*n* 8 wt 6 gm	*n* 27 wt 30 gm	*n* 22 Wt 6 gm
7	*n* 9 wt 8 gm	*n* 5 wt 7 gm	*n* 20 wt 14 gm	*n* 5 wt 3 gm
8	*n* 10 wt 20 gm	*n* 2 wt 2 gm	*n* 12 wt 7 gm	*n* 3 wt 2 gm
9	nil	*n* 2 wt 3 gm	nil	nil
10 -16	nil	nil	nil	nil

Table 7.23. Debitage by raw material and weight excavated from R4D2.

The excavation at R4D2 produced trends for unchanging artefact size, decreasing density with increasing depth and the overall depth of cultural material were remarkably similar to R4A3.

Spit No	Depth	Soil Excavated	Rocks Excavated	Total Weight of Cultural Material
S	n/a	n/a	6kg	1502gm. 1 axe = 562gm
1	0-2cm	24kg	10kg	708gm
2	2-4cm	21kg	11kg	294gm
3	6-8cm	25kg	3kg	175gm
4	8-10cm	30kg	4kg	258gm
5	10-12cm	35kg	9kg	74gm
6	12-14cm	23kg	6kg	63gm
7	14-16cm	34kg	7kg	58gm
8	16-18cm	24kg	14kg	31gm
9	18-20cm	31kg	19kg	121gm
10	20-22cm	32kg	12kg	49gm
11	22-24cm	29kg	17kg	28gm
12	24-26cm	33kg	21kg	22gm
13	26-28cm	33kg	36kg	nil
14	28-30cm	32kg	29kg	nil
15	30-32cm	29kg	15kg	nil

Table 7.24. Weight of soil, rock and cultural material excavated from R4D2 by spit.

7.6.3 **Excavation at R4D4**

Excavation of R4D4 was the third and final excavation at this reduction floor. A number of unusual artefacts were recovered from R4D4, including three broken chert flakes from Spit 1, a quartzite core with five negative scars from Spit 2 and one complete white chert flake from Spit 4. The quartzite core is most unusual, as despite numerous quartzite flakes this was the only core excavated. Similar raw material can be found in nearby creek beds. A basalt stone axe that had no obvious flaws was also recovered from the surface of the site. The attributes of these artefacts are listed at Table 7.25. The data in Table 7.25 are not as detailed as previous tables, due to the small number of artefacts in each set (*n*1 for three sets).

Surface Basalt							
Axe	**Length**	**Width**	**T/ness**			**Weight**	
	110 mm	107mm	34 mm			592mm	
Spit 1 Chert Complete	**Length mm**	**Width mm**	**T/ness mm**	**P Width mm**	**P T/ness mm**	**Weight gm**	**E Angle deg.**
Mean	**20**	**8**	**8**	**18**	**5**	**5**	**82**
Count	1	1	1	1	1	0	1
Spit 1 Chert Broken	**Length**	**Width**	**T/ness**	**P Width**	**P T/ness**	**Weight**	**E Angle**
Mean	**20**	**16**	**5**	**11**	**5**	**2**	**77**
Std. Dev.	3	5	2	5	1	0	12
Count	3	3	3	3	3	3	2
Spit 2 Quartzite Core	**Length**	**Width**	**T/ness**			**Weight**	
Mean	**51**	**52**	**40**			**120**	
Count	1		1			1	

Table 7.25. Attributes of the stone axe, chert flakes and quartzite core excavated from R4D4.

The data for basalt flakes (shown in Figure 7.19 and 7.20) indicates decreasing density over depth. Only three of the 35 complete basalt flakes were excavated from levels deeper than Spit 4. The two longest flakes were in Spit 2, but a sustained variation in flake size is not perceptible (Figure 7.19).

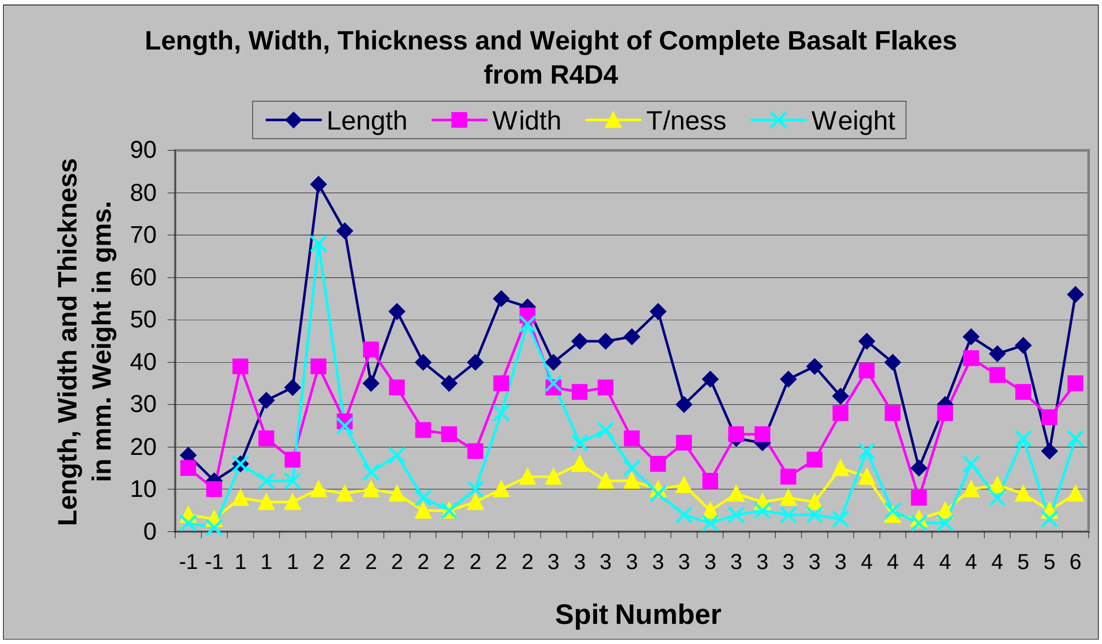


Figure 7.19. Length, width, thickness and weight of complete basalt flakes excavated from R4D4 (*n*35).

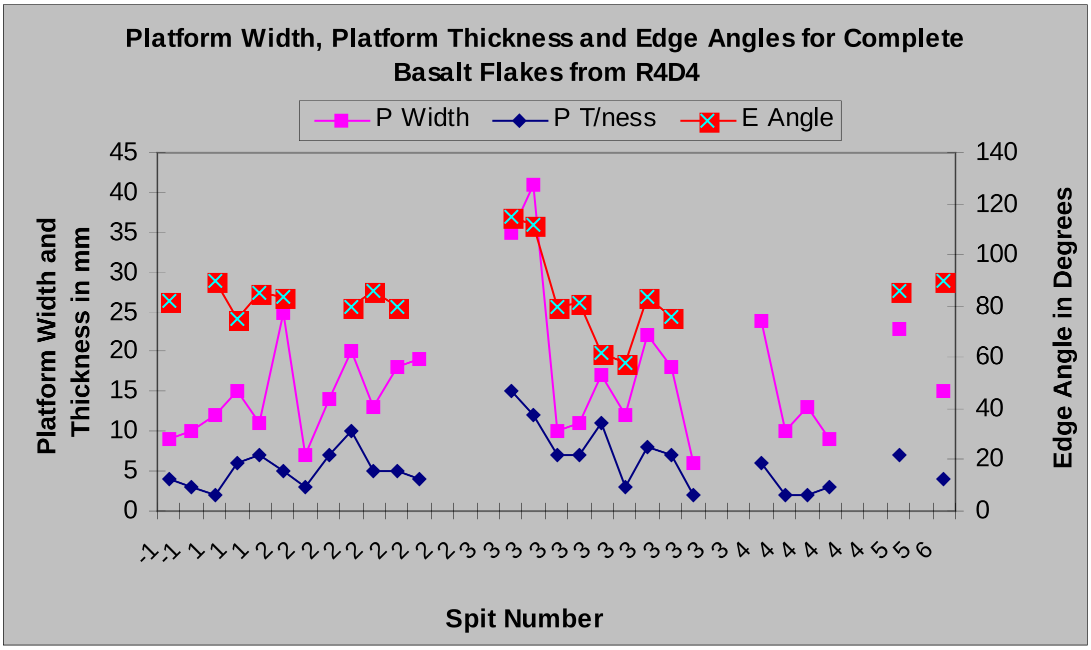


Figure 7.20. Platform width, platform thickness and edge angle for complete basalt flakes excavated from R4D4 (*n*35). Platform width and thickness on the left axis, edge angle right axis.

Attributes of basalt and quartzite flakes are shown in Figures 7.21 to 7.22. Two flakes excavated from Spit 3 had extremely high edge angles (Figure 7.20). These are among the highest recorded at R4 but the flakes from above and below Spit 2 are all in close proximity to an average of 80 degrees.

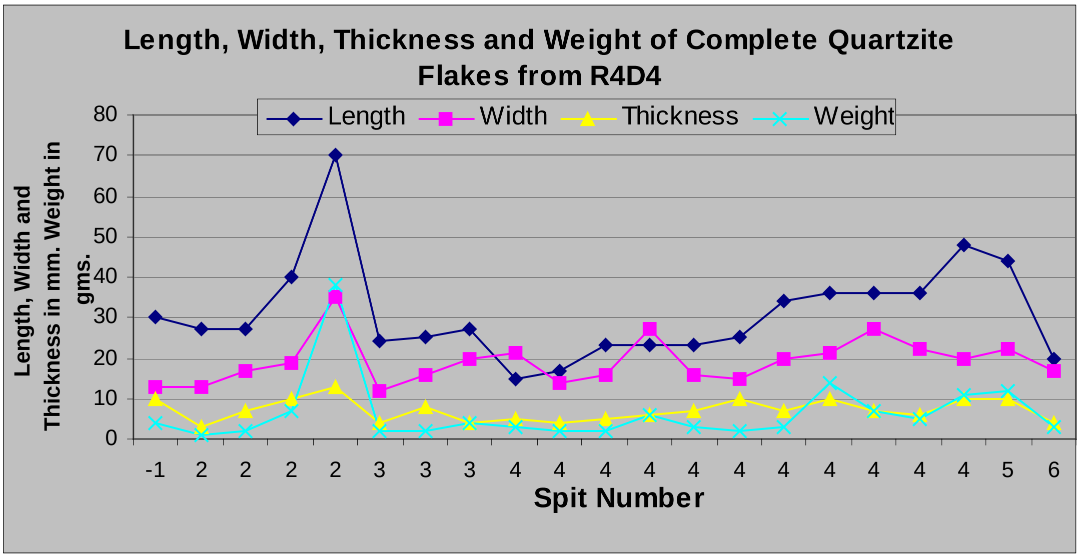


Figure 7.21. Length, width, thickness and weight of complete quartzite flakes excavated from R4D4 (*n* 21).

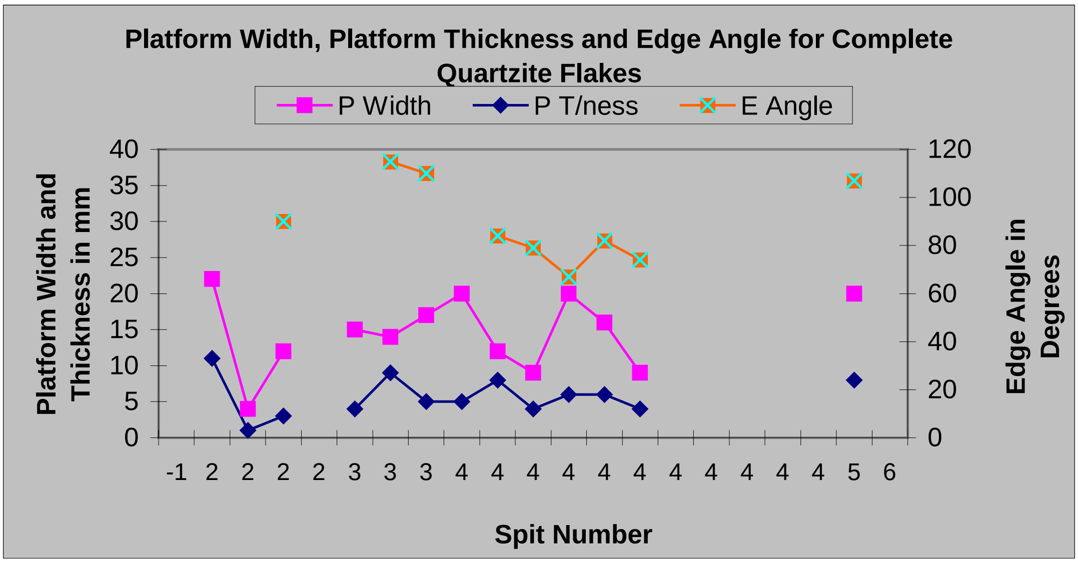


Figure 7.22. Platform width, platform thickness and edge angle for complete quartzite flakes excavated from R4D4 (n13). Platform width and thickness left axis, edge angle right axis.

A descriptive analysis of complete basalt and quartzite flakes excavated from R4D4 are shown in Tables 7.26and 7.27 respectively. At 90° degrees quartzite flakes have a mean average edge angle 6 degrees higher than basalt at 84° degrees (Tables 7.26 and 7.27).

	Length mm	Width mm	T/ness mm	P Width mm	P T/ness mm	Weight gm	E Angle deg.
Mean	**39**	**27**	**9**	**16**	**6**	**14**	**84**
Standard Error	2.56	1.746	0.56	1.57	0.63	2.42	3.22
Median	40	27	9	14	5	10	83
Mode	40	34	7	10	7	2	80
Standard Dev.	15	10	3	8	38	14	14
Sample Var.	230.32	106.78	11.24	66.96	10.84	205.16	187.64
Kurtosis	1.01	-0.56	-0.54	2.47	1.05	5.32	1.804
Skewness	0.53	0.109	0.20	1.48	1.06	2.05	0.66
Range	70	43	13	35	13	67	57
Minimum	12	8	3	6	2	1	58
Maximum	82	51	16	41	15	68	115
Sum	1355	948	301	439	157	497	1506
Count	35	35	35	27	27	35	18

Table 7.26. Descriptive analysis of complete basalt flakes excavated from R4D4.

	Length mm	Width mm	T/ness mm	P Width mm	P T/ness mm	Weight gm	E Angle deg.
Mean	**31**	**19**	**7**	**15**	**6**	**63**	**90**
Standard Error	2.70	1.20	0.60	1.47	0.75	1.76	5.67
Median	27	19	7	15	5	3	84
Mode	27	20	10	20	4	2	#N/A
Standard Dev.	12	6	3	5	3	8	17
Sample Var.	153.94	30.46	7.627	28.25	7.39	65.73	289.94
Kurtosis	3.84	2.10	-0.83	-0.41	-0.06	12.34	-1.35
Skewness	1.65	1.24	0.32	-0.45	0.35	3.28	0.38
Range	55	23	10	18	10	37	48
Minimum	15	12	3	4	1	1	67
Maximum	70	35	13	22	11	38	115
Sum	650	403	150	190	74	133	808
Count	21	21	21	13	13	21	9

Table 7.27. Descriptive analysis of complete quartzite flakes excavated from R4D4.

The quantity of quartzite and basalt flakes in R4D4 steadily decrease from the surface down to Spit 4 (Tables 7.28 and 7.29). In Spit 3 the number of basalt flakes outstripped quartzite flakes. Quartzite flake quantities increased from the basal deposits until Spit 4 where numbers remained relatively constant.

The weight of rock excavated from spits at R4D4 increased with depth (Table 7.29). There are slight variations in the weight of soil excavated and this may be partly attributed to variation in the volume of rock present and minute differences in spit size, given that these were two centimetres in depth.

R4D4 has an increase in debitage (for all types of raw material) in Spit 1 compared with the surface (Table 7.28). Within Spit 5 basalt and quartzite flake quantities were significantly reduced, whilst quartz and chert maintained relatively high levels, but decreasing in lower spits. Debris was excavated from Spit 13 in R4D4. However the two spits immediately above Spit 13 and the three spits below were culturally sterile (Table 7.28).

A quartzite and chert core weighing 33gms and 8gms respectively were excavated from Spit 4. These cores are unusual at R4 as no other cores of these material types were noted on the surface of this site of recovered during excavations. A charcoal sample from Spit 4 returned a radiocarbon determination of 386 ± 46BP (Wk 11647). This was the only charcoal sample collected from R4D4 and was less than one gram in weight.

The 26cm depth of cultural material at R4D4 is significant given that it is an open site in a semi-arid region. However, erosional processes seem to be impacting on the surface as significant differences in raw material by weight between the surface and subsurface are noticeable (Table 7.29).

As for the previous two excavations at R4, basalt comprised the majority of debitage recovered from R4D4. Quartzite remains a significant proportion of the assemblage with minimal quantities of chert and quartz (see Figure 7.23). The percentage of each raw material type recovered from R4D4 is: basalt 87%, quartzite 12.5% and chert 0.6%.

Spit Number	**Basalt**	**Quartzite**	**Quartz**	**Chert**	**Totals**
S	*n* 59 wt 51	*n* 12 wt 11	nil	nil	*n 71* wt 62
1	*n* 314 wt 354	*n* 23 wt 118	*n* 223 wt 318	*n* 27 wt 25	*n 587* wt 815
	n 43 wt 227	*n* 1 wt 10	*n* 166 wt 334	*n* 18 wt 16	*n 228* wt 587
3	*n* 107 wt 113	*n 1* wt 2	*n* 110 wt 42	*n* 11 wt 13	*n 229* wt 170
4	*n* 34 wt 50	*n* 34 wt 50	*n* 21 wt 12	nil	*n 89* wt 112
5	*n* 4 wt 4	*n* 68 wt 38	*n* 72 wt 38	*n* 13 wt 23	*n 157* wt 103
6	*n* 3 wt 2	*n* 3 wt 4	*n* 1 wt 1	*n* 7 wt 12	*n 14* wt 19
7	*n* 1 wt 3	*n* wt	*n* 3 wt 3	*n* 21 wt 3	*n 25* wt 9
8	*n* 4 wt 3	*n* 5 wt 2	*n* 1 wt 1	*n* 7 wt 9	*n 17* wt 15
9	nil	*n* 4 wt 3	nil	*n* 5 wt 2	*n 9* wt 5
10	nil	*n* 5 wt 4	nil	*n* 6 wt 2	*n 11* wt 6
11	nil	nil	nil	nil	
12	nil	nil	nil	nil	
13	*n* 1 wt 2	n 1 wt 8	nil	nil	*n 2* wt10
14	nil	nil	nil	nil	
15	nil	nil	nil	nil	
16	nil	nil	nil	nil	

Table 7.28. Debris by raw material and weight excavated from R4D4.

Spit No	**Depth**	**Soil Excavated**	**Rock Excavated**	**Weight of Cultural Material Excavated.**
S	n/a	n/a	4kg	811gms. Includes one stone axe weighing 592gms.
1	0-2cm	26kg	10kg	1237gms
2	2-4cm	23kg	6kg	1652gms
3	6-8cm	21kg	10kg	535gms
4	8-10cm	22kg	13kg	382gms
5	10-12cm	22kg	12kg	160gms
6	12-14cm	22kg	13kg	44gms
7	14-16cm	21.5kg	18.5kg	9gms
8	16-18cm	26kg	9kg	20gms
9	18-20cm	24kg	11kg	14gms
10	20-22cm	23kg	17kg	13gms
11	22-24cm	26kg	22kg	8gms
12	24-26cm	20kg	12kg	nil
13	26-28cm	24kg	12kg	10gms
14	28-30cm	25kg	11kg	nil
15	30-32cm	27kg	14kg	nil

Table 7.29. Weight of soil, rock and cultural material excavated from R4D4 by spit.

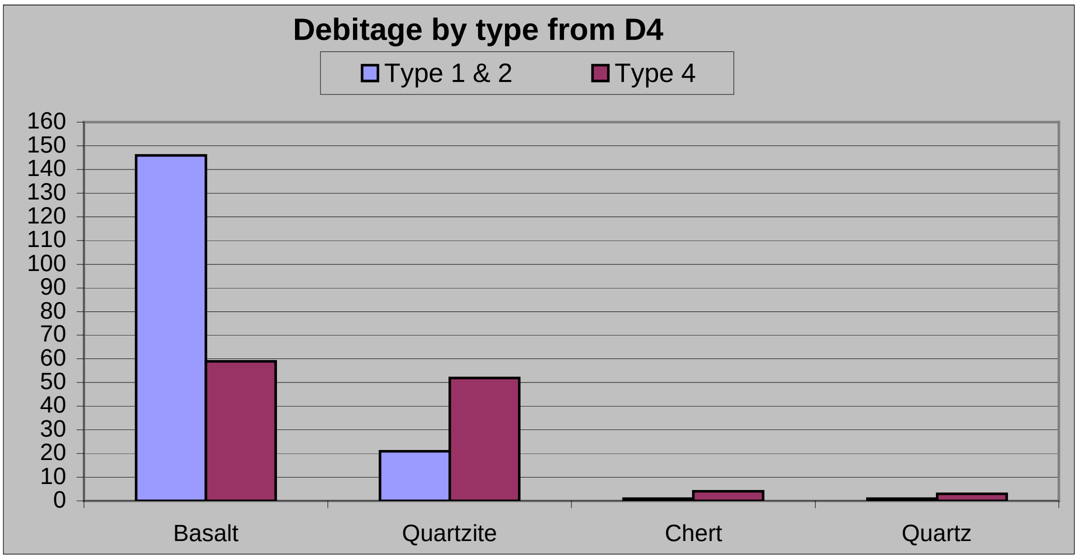


Figure 7.23. Debitage by type recovered from R4D4.

7.7 **Changes over time at R3 and R4**

The geomorphology at both sites is similar and this is principally due to the high quartzite ridges to their east. These uplifted Myally beds are the source of colluvium that has build up covering cultural material at both reduction floors.

Notwithstanding the affects of trampling, the absence of clay limits the vertical movement of cultural material in the subsurface as this substance expands and contracts markedly with variations in water content. In addition, compared to alluvial formations, colluvial is less likely to transport cultural material from primary to secondary depositional sites. In combination, these issues support the integrity of archaeological evidence recovered from R3 and R4.

At R3 all knapped flakes were basalt debris produced during the production of axes. The presence of quartzite hammerstones or grindstone particles on the surface maybe attributed larger objects being less prone to trampling and being covered by colluvial formations. Recycling of larger stones from broken or worn grindstones as hammerstones, which keeps these larger tools in use until further reduced in size may limit the amount of larger objects being enveloped by the colluvial process.

Holdaway *et al*. (2004) suggested that some surface deposits in the arid region are derived from many separate events of occupation. This argument is also reasonable for semi-arid regions such as northwest Queensland. Holdaway *et al*. (2004) suggested that '…locations in the landscape may be used by a variety of people, in a variety of ways, and at a variety of times'. Separate camping and reduction areas during periods of occupation at sites may, over the centuries, become aggregated as advanced by Dewar and McBride (1992). This amalgamation seems to have at parts of R3 (as indicated by the presence of other types of raw material), but has not occurred in the three squares excavated at R3. It could be that some areas such as the excavation site at R3 have remained discrete knapping areas for an extended period of time. Conversely, the absence of these materials from the excavations at R3 may reflect the small sample size

Fluctuations in temporal discard rates are noted at R3. Temporal changes in intensity of knapping probably suggest that axe production increased over time. Temporal change in artefact size is difficult to determine because of the low number of complete basalt flakes. The presence of larger flakes in the lower spits of R3 may in fact suggest post-depositional processes at work. Temporal change in artefact type does not occur, as all subsurface flakes were basalt flakes, which are trimming flakes removed during the production of stone axes**.**

The moving analysis by percentage based on the quantity of cultural material recovered the three excavated squares at R4 indicates that quartzite flake production was higher than basalt flakes until Spit 4 when both types of raw material reached similar rates of discard (Figure 7.24). In addition, at Spit 6 the number of flakes discarded for both raw material types increased significantly compared to deeper spits. The increased numbers of quartzite flakes are not associated with the production of leilira blades, which are significantly larger in size. Indeed, although present elsewhere at Moondarra (see Chapter 9) evidence of leilira production is absent from R4. The quartzite flakes recovered from R4 are most likely discarded artefacts from the ‘subsistence tool kit’, nevertheless they were also knapped at the material source and only one small quartzite core was recovered from the site. The percentages of raw materials (type 1 and 2) excavated from R4 are: basalt 69.9%, quartzite 27.7%, Quartz 1.6% and chert 1.0%. This suggests that axe reduction was the principle activity conducted at R4.

Figure 7.25 indicates the quantities of type 1 and 2 flakes excavated from three excavations at R4. This moving analysis uses dates BP (bold print) to indicate changing rates of production rates over time. A clear increase in basalt trimming flakes commenced at about 500 to 600 years BP.

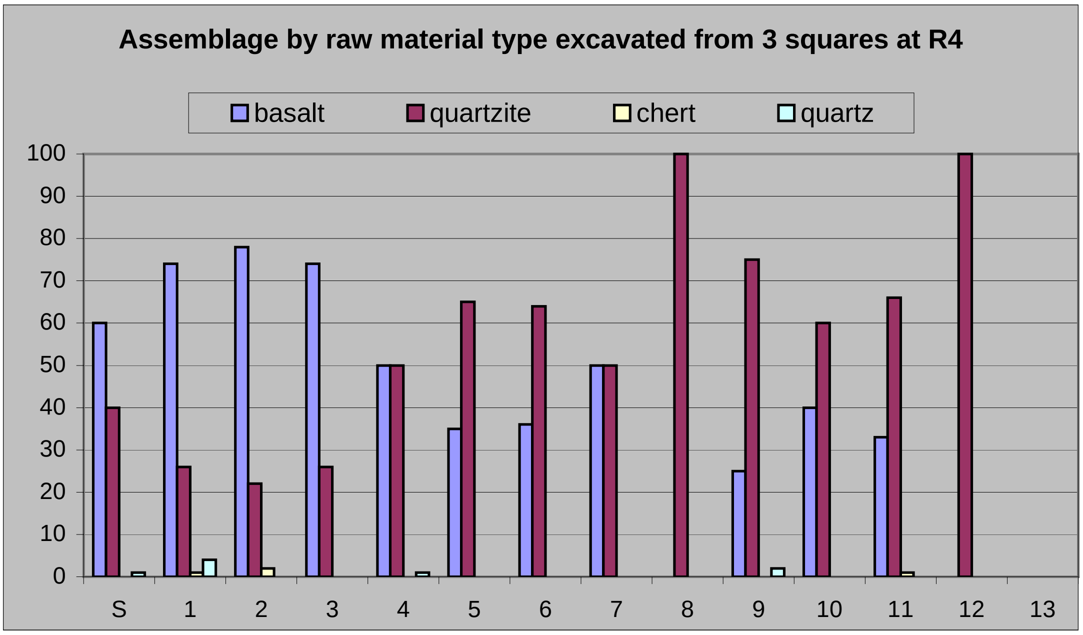


Figure 7.24. Moving analysis by percentage based on the quantity of cultural material recovered from 3 squares at R4.

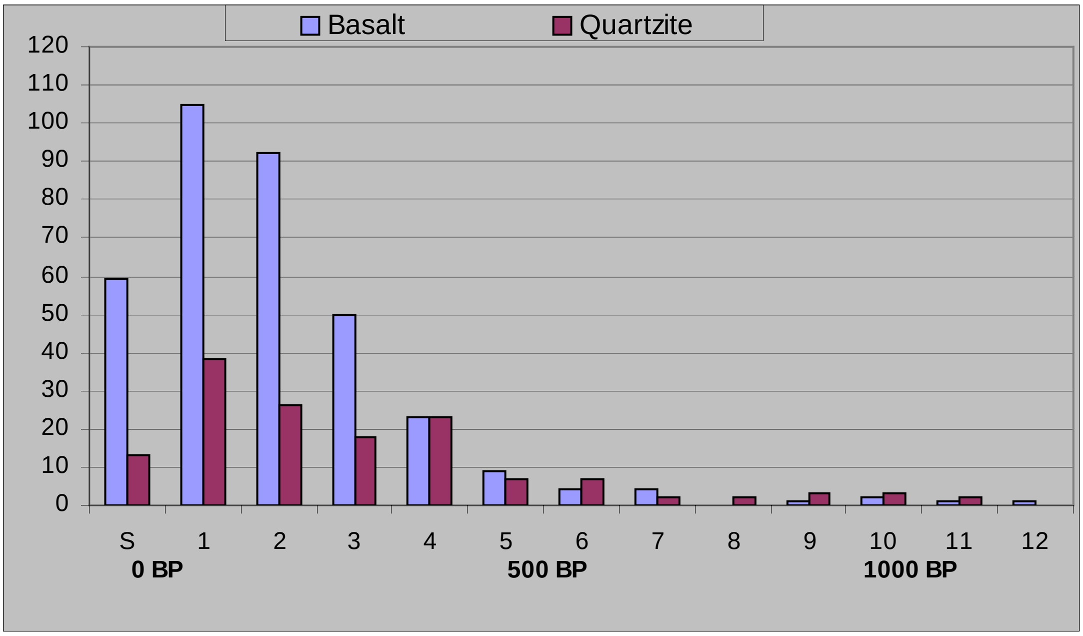


Figure 7.25. Quantity of basalt and quartzite flakes excavated from 3 squares at R4.

- Note. Bold print links to years BP for spit numbers.

Figures 7.26 and 7.27 represent moving aggregates based on material from the three excavated squares at R4. Apart from a few outliers in Spits 1 and 2, the length of basalt flakes seems to have remained constant over time. Flake length in the lower deposits is within the range of the more recent cultural deposits. It appears that 10mm is the minimum length of complete basalt flakes removed from the axe cores.

The trend for unchanging quartzite flake length seems to be supported by Figure 7.26, which is an aggregate of the 40 quartzite flakes by spit.

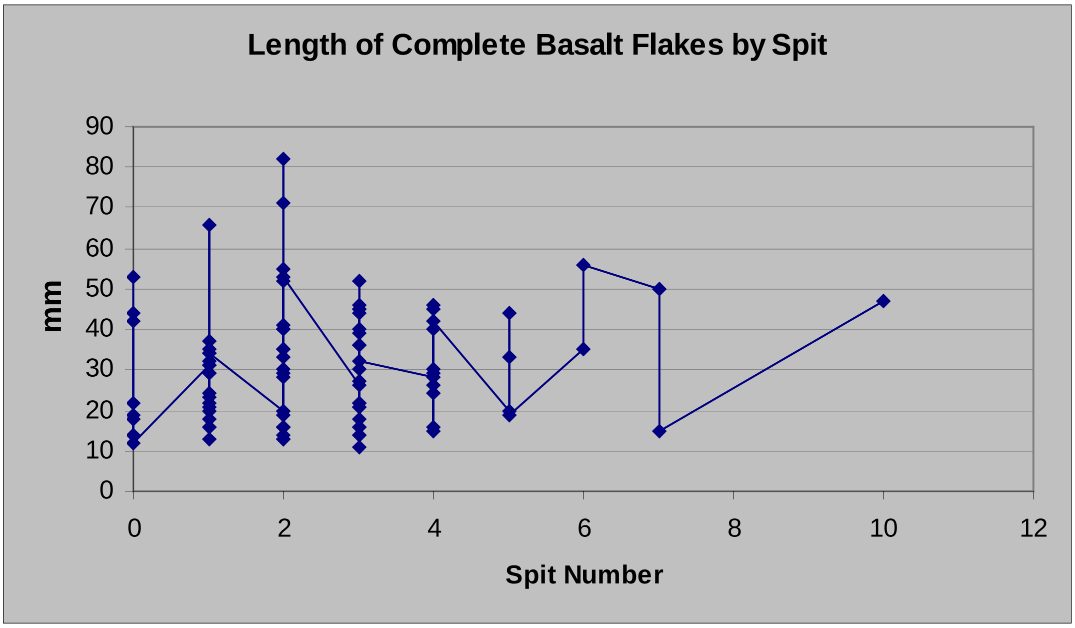


Figure 7.26. Relative temporal change of type 1 basalt flake size from excavations at R4 (*n*94).

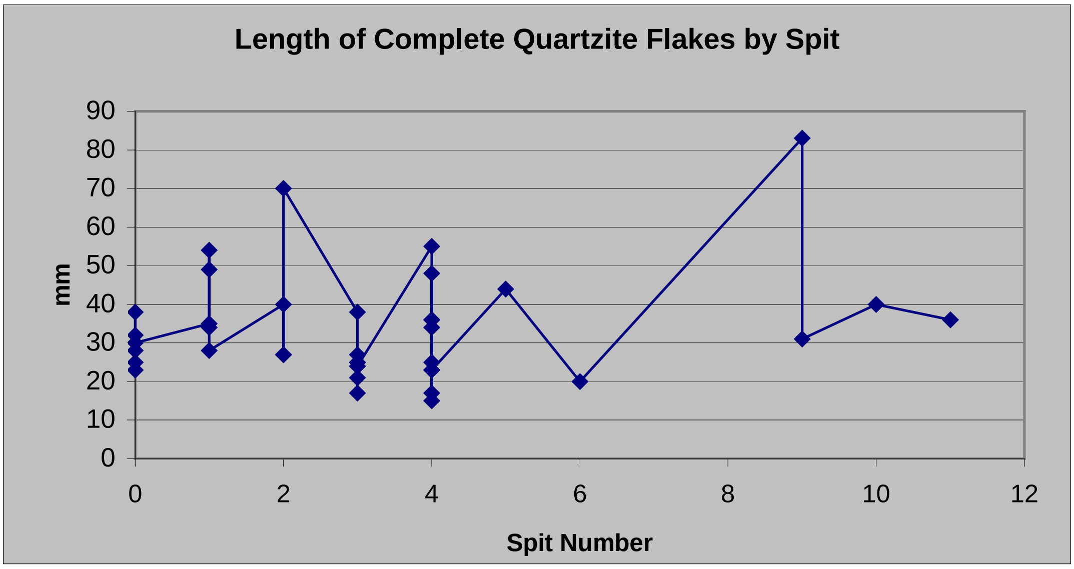


Figure 7.27. Relative temporal change of type 1 quartzite flake size for excavations at R4 (*n*40).

The summary of descriptive statistics for complete quartzite and basalt flakes from R4 is illustrated in Tables 7.30 and 7.31 identifies the wide range in length and the other attributes measured. Despite the wide range for type 1 (complete) quartzite and basalt flakes (Tables 7.30 and 7.31), there appears to be a trend for unchanging length in both raw material types (Figures 7.26 and 7.27). A few outliers have noticeably increased the range (Figures 7.26 and 7.27).

At R4 comparative analyses between the percentages of broken quartzite and basalt flakes from the three excavated squares provided a similar result. The quantity of broken flakes was 26.7% for basalt and 29.28% for quartzite. The percentage of basalt artefacts increased markedly compared with quartzite flakes in the upper levels that are more likely to be impacted upon by cattle trampling. If there was a significant increase in the percentage of broken basalt flakes, then this would support an argument for post-depositional change, however this was not the case.

Analysis of quartzite flakes reveals that the quartzite flakes were knapped offsite at the material source. Archaeological evidence supports this notion with only one quartzite core recovered at R4. If the quartzite flakes were knapped on the axe reduction floors, then numerous quartzite cores would be onsite, which is not the case. Basalt cores (technically flakes) are moved off-site in the form of axes. The quartzite flakes found at the reduction floors and macroblades recorded at the quarries appear to be two different implements (see Chapter 9). The quartzite flakes from the reduction floors are smaller and most likely used in the subsistence tool kit.

	Length mm	Width mm	T/ness mm	P Width mm	P T/ness mm	Weight gm	E Angle deg.
Mean	**34**	**21**	**85**	**148**	**62**	**97**	**83**
Standard Error	2.19	1.46	0.56	0.90	0.43	3.09	3.22
Median	30.5	19.5	7.5	14	6	4.5	81
Mode	25	20	7	12	6	2	79
Standard Dev.	14	9	4	5	2	20	14
Sample Var.	193.31	85.77	12.715	25.65	5.98	382.97	198.14
Kurtosis	3.61	12.84	4.92	0.16	0.22	28.50	0.73
Skewness	1.67	2.97	1.65	0.32	0.42	5.09	1.05
Range	68	56	19	23	11	120	51
Minimum	15	9	3	4	1	1	64
Maximum	83	65	22	27	12	121	115
Sum	1346	834	322	449	190	379	1580
Count	40	40	40	31	31	40	19

Table 7.30. Summary of descriptive statistics for complete quartzite flakes excavated from R4 (*n* 40).

	Length mm	Width mm	T/ness mm	P Width mm	P T/ness mm	Weight gm	E Angle deg.
Mean	**31**	**23**	**7**	**14**	**5**	**9**	**81**
Standard Err.	1.48	1.064	0.34	0.96	0.37	1.32	2.05
Median	29	22	6	13	4	4	81
Mode	16	17	5	10	2	2	86
Standard Dev.	14	10	3	8	3	13	14
Sample Var.	207.86	106.60	11.02	59.94	8.99	163.78	189.54
Kurtosis	0.94	-0.22	1.58	2.268	2.577	8.39	2.88
Skewness	0.94	0.57	1.26	1.37	1.56	2.72	0.33
Range	71	47	17	37	14	67	81
Minimum	11	4	2	4	1	1	40
Maximum	82	51	19	41	15	68	121
Sum	2873	2180	639	927	306	875	3655
Count	94	94	94	65	65	94	45

Table 7.31. Summary of descriptive statistics for complete basalt flakes excavated from R4 (*n* 94).

The two types of quartzite quarries recorded in Chapter 5 support this notion. Quartzite flakes knapped from the fine-grained grey-black quarry at Q23 are absent from both surface and excavated material from R4. Similarly, leilira blades were not observed on any of the six reduction floors. The form of these macroblades is prismatic and the average length is 100mm-120mm, which is considerably larger than the flakes recorded from R4 (see Table 7.29). Moreover, numerous large flakes were noted in the bed of Stone Axe Creek (Q 24). One large specimen was 220mm x 85mm x 26mm which is exceptionally large when compared with the quartzite flakes at R4.

Gramly (1980:823) suggested that workshops (reduction floors) at lithic sources may posses a greater range of tool forms than other archaeological sites. This situation occurs when different tools or lithic materials are carried into the quarry. Gramly's (1980) suggestion may explain the presence of quartzite and some quartz and chert flakes that are exotic to the immediate area and the smaller quartzite flakes that have been knapped at the material source and discarded at the reduction floor.

The descriptive analysis of platform variables and edge angles for complete and broken basalt flakes resulted in similar mean measurements. The lack of any significant difference between these variables is a 'probable outcome' when these features are unlikely to be distorted by breakage. Reliable measurements can be obtained from complete and broken flakes when the platform variables are intact.

The similarity of flake thickness for complete and broken flakes from the surface of R4 requires some explanation. A high percentage of flakes are broken on the margins and do not fit neatly into the category of transverse or longitudinal breaks. Nevertheless, on broken flakes with platforms and bulbs, the majority of breaks are transverse with longitudinal examples being an exception. In assemblages such as this, maximum thickness on broken flakes may not be excessively affected, as the width of flake margins may change but not thickness. In addition, on these trimming flakes there is limited variation in flake thickness until near the termination point. Therefore, a measurement taken on a traversely broken flake or one broken at the margins might provide a similar measurement for width, which is comparable to its original maximum thickness. The ratio of platform width to platform thickness for complete and broken basalt flakes is 1:2.91 (*n*200) and 1:3.09 (*n*311) respectively. This may suggest that the broken flakes were originally of similar size to complete flakes.

The presence of an axe produced from a basalt river cobble supports the idea that large flakes were removed from basalt cobbles along stone Axe Creek and other smaller waterways. Wherever basalt of suitable size for manufacturing axes is found at Moondarra, it seems to have been assayed for axe making qualities (see Chapter 5).

The length, width, thickness and weight of the basalt trimming flakes appear to be uniform with increasing depth at R4. This consistency indicates that the practice of moving the axes to the sites (known here as ‘reduction floors’) for the removal of smaller trimming flakes has operated for an extended time.

Production of both basalt and quartzite flakes at R4 increased noticeably at Spit 4 when basalt flake production outstripped that of quartzite flakes. Prior to this, quartzite flake represented higher percentages of the assemblage, but this calculation is based on reduced numbers of flakes. The descriptive analysis of artefacts suggested that at R4, basalt and quartzite flake size and edge angles were essentially unchanging over time. A few larger outliers were noted, but these flakes were within the range of the upper deposits.

The paucity of basalt and quartzite cores from R4 may be the result of different patterns of past human behaviour. First, the use of axes as utilitarian and/or exchange goods probably explains the scarcity of basalt cores (axes) onsite as they would have been either exchanged or used by the Kalkadoons. Second, the presence of only a single quartzite core at R4 can be explained by the knapping of these flakes at the material source. In addition, smaller quartzite flakes recovered from the surface and excavations at R4 may have been Aboriginal domestic tools used during camp occupation. Macroblades or leilira blades are evident at the quartzite quarries, but not visible at the reduction floor.

Chapter 8 **Defining axe production at Moondarra**

8.1 **Introduction**

This chapter is a more detailed analysis of archaeological data from R3 and R4. It begins with an estimation of the number of axes produced at the complex and includes an empirical and theoretical analysis of platform variables on axe trimming flakes to test for correlations between these measurements. The relationships between platform variables and flake size can provide an understanding of the fracturing predictability of Moondarra basalt. The chapter continues with an analysis of dates obtained from the three excavations, which may reveal how axe production expanded across the complex and incorporated new methods of quarrying. In addition, dating the site in combination with a geological assessment of northwest Queensland, supports a proposition that Moondarra is not associated with the movement of stone axe technology from northern Australia to southeastern Australia. Finally, an argument for changing penetrability is advanced to interpret the effects of cattle trampling at R3. The surface of R3 showed unambiguous evidence for intense cattle traffic trampling on site.

8.2 **Axe production estimates at Moondarra**

A technique for estimating the number of axes produced from a site involves dividing the number of broken and complete basalt trimming flakes by the average number of negative scars on finished implements. As long as the ensuing figure is considered as an estimate based on archaeological evidence, the result might be considered reasonable**.** However, the axe production methods at Moondarra do not entirely support this methodology.

Flake numbers for particular locations such as the site of excavation at R4 can be extrapolated for the whole of the site, however the degree of accuracy of this method may be doubtful. In this case there is uncertainty as the number of flakes removed at the quarries and reduction floors varies. Axes were brought to the reduction floors after primary or secondary stages of reduction (see Chapter 10). At these stages of production, the preform has been struck numerous times resulting in negative scars, some of which remain detectable on the completed implement. If the axe has been reduced to the second stage of reduction at the quarry then even more flakes remain at the material source. Consequently, there is a discrepancy between the number of negative scars on the axe and the number of trimming flakes at the reduction floor. Therefore, any estimated production level based on the number of flakes present at the reduction floors, divided by the average number of flakes removed from axes, by necessity must be a gross underestimation of actual production levels.

Based on extrapolated flake discard numbers divided by the average number of flakes removed from axes, the minimal estimated number of axes produced at R4 is 31,182 stone axes (1,091,387 flakes ÷35, an average of negative scars per axe). It is with extreme cautiousness that this estimate is extended to include the other five reduction floors, providing an estimation of 257,168 axes. While Hiscock (forthcoming) does not attempt these estimates, he calculated that 0.8 million axe blanks are remaining on site. A comparison between these figures suggests, that about one in four axe blanks resulted in rejects. As highlighted earlier, extrapolation of data to these extremes is likely to result in some error.

Despite embracing a conservative approach to estimating the number of axes produced at Moondarra, historical records noted that one in three axe blanks resulted in a finished product. Brayshaw (1990:158) cited an ethnographic account by Chatfield from near Charters Towers, which is approximately 700 kilometres due east of Moondarra:

> I know that until 1867 this and another quarry in this neighbourhood were frequented by the blacks, who used on the spot to chip out tomahawks, and one in three could be chipped into the proper shape the rejected stones were left half unfinished, and those approved of carried from camp to camp, and polished at leisure… Chatfield, June 2:19, *Queenslander*

8.3 **Fracture mechanics of Moondarra basalt**

Barton (2001:345) suggested that knappers could exert substantial control over platform thickness, platform width and edge angle. Hiscock (1988a:371-2) proposed that the production of tulas demonstrated that wide platforms can be regularly produced by well controlled techniques and that like platform width, platform thickness may indicate increased control of the placement of blows, possibly related to overhang removal.

The analysis of platform width, platform thickness and edge angle of 217 complete and broken basalt flakes from the subsurface of R4 is summarised in Figure 8.1. This suggests that edge angle is independent of platform thickness and platform width. Figure 8.1 shows platform thickness and width increasing in tandem with edge angles remaining constant. The line across Figure 8.1 is set at about 80 degrees to highlight the lack of association between edge angles and platform variables on Moondarra axe trimming flakes.

Experimentation has revealed that change in one of these variables can result in minor change in the other two attributes (Dibble 1997a:154). The descriptive evidence presented here has supported this notion as some of these associations are minimal. The correlation coefficients used in this thesis are from the statistical package in Microsoft Excel (XP). This system uses one-sided p-values of 0.05. The scattergram in Figure 8.1 supports the correlations presented in Table 8.1. This data shows:

1. A strong positive correlation between platform width and platform thickness.
2. A slight negative correlation between platform thickness and edge angle, and
3. A slight positive correlation between platform width and edge angle.

These correlations are important, as they suggest that for the axe trimming flakes at Moondarra, a minimal statistical measure exists between edge angles and platform thickness and edge angles and platform width. A strong positive correlation does exist between platform width and platform thickness.

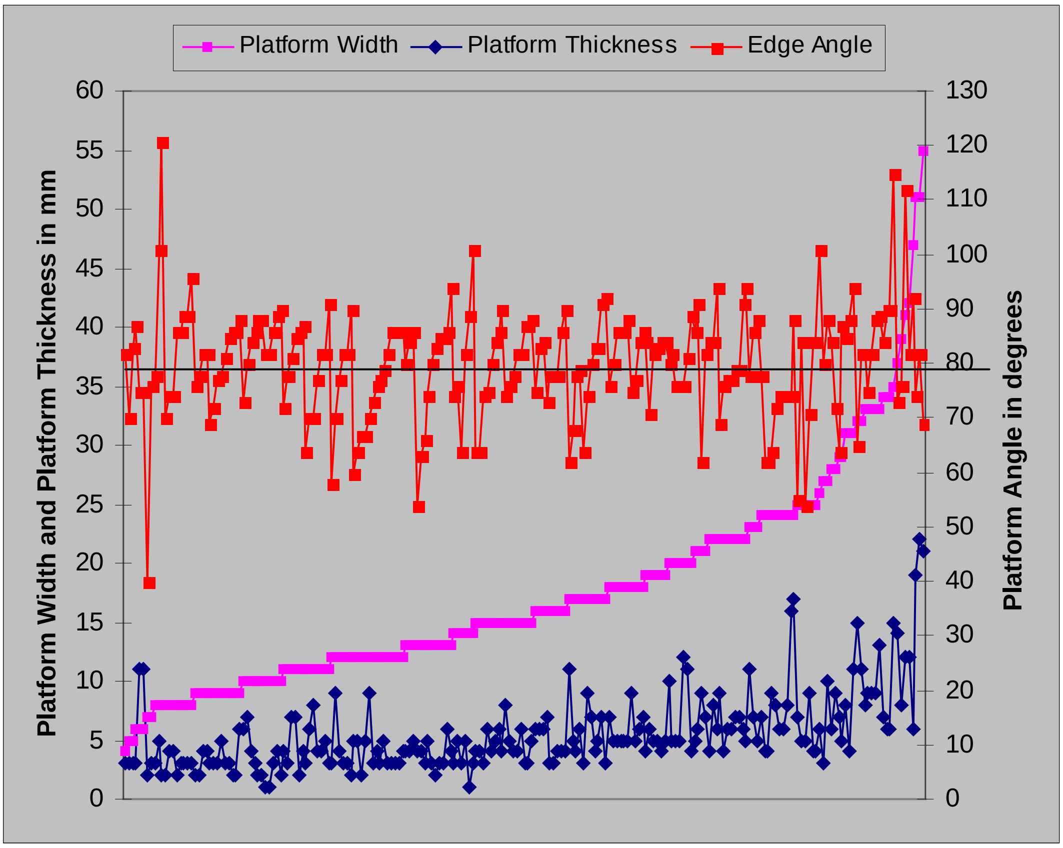


Figure 8.1. Comparative analysis between platform width, thickness and angle of basalt trimming flakes (*n*217).

Variables	Correlation
Platform Thickness to Edge Angle	-0.0498
Platform Width to Platform Angle	+0.0679
Platform Width to Platform Thickness	+0.6982

Table 8.1. Correlations between platform thickness, width and platform angle of complete and broken basalt flakes (*n*217). p-value 0.05.

Empirical and theoretical methods are available in the literature to assist in understanding the fracture mechanics of basalt flakes. Essentially, in the case of Moondarra, correlations between platform variables and flake mass can be calculated for complete flakes. This data can be then applied to estimate the original mass of broken flakes.

Hiscock and Clarkson (2000:100) suggested that it is a mistake to comprehend the variables of fracture mechanics solely from experimentation. They advocated that fracturing has created the empirical archaeological record and it preserves the image of underlying relationships and the complexity and variation that occurs in non-laboratory circumstances.

Andrefsky (2002:23) suggested that the best kinds of stone for knapping are those that can be fractured in a reliable and predictable manner, and these stones are brittle, homogeneous and isotropic. They should not possess direction dependent properties such as bedding planes, fissures, cracks or inclusions. He suggested that glass and obsidian are probably the best examples of this kind of material, followed by cherts, flints, or chalcedonies with a high percentage of silica. Quartz or cryptocrystalline silicates are not as predictable to fracture as obsidian. Basalts are classified together with andesite, quartzite and rhyolite, and have lesser degrees of homogeneity and are more brittle than those previously mentioned (Andrefsky 2000:23).

Many archaeologists have studied the mechanics of stone fracture (Faulkner 1972; Speth 1972, 1974,1975; Dibble and Whittaker 1981; Dibble and Pelcin 1995; Pelcin 1996; Pelcin 1997a, 1997b, 1997c, Pelcin 1998. According to Andrefsky (2002:23), the Australian researchers Cotterell and Kamminga (1979, 1986, 1987, 1990) have conducted the most comprehensive examination on stone fracture mechanics.

At the University of Pennsylvania, Dibble and Whittaker (1981) analysed the fracture mechanics of glass by using a mechanical device that dropped steel ball bearings from a fixed height onto plate glass cores. Two of their paramount conclusions were:

1. For any platform angle, mass is a function of platform thickness (PT), and

2. For any PT, larger exterior platform angles (EPA) result in larger flakes.

Dibble and Pelcin (1995) have identified platform thickness as a major determinant of flake mass, and supported the notion that indenter mass and velocity are significant factors, but that 81% of flake mass is accounted for by the exterior platform angle and platform thickness.

Andrefsky (2002), and Shott *et al*. (2000) have questioned of Pelcin's (1997b) later experimental results, which relied on establishing platform thickness and exterior platforms on theoretical rather than empirical measurements. They believe that the stringent assumptions set by Pelcin's (1997b) experiments are impractical. Shott *et al*. (2000:878) acknowledged that Pelcin (1997b) has properly qualified his analytical conclusions, by stressing their relevance to the materials worked and the controlled environments of his experimentation.

Pelcin's (1997b) theoretical platform thickness shown in Figure 8.2 is represented by the extension of the line normal to the platform that extends to the juncture of the flake's dorsal or interior surface. The theoretical platform angle is the angle formed by the two lines. Shott *et al*. (2000:878) hypothesised that considerable latitude exists in these measurements as on curved or irregular surfaces tangents can be drawn from many points resulting in one artefact potentially providing many pairs of platform thicknesses and angle values. Shott *et al*. (2000) considered these variables as, both a strength and a weakness in Pelcin's (1997b) theoretical measurements, as differing measurements would confuse comparative analyses. On the other hand, they argued that empirical platform thickness is the maximum distance of the platform between the dorsal and ventral surfaces and that this is how it is understood by most archaeologists (see Figure 8.2).

Davis and Shea (1998) tested Pelcin's (1997b) theoretical platform variables by abrading 33 obsidian flakes, sharpening them and then estimating the original size by applying Pelcin's predictor equation. This calculation produced a result that reduced the original flake mass by 33%, based on empirical measurements before the testing. They suggested that the predictor equation failed to adequately incorporate platform width with platform thickness and exterior platform angles. Nevertheless, Shott *et al*. (2000) suggested that the importance of Dibble and Pelcin

(1995) and Dibble (1997b) was the identification of platform thickness as a major determinant of flake size.

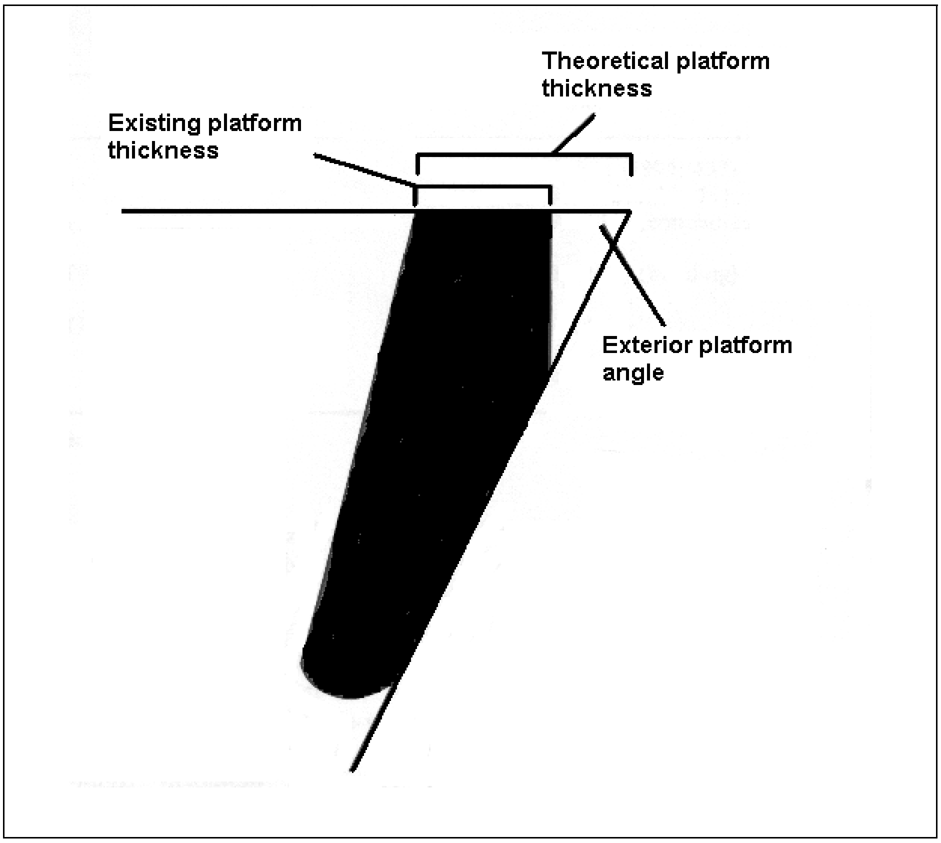


Figure 8.2. Theoretical platform thickness (from Pelcin 1996: Figure 216).

A comparative empirical test between the basalt debitage flakes at R4 created during the production of axes and the debitage from the manufacture of finished tools in Bradbury and Carr's assemblage in Shott *et al.* (2000) may provide a useful insight to the fracture mechanics of Moondarra basalt and how Aboriginal knappers maintained precision in toolmaking.

8.4 **Correlation of platform variables to mass**

Three correlation tests were conducted between mass and platform thickness, width and platform area (Figures 8.3 to 8.5). The results obtained by Odell (2000:883) on obsidian flakes were r = 0.78, r = 0.72, and r = 0.81 respectively. They also noted that mass does not associate clearly with exterior platform angle although, their results suggested a significance of r = +0.14.

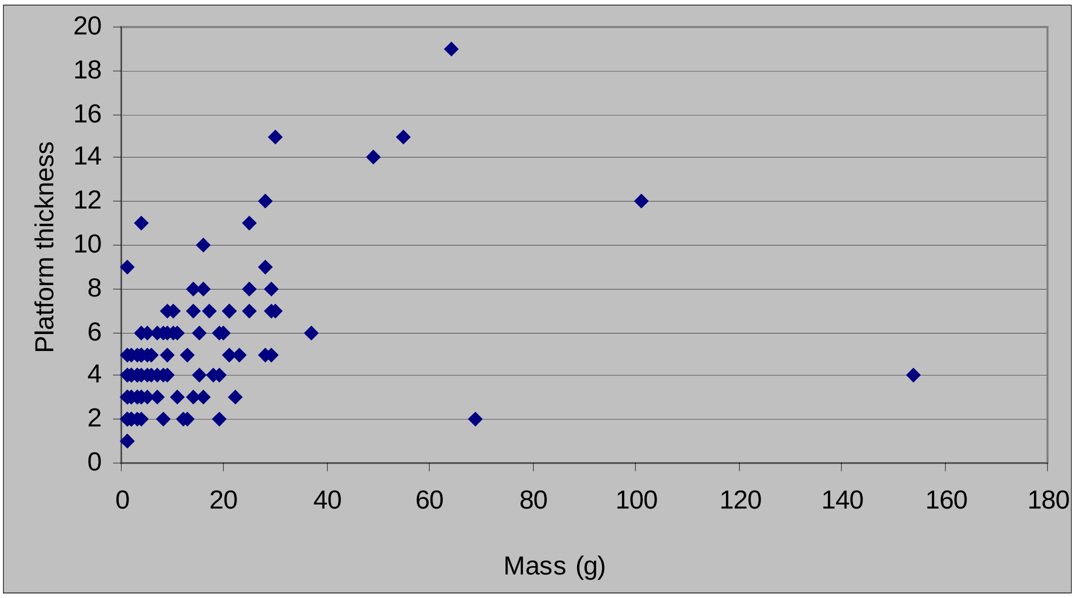


Figure 8.3. Scattergram of the relationship between platform thickness and mass of basalt trimming flakes (*n*115, correlation = + 0.464).

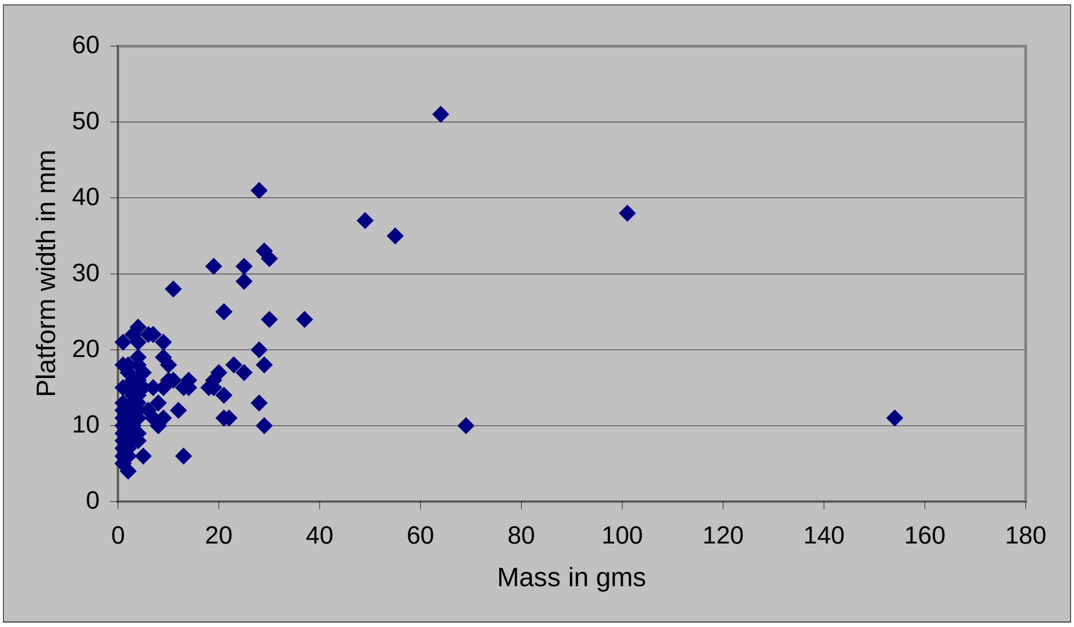


Figure 8.4. Scattergram of the relationship between platform width and mass of basalt trimming flakes (*n*115, correlation = + 0.458).

Table 8.2 shows a comparison between empirical platform variables from Moondarra basalt trimming flakes and the experiment conducted by Bradbury and Carr (cited in Shott *et al*. 2000:883). The Moondarra correlations are consistently lower, but as for Bradbury and Carr experiment, there was greater correlation between platform area and mass. This consistent reduction may be partly attributed to basalt fracturing being less predictable than obsidian as previously suggested by Andrefsky (2002). Nevertheless, the Moondarra correlations for mass to exterior platform are medium to strong. It is argued that the consistently lower correlations between mass and platform variables, as presented in Table 8.2, are possibly misleading and not an accurate reflection of the predictability of basalt fracturing.

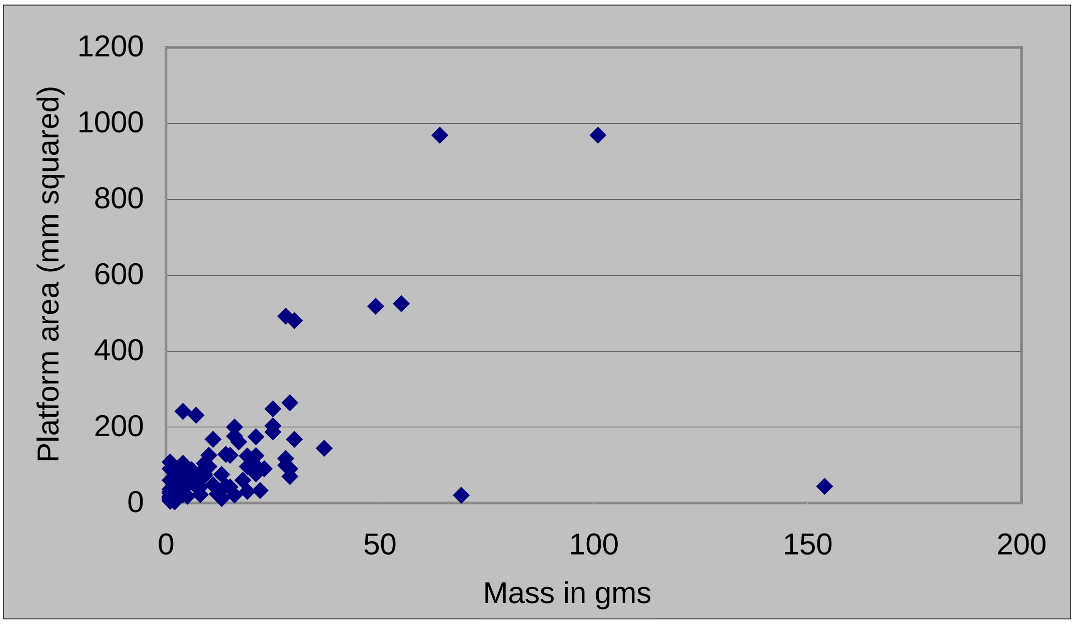


Figure 8.5. Scattergram of the relationship between platform area and mass of basalt trimming flakes (*n*111, correlation = + 0.565).

The reason for the seemingly lower correlations between mass and exterior platform variable might be the morphology of the knapping surface, which is almost exclusively the turtle backed dorsal surface of the axe blank. Pelcin's (1997c) experiments on the effects of flake morphology on flake mass suggested:

1. The relationship between platform thickness and flake mass is not influenced by core surface morphology, and

2. The relationships that exists between platform thickness and flake thickness and flake length is significant. Shott *et al*. (2000:894) proposal that platform width's influence on flake size appears limited seems to partly support Pelcin's (1997c) second argument.

Variables	**Correlation Moondarra basalt**	**Correlations on obsidian, Shott *et al.* 2000**
Platform thickness and mass (*n*115).	+ 0.464	+ 0.78
Platform width and mass (*n*115).	+ 0.458	+ 0.72
Platform area and mass (*n*111).	+ 0.565	+ 0.81

Table 8.2. Comparative analysis of correlations between multiple platform variables of basalt trimming flakes. p-value 0.05.

The argument for morphology influencing mass as presented here is based on empirical evidence and suggests that Pelcin's (1997c) initial argument is not transferable to axe trimming flakes at Moondarra. However, his second finding is essential to understanding how Aboriginal knappers obtained predictability in reducing the thickness of axe blanks.

One principal issue is to explain why the significance of platform variables to mass is lower than expected (see Figures 8.3 to 8.5). In contrast to results in Pelcin (1997c), morphology seems to be a factor as the convex shape of the turtle-back (dorsal side of the axe blank) limits the potential propagation of both the termination point of the fracture (length) and the width (margins) of the flake being struck from the core (axe). At the quarries, the dorsal side of the axe blanks are roughly trimmed into a shape resembling a turtle back and then transported to the reduction floors for the removal of finer flakes. With this shape, in most instances the curved surfaces would limit the full extension of flake length and flake width, as the edges of the curved profile would terminate the fracture earlier than would be the case on flat surfaces. In other words, depending on the degree of curvature on the surface of the core, a reduction to a certain depth is restricted in both length and width. The curved dorsal surface has to be trimmed sufficiently in order to form a symmetric profile to the ventral surface, thus balancing the weight of the implement over the intended cutting surface.

Although not related to fracture mechanics during the axe reduction process, the depth of the reduction might be more important to the knapper than mass, flake length or width. As previously mentioned, the reductive mistake that cannot be remedied is an unexpected decrease in axe thickness (caused by an unexpected increase in the thickness of the trimming flake), which can immediately render the blank to the rejected category. Rigid standards, required to meet the rigours of use, seem to have existed in relation to minimum axe thickness.

The fracturing predictability of Moondarra basalt can be examined by establishing the correlation between platform thickness and flake thickness. These variables are part of the calculations for mass. However, as morphology appears to limit potential width and length of flakes, the exclusion of these factors and a correlation test between platform thickness and flake thickness might provide higher levels of significance. This would support the notion that morphology influences flake mass.

A correlation test of platform thickness and flake thickness on Moondarra basalt trimming flakes (based on a 10% trim), between platform thickness and flake thickness returned a significant positive result of +0.79. This degree of predictability compares well with the range of +0.72 to +0.81 achieved by Shott *et al.* (2000) shown in Table 8.2. This result may be only applicable to basalt trimming flakes at Moondarra, however it demonstrates that mass may not always provide an accurate estimate of the fracturing predictability of basalt trimming flakes.

Curvature of the knapping surface on trimming flakes appears to influence both flake length and width, therefore reducing the value of mass correlations with these variables. Figure 8.6 is a scattergram of 111 basalt flakes with a 10% trim applied to reduce the effects of residuals. Some flakes in Figure 8.6 have the same dimensions for both platform thickness and flake thickness and are superimposed seemingly reducing the actual number in the scattergram.

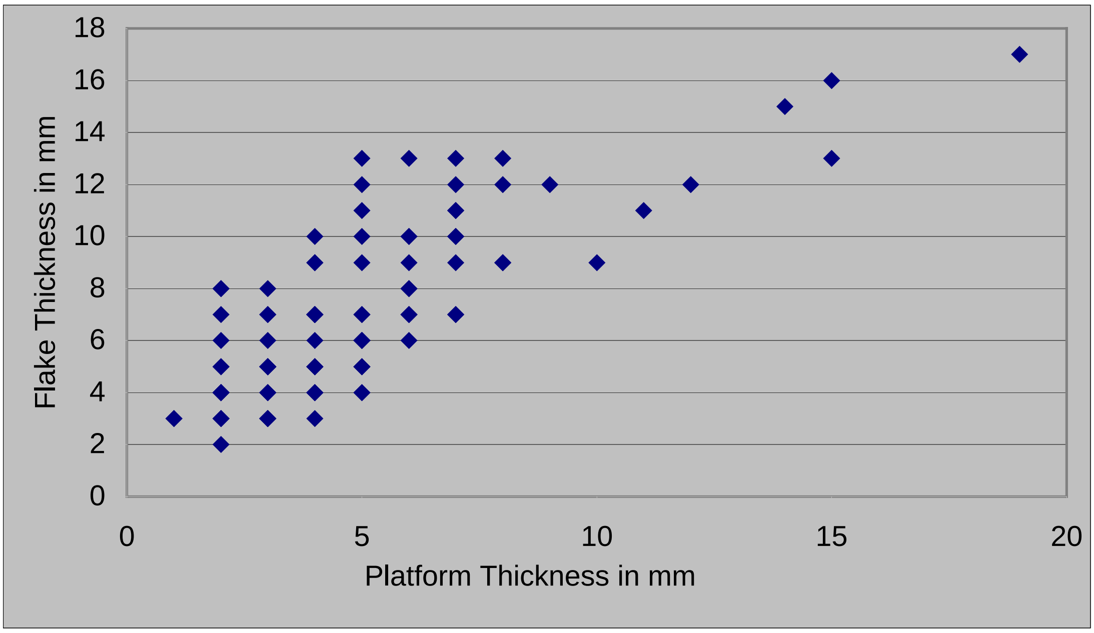


Figure 8.6. Scattergram of the relationship between platform thickness and flake thickness (*n*100, correlation = + 0.79).

8.5 **Fracture mechanics of Moondarra basalt**

The correlations between platform thickness and flake thickness suggest that knappers at Moondarra could exert substantial control over the thickness of flakes by controlling platform thickness. The descriptive data suggests that as platform thickness increases incrementally, flake thickness also increases (Figure 8.7). The correlation between platform thickness and flake thickness, based on a 10 percent trim, is +0.79. This is a very strong positive correlation and provides an insight into how knappers exerted control over flake thickness. It seems improbable that the knappers at Moondarra did not continually control flake thickness when reducing axe blanks into symmetric axe profiles.

The Moondarra correlations for platform variables are lower than the experiments by Bradbury and Carr (cited in Shott *et al*. 2000). This reduction may be partly attributed to basalt fracturing being less predictable than obsidian. Nevertheless, Moondarra correlations in these earlier tests were medium to strong (Table 8.2).

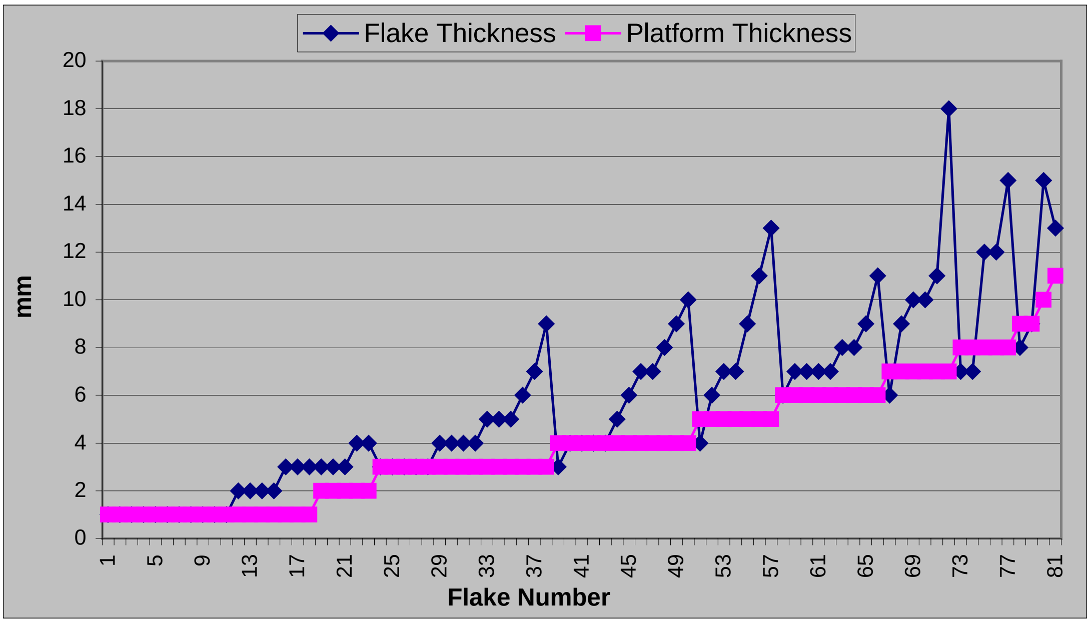


Figure 8.7. Descriptive analysis of flake thickness and platform thickness (*n*81).

It is argued that the consistently lower correlations between mass and platform variables as presented in Table 8.2 are possibly misleading and are not an accurate reflection of the predictability of basalt fractures at Moondarra. Pelcin's (1997c) experimentations on the effects of flake morphology on flake mass suggested that the relationship between platform thickness and flake mass is not influenced by core surface morphology. In addition, he suggested that the relationship between platform thickness and flake thickness on flake length is significantly influenced.

At Moondarra, when knappers reduced the thickness of the axe blank by removing trimming flakes the depth of reduction may be more important than mass, flake length or width. It appears that the predictability of Moondarra basalt fracturing mechanics can be examined by establishing the correlation between platform thickness and flake thickness. These variables are factors in establishing flake mass, however morphology appears to limit flake width and length as evidenced in the lower correlations in Table 8.3.

Table 8.3 illustrates the correlation between platform dimensions and edge angle from R3 and R4 with a 5% trim applied to eliminate the influence of outliers. This table indicates that there is a slight positive correlation between platform thickness and platform width to edge angles. A strong positive relationship exists between the platform width and thickness.

Variables	**R3 Correlations *n* 47**	**R4 Correlation (Data from R4, Table 6.18. *n* 217)**
Platform Thickness to Edge Angle	+ 0.192	-0.0498
Platform Width to Edge Angle	+ 0.011	+0.0679
Platform Width to Platform Thickness	+ 0.602	+0.6982

Table 8.3. Correlations between platform thickness, platform width and edge angles for basalt flakes excavated from R3 and R4. p-value 0.05.

The correlation tests in Table 8.3 have produced slightly different correlations, as would be expected from two separate assemblages. However, this difference is relatively minor with R3 returning a weak positive association for platform thickness to edge angle whereas, at R4 this relationship was an extremely weak negative correlation, but the degree of change is relatively minimal. This result may reveal consistency in the fracture mechanics of Moondarra basalt and could indicate how a skilled knapper acquired a significant degree of predictability during axe production. Dibble (1997) and Dibble and Whittaker (1981) suggested that edge angle and platform thickness and edge angle and platform widths are independent variables controlled by the knapper and Pelcin (1996, 1997a, 1997b, 1997c) argued that angle of blow and platform width affect the relationship between platform angle and resulting flake mass. Both of these assertions seem to be supported by the data from Moondarra.

8.6 Dates and relationships between sites and production

An estimated date of 670BP from R3 is unexpectedly recent, but is consistent with the dates obtained from R4. This date may be associated with an increasing intensity of axe production at R4, evidenced by the accelerated increase in the discard rates for basalt flakes at about 500-600 years BP. Increasing demand for exchange axes could have increased the number of reduction floors to include localities with limited water availability. With a long-term water supply, R4 is probably the oldest axe reduction floor at Moondarra as suggested by the AMS dates.

Assuming that sedimentation and erosion rates during the late-Holocene were relatively comparable, the maximum age of the cultural material recovered from Spit 8 at R4A3 is 850 b.p. (465 + 57) x (13 ÷ 8) and for Spit 4 at R4D4, 1170 years b.p. (380 + 46) x (11 ÷ 4). The maximum geomorphic date of 1,170 BP for reduction floor 4 at Moondarra establishes the timing for axe production at a major quarry in northwest Queensland.

The AMS dates obtained from R3 and MP1 were younger than those from R4. An argument to explain the difference between R4 and R3 may be that with a limited water supply R3 would be less attractive to human habitation. This limitation may not necessarily prevent synchronous knapping at both sites but the preferred argument is that this site equates to the rapid intensification of axe production that occurred at R4 at about 500-600 years BP. The AMS date of 414BP± 47 at MP1 may also be associated with increased demand for raw materials to meet an expanding exchange market.

A date of 1200 BP for the commencement of axe production at Moondarra is congruent with three different studies. First, Davidson *et al*. (1993) advanced a date of 1,000 years for an axe particle at Cuckadoo 1, approximately 200km southeast of Moondarra. Second, Hiscock’s unpublished date of 1,200BP (pers. comm.) for an axe (made from a river pebble) from the Mt Isa district. Third, Harry Allen (1997) suggested that macroblades only occurred in Kakadu in the last 1,000 years and more recently in central Australia (see also Chapter 9).

Smith’s (1993) research at Therreyererte in the Simpson Desert suggested a marked increase in the quantity of artefacts in the deposits about 500-600 years is comparable with the marked increase in both quartzite and basalt flakes at Moondarra about 500-600 years ago (Figure 7.25). Simultaneous increases in axe production at Moondarra and Therreyererte may represent changing social relations or alliance networks in the arid zones. Hiscock and Wallace (2005) support Veth's (1989) suggestion that ethnographic forms of desert economy and subsistence are relatively recent behaviour.

Despite being geographically positioned between Pleistocene dates for stone axes to the northwest and northeast, and the presence of axes on the eastern seaboard at about 5,000 years ago (Morwood and Hobbs 1995), it seems that Moondarra might not be associated with the transfer of axe technology to the east coast. A date of 1,200 years ago for stone axe production suggests that Moondarra is related to the movement of edge ground stone axes into the central arid regions of Australia at about 1,000 years ago. This supports the suggestion that ground edge axe technology entered eastern Australia via Cape York, and was thus not overtly influenced by axe technology from northwest Australia. There is a distance of approximately 700 kilometres between Moondarra and the closest stone axe quarry to the east (John Richter 2003, pers. comm.).

8.7 **Changing penetrability at R3**

The effects of trampling on subsurface artefacts at R3 must have significantly changed since the introduction of domestic cattle into the area since the 1880s. If consideration was allowed for cattle trampling to affect the subsurface artefacts down to spit two, then it may be argued that cattle trampling has increased the weight load on the surface of R3 compared with the impact of humans and native animals prior to the late nineteenth century. This increased weight load on the surface may have resulted in increasing the percentage of debitage in the upper levels of the assemblage and moved the 127BP charcoal sample deeper into the subsurface. This discrepancy may be due to changes in the rate of sediment accumulation at R3. On the other hand, a more likely explanation is changing penetrability at the site.

A suggestion for changing penetrability may be formulated to support the increased size of flakes within the basal layers in conjunction with a proportional increase of debitage in the higher spits and the 127BP date from a relatively deeper level. As mentioned in Chapter 4, stratigraphic layers are not distinguishable in this colluvial formation. Therefore the principles of superimposition cannot be applied to detect older or younger deposits.

Changing soil penetrability caused by the wet and dry seasons in this semi-arid environment may increase the effects of cattle trampling. The soil is quite compact during the dry season however, during the wet season the topsoil becomes softer. In these conditions, trampling in the upper levels of the subsurface might break artefacts. The effects of trampling are dependant on the occurrence of cultural material in the ground and the intensity of trampling (Schiffer 1996:126). Schiffer argued that these variables are not interdependent. Therefore, changes in intensity of trampling or weight loading on the surface may be archaeologically measurable by the changing percentages of debitage with variations of depth. Seasonal variation in penetrability has been documented by Deal (1985) who noted high penetrability during wet seasons and low penetrability during dry periods.

In loose substrates artefacts can be sorted by size (Behrensmeyer and Boaz 1980:80; De Boer and Lathrap 1979:133; Schiffer 1996). Stockton (1973) was able to demonstrate, in artificial experiments, that trampling in sand caused larger objects to be displaced upwards and smaller objects were pushed deeper in the substrate. Hofman’s (1986) hypothesis of flake size sorting suggested a similar result to Stockton (1973), but is based on soil expansion and contraction. The archaeological record of flake size at R3 appears contradictory with Deal’s (1985) archaeological experiment and Stockton (1973) and Hofman’s (1986) research, but the combined effect of varying penetrability due to seasonal change and the introduction of livestock to the area since the 1880s may explain this phenomenon. The absence of clay in the soil may not counter the increased weight and penetrability of heavy stock upon the wet topsoil and fracturing flakes. It appears that human and cattle trampling may be distinguishable in the archaeological record by the changing percentage of debitage to complete and broken flakes.

8.8 **Conclusion**

The absence of secondary depositional sites created by alluvial process at both reduction floors enables some degree of certainty in the archaeological interpretations. An alluvial system impacting on the reduction floors would make interpretations of changes in artefact size, density by artefact type and material type difficult or impossible to analyse.

The data from R3 suggests that for approximately 700 years this part of the site was exclusively used for knapping axes, which is perplexing in the light of discard behaviour elsewhere on R3 and at R4. This may well indicate that knapping and camping areas were discrete during habitation phases, but generally become aggregated over time as suggested by Dewar and McBride (1992).

The later dates for R3 compared to R4 may be explained by greater numbers of people visiting the complex to produce axes. This expansion may be associated with increased demand. As a consequence, some groups occupied locations where surface water was not available for extended visits. If groups were moving to different quarries in close proximity to reduction floors, then the dates obtained or the depth of cultural material at both sites might be similar.

The basal dates for R4 at 1,170 years suggests that Moondarra may not be associated with edge ground stone axe technology entering eastern Australia. If this technology was transferred via northwest Queensland it would be expected to appear earlier in the archaeological record at Moondarra when this technology is 5,000 years old on the east coast (Morwood and Hobbs 1995). The basalt quarries in northwest Queensland were essentially within the estates of the Kalkadoon people and Moondarra is the most expansive quarry in the highlands. The rocks to the north, south and east of Mt Isa are sedimentary rocks formed in an inland sea and unsuitable for axe production (see Chapter 3). Therefore, it seems doubtful that axes were produced earlier in northwest Queensland. The northwest Highlands appear to be a geological artery that stone axe technology would have to flow through to enter eastern Australia from Arnhem Land or the Kimberley Ranges where Pleistocene dates have been recorded.

The low volume of rock to soil from the excavated spits at R3 seems too low and regular to prevent changes in trampling from impacting on the vertical movement of artefacts in the upper spits. Extremely rocky soils would limit the affects of trampling. The presence of quartzite hammerstones or grindstone particles only on the surface maybe due to larger objects being less prone to trampling and being covered by colluvial formations. Recycling of larger stones from broken or worn grindstones as hammerstones, which keeps these tools in use until further reduced in size may limit the amount of larger objects being enveloped by the colluvial process.

Livestock may have compounded the effects of changing soil penetrability at R3. This hypothesis is not transferable to R4, but this does not negate the argument. Cattle watering at the nearby waterhole sometimes do traverse R4, nonetheless the impacts of cattle trampling onsite are minimal.

The idea for changing penetrability explains why larger flakes are found in the lower spit levels at R3 compared with those spits from near the surface. A change in reduction technology is not supported to explain the phenomenon of increasing artefact size with increasing excavation depth, as a decreasing proportion of debitage in relation to the larger flakes in the lower spits, appears to contradict this assumption.

Chapter 9 Interpretation of leilira blades

9.1 Introduction

The presence of leiliras at Moondarra extends the known archaeological record of these artefacts from eastern Arnhem Land into northwest Queensland. The absence of leilira blades from six habitation sites at Moondarra and other sites in Kalkadoon country may assist in defining clear boundaries between two blade types that were used as either functional or ritual/ceremonial objects. An argument is advanced here that Moondarra provides archaeological evidence to allow a distinction between these types of artefacts in northwest Queensland.

9.2 Leilira blades

The term leilira was first coined by Spencer and Gillen (1968 [1899]:652) and is currently the archaeological term used to describe large blades produced in northern and central Australia. Roth initially described these as macroblades (1897) and later he used the term lancet flakes (1904).

McCarthy described leiliras or large blades as:

> The leilira is either a long pointed blade triangular in section, or an elongate rectangular blade trapezoid in section. The striking platform is plain and high angled. The lateral margins may be trimmed, frequently at the butt end only and often up to the point. This trimming may extend to a central or lateral ridge and have some flat outer surface with a ridge on each side. The distal end is trimmed or plain point but it may be an oblique thin edge. They range in size up to 8 inches long (20cm)… The leilira is used for cutting up animals, cutting cicatrice scars, circumcision and subincision on men and introcision on women. (McCarthy 1967:32)

The presence of large blades on two quarries at Moondarra extends the known archaeological record of these artefacts several hundred kilometres due south of Lawn Hill. These large blades are an archaeological mystery in northern Australia being conspicuously absent from habitation sites near quarries or reduction floors where archaeological evidence for large-scale production is found (see Allen 1997).

In addition, this blade technology was also used to produce smaller knives and spoons in northern and central Australia (Roth 1904; Baldwin Spencer 1928), and the changing function of blades (based upon size difference) attaches some confusion to their associations with myth and ritual and discard practices (Allen 1996, 1997, Graham and Thorley 1996).

In Chapter 5, two quartzite leilira blade quarries were identified as Q23 and Q24. With debris from leilira production covering an area of 10m x 6m x 0.3m, Q23 suggests large-scale macroblade production. This blade reduction floor is within 30m of the large quartzite boulders, where the raw material was quarried. The second quarry identified in Chapter 5 as Q24 is a two kilometre long section of the northern reaches of Stone Axe Creek. This quarry differs from Q23 in that there is not a large amount of debitage, but is characterised by the presence of numerous quartzite cores and flakes up to about 15cm in length. The creek incising into the landscape has exposed large quartzite boulders. When flooding occurs after summer storms the normally dry creek-bed becomes a raging torrent, which separates and stirs debris, flakes and cores. It buries particles under gravel and transports gravel from some other places, exposing additional sources of new raw material. This dynamic state probably results in new raw materials surfacing in areas that have been previously quarried. In effect, the creek has the potential to produce unused raw material on a regular basis. Photographs of blade debris from Q23 and Q24 are shown in Plates 9.1 and 9.2 respectively. The blades from the creek show minor chipping and slightly rounded edges that are probably the result of tumbling in the stony creek bed.

Leilira blades are distinguished here from smaller quartzite flakes by their minimum length of 100mm. Maximum length for complete quartzite flakes was 83mm for the specimens found on R4 (in close proximity to Q23 and Q24). The complete absence of large leilira blades from the surface of the six reduction floors, and excavations on R2 and R4, and other major camping sites supports the suggestion for two separate tool types categorised on the basis size (specifically length). The archaeological evidence for the size of smaller blades found at habitation sites near Mt Isa seems to be supported by the observations of Paton (1994) who noted that at a leilira blade quarry the length ranged from about 90mm to 270mm in length.

Different tool types based upon function and size seems to be supported by both ethnographic observations and archaeological evidence. Roth (1904:22) noted that in northwest Queensland temporary knives were made from chert or quartzite, used in the removal of emu and kangaroo skin and then discarded after use. Knives that were bartered were used as fighting implements, but were also used for incising generally. The base of these exchanged knives had *Triodia* or *Grevillea* gum attached to assist in gripping the tool and sometimes they were lengthened with a wooden handle attached to the base. In addition, they were enclosed in *Melaleuca* sheaths with emu feathers used to protect the point.

The spearheads or leilira blades observed by Roth (1904:18) were made from quartzite or andesite and knapped almost identically to knives except that they were thicker and longer. Binford and O’Connell (1984:415) also noted that the only morphological difference between blades used for various purposes was flake size, retouching and hafting.

Allen (1997:369) has suggested that this similar morphology for spoons, knives and spearheads and fighting picks complicates the precise identification of large blade quarries. At Moondarra, Q24 comprises a mixture of both tool types (see Plate 9.1).

However, the presence of only larger sized and apparently unused tools at Q23 indicate that leilira blade production was the principle activity conducted at this site. The production of large blades on this site may be partly attributed to the available size of raw material. Some of the quartzite boulders remaining near Q23 are close to a metre high and approximately 70-80cm across.

9.3 **Distribution of large blades**

The knives noted by Roth (1904:18) had a slightly more southern provenance than spearheads. Lawn Hill was the region cited by Roth (1904:18) as the source for spearheads and he believed that the raw materials used for knives came from several sources such as Lawn Hill, the head of the Burke and Wills River (now the Burke River), the headwaters of the Georgina River and the Toko and Selwyn Ranges.

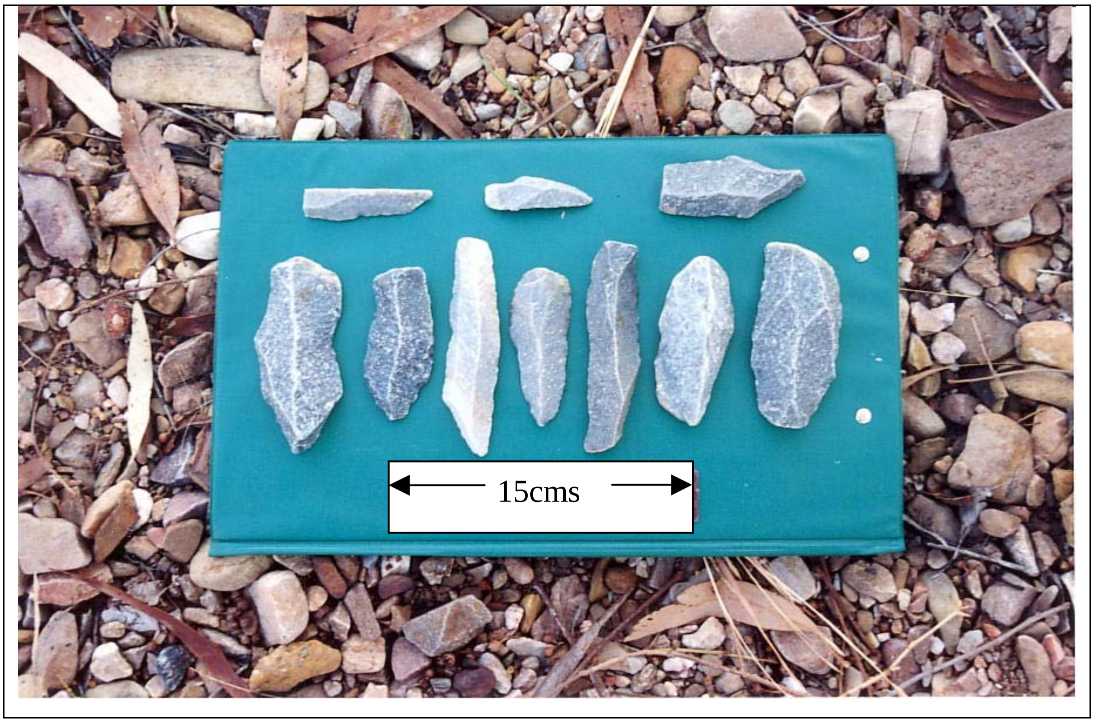


Plate 9.1. A selection of possibly rejected small and large blades from Stone Axe Creek (Q24).

Plate 9.2. Unused blades and debris from the production of leiliras on Q23.

A sketch by Davidson (1935:166) of large blades and the method of hafting in northern Australia is shown in Figure 9.1.

The presence of two large blade quarries at Moondarra extends the known archaeological distribution of this type of quarry from Arnhem Land southeast to Mount Isa. While this represents an expansion of the archaeological distribution for large blades, it does not change the known ethnographic distribution. Figure 9.2 shows Allen’s 1997 distribution map for leilira and other blade quarries and the location of Moondarra.

Roth (1904) cited Lawn Hill (approximately 250km north of Moondarra), as a source for spearheads (see Figure 9.3) and Kinhill (1994) recorded the presence of blades here. However, Allen (1997:371) argued that the small size of the blades at Colless Creek near Lawn Hill (described by Hiscock 1984:148 and Hiscock and Hughes 1980), suggests that these were not leiliras. Nonetheless, Roth’s (1904) ethnographical observations suggest that spearheads were sourced to this region.

9.4 Large blades and habitation sites

The presence of the quarries but absence of macroblades from reduction floors and other habitation sites in the Mt Isa region suggests that these implements might have been produced wholly for exchange and not intended for domestic consumption. However, Akerman (pers. comm. 2004) has suggested that the absence of large blades from Aboriginal campsites may be a consequence of reduction into smaller artefacts.

This form of rationing is thought to be unlikely at Moondarra for three reasons. First, being at the source of raw materials it seems doubtful that larger blades would have been reduced to smaller forms with an abundance of raw material available at two sites within 500m. Second, Stone Axe Creek has the potential to be replenished with suitable raw material. Third, the morphology of these smaller unretouched blades suggests that they have not been reduced from larger tools. The presence of platforms on the smaller quartzite blades showing a relatively strong correlation of

0.59 (10% trim on *n*115) between platform thickness and flake thickness suggests that these smaller, unretouched flakes have not been reduced from larger blades.

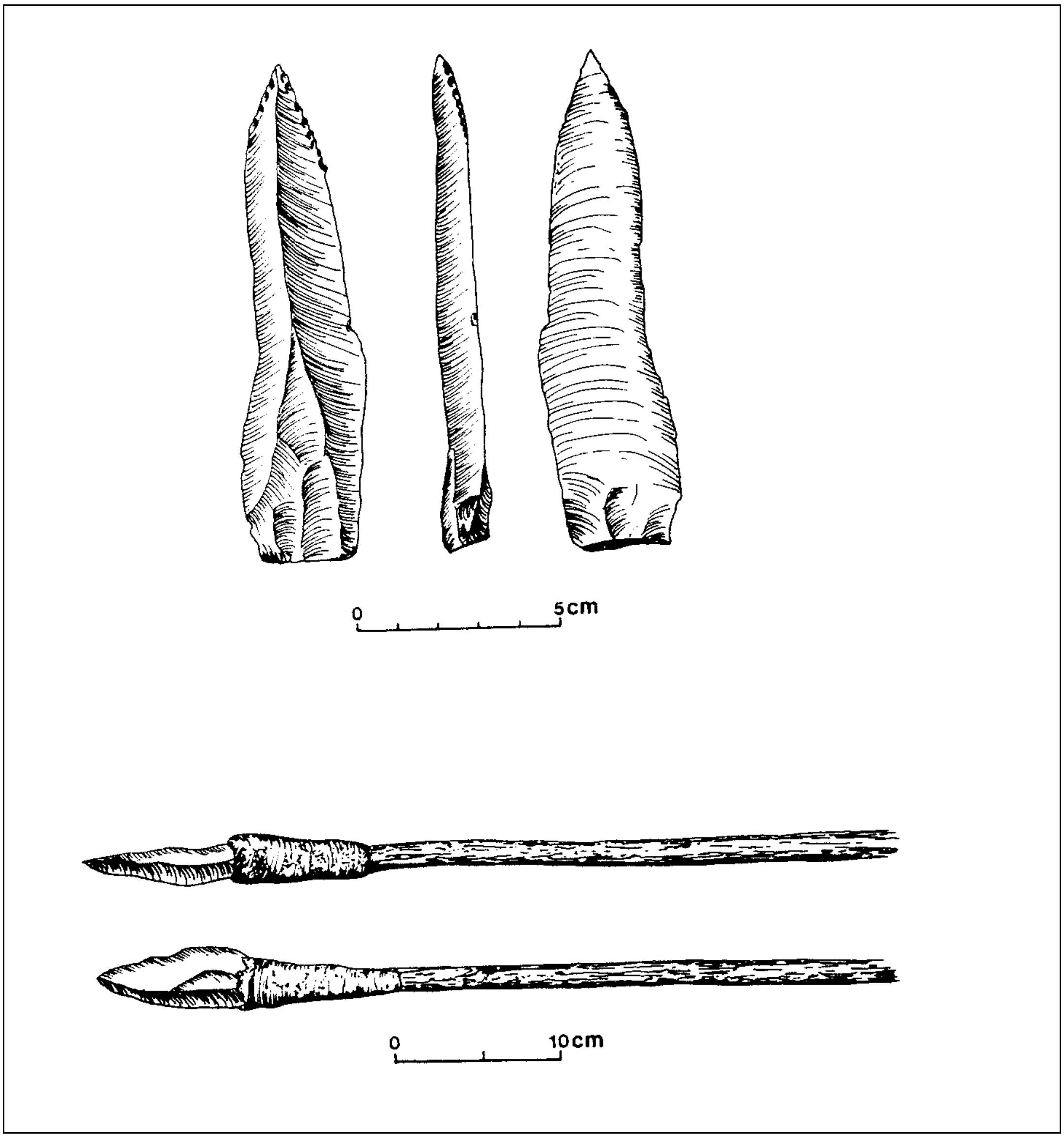


Figure 9.1. A sketch of a large blade and the method of hafting (from Davidson 1935:166).

Barton (1986), Bergman (*et al*. 1983), and Paton (1994) have all suggested that diagnostic traits such as bulbs of percussion seldom occur when flaking occurs laterally. When force is applied to these thinner flakes, snapping generally occurs as, a result of stress fracturing caused by the thinner artefacts bending on impact (Paton 1994:176).

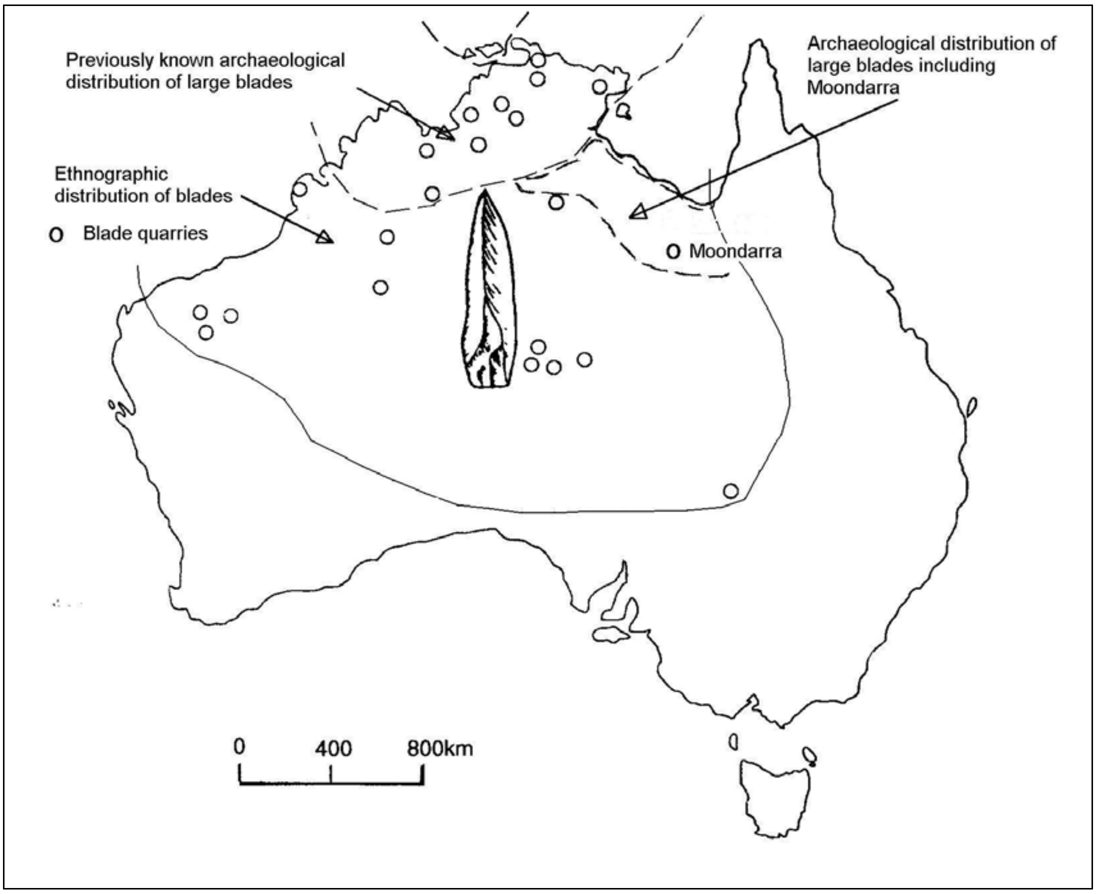


Figure 9.2. The location Moondarra and other blade quarries (after Allen 1997:368).

Paton (1994:174) suggested that this type of breakage results in squarish segments, which he recorded when surveying habitation sites in the region of known blade quarries. His observations led him to consider the proposition that the blades had been deliberately broken. This type of debris that Paton (1994) has recorded from camping sites is not found at Moondarra or on other major camping sites in the Mt Isa region.

Furthermore, the colour and grain of the smaller blades are similar to the quartzite boulders found at Stone Axe Creek (Q24), which are easily distinguished from the dark gray fine quartzite found at Q23. This implies that large blades from Q23 were not reduced to a smaller form, which is circumstantial evidence that artefacts produced from raw material sourced to Q24 was not rationed. Therefore, this type of recycling or deliberate breakage seems unconvincing in the case of large blades at Moondarra. Nevertheless, rationing is certainly a possibility when raw materials become scarce and the snapped quartzite flakes described by Paton (1994) may be an attempt to obtain smaller tools.

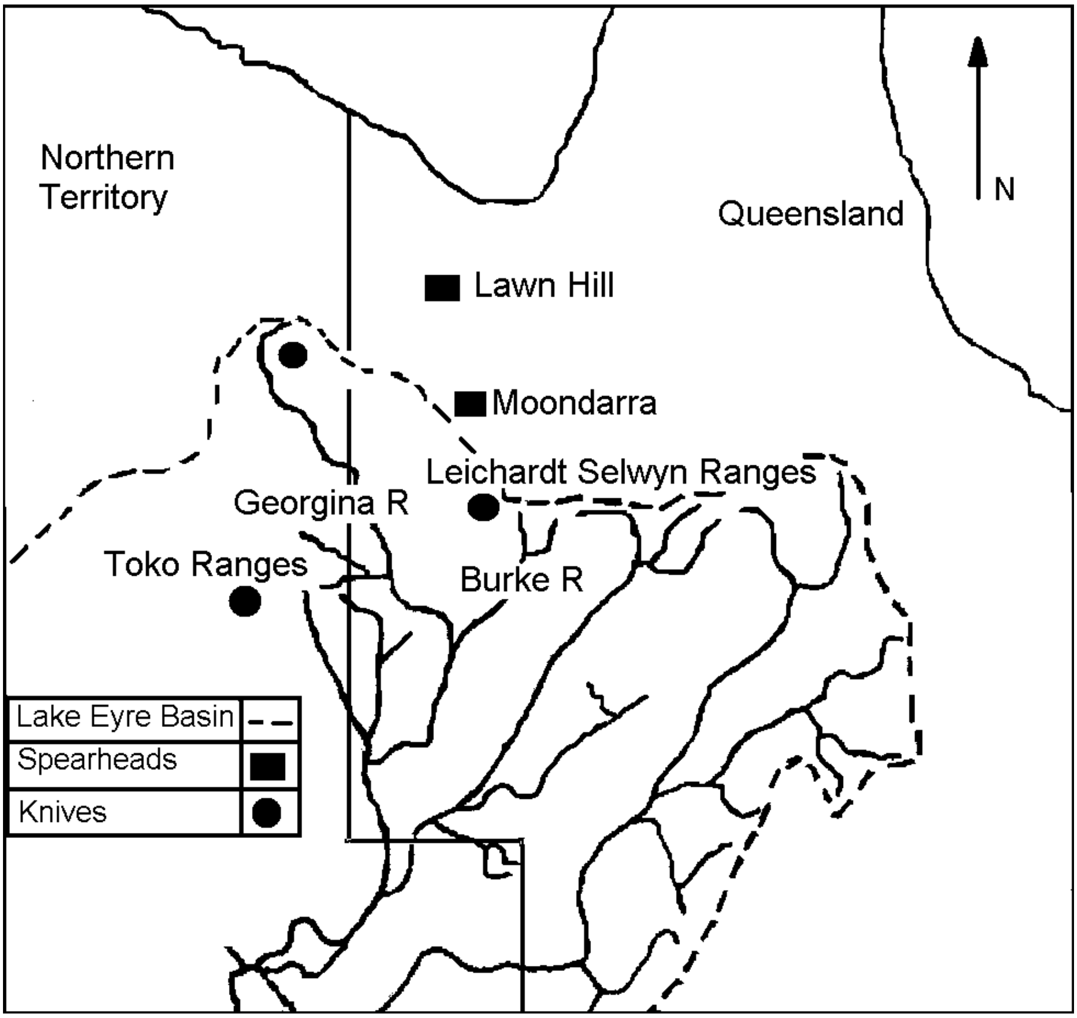


Figure 9.3. Sources for knives and spearheads mentioned by Roth 1904 and the location of Moondarra.

The paucity of large blades on archaeological sites has a different interpretation in Central Australia (see Graham and Thorley 1996). In this region leiliras are thought to have symbolic and mythological power and thus these artefacts may not be readily abandoned near habitation sites (Graham and Thorley 1996). Allen (1997:371) has also suggested that the absence of large blades from archaeological sites in central Australia might be explained by curatorial practices associated with ritual status. He hypothesised that in northern Australia the spear hafting technology possessed both ritual and secular values whereas in central Australia, these blades were not used as spearheads and they were used in ritual (such as scarification), exchange and other ceremonies (Allen 1997:370).

Graham and Thorley (1996) have observed large blades on surface sites in the James, Waterhouse and McDonnell Ranges and cited Ken Mulvaney who noted similar observations at an open site near Helen Springs. They doubted the interpretations of Paton (1994:175) and Allen (1991) who suggested that large blades produced on quarries were removed from the local area by long distance exchange networks and consequently are not found at habitation sites. Paton (1994:173-175) surveyed 15 habitation sites at varying distances from four blade quarries and noted the absence of unbroken large blades. This result is similar to the six habitation sites at Moondarra and two significant camping grounds to the north where the absence of large blades is noted.

9.5 **Dating blade technology**

Graham and Thorley (1996:75-6) argued that there are no secure dates for large blade production prior to the late-Holocene. They suggested that this technology was associated with pearl shell and Kimberly point exchange systems (Akerman 1994; McBryde 1987) which are late-Holocene additions to ceremonial exchange systems.

Allen (1997:364-5) has drawn attention to the fact that despite the excavation of 14 rockshelters in western Arnhem Land accurate dates for these large blades has not been forthcoming. Schrire (1982:151) obtained a date between 2000-4000 BP from three complete and one broken flake from Jimeri 1 site, southeast of Oenpelli. However, Allen (1997:365) has suggested that the stratigraphic context of the dates and artefacts may be the result of post-depositional mixing. Table 9.1 shows sites and dates for large blades excavated from deposits in western Arnhem Land.

By contrast, dates for large blades younger than 1000 years have been recorded from eight sites (Allen 1997:366). Despite the lack of direct evidence for dating the large blade technology at Moondarra there may be an association between these more recent dates and the commencement of axe production for exchange at Moondarra. Despite this paucity of accurate dating for large blades, smaller unifacial and bifacial points have been dated to 5,000 BP in western Arnhem Land and 4,500 BP in the western Kimberly (Allen 1989:96, Bowdler & O'Connor 1991:60, and Veitch 1991).

Researcher	**Site**	**Dates**
Kamminga & Allen 1973. Dated by Gillespie & Temple 1976.	Balawuru, Leichardt	<2200 BP
Jones & Johnson, 1985	Anbangbang	600-1400 BP

Table 9.1. Dates for large blades in western Arnhem Land.

9.6 **Conclusion**

The presence of leilira blade quarries at Moondarra extends the known archaeological region for these artefacts southeast from Arnhem Land to northwest Queensland. The complete absence of large blades from the six reduction floors and habitation sites at Moondarra is consistent with the observations of Allen (1991) and Paton (1994). Their argument, that after production these blades immediately entered long distance exchange networks is the preferred explanation for their absence from habitation sites (as opposed to quarries) at Moondarra and elsewhere in the region.

Dating this large blade technology at Moondarra is not possible without further archaeological research. Nevertheless, the eight dates from northern Australia for less than 1000 years is in line with the timing of axe production at Moondarra.

This research has provided some additional information on the archaeological distribution of blade technology in northern Australia. The measurement of all quartzite blades recorded from the excavations has provided a maximum size of 83mm for the apparently smaller blades. A distinction of tool type, based on size and inferring secular and ritual values dependant on location, will continue to be the subject of archaeological research. Previous researchers at Moondarra have concentrated on axe production. This may be explained by the fact that leilira blade production is not evident on the axe reduction floors and is only observable at the material source.

The significance of leilira blade production for exchange is that in conjunction with axe production, it reinforces the notion that a hunter-gatherer society was producing items principally for exchange. This idea suggests that Aboriginal production at Moondarra is a significant rather than an incidental activity. Specialised production for exchange rather than for subsistence seems to challenge some aspects of embedded procurement in hunter-gather societies as expressed by Binford (1977) and this issue is discussed in Chapter 11.

Chapter 10 **Estimating standardisation in axe production**

10.1 **Introduction**

The chapter examines whether standardisation in axe production was practised at Moondarra and commences with some definitions of standardisation of production, how this is measured and some factors affecting standardisation and the degrees of specialisation. Relative homogeneity is based on archaeological evidence for a general reduction sequence at Moondarra and the level of technological standardisation is based on metrical analyses for axes produced at three sources. This type of analysis is in accord with Mills (1995) who suggests that assemblages cannot be standardised in an absolute sense, but relative to other assemblages. Understanding axe production at Moondarra is the foundation for the following chapter, which reviews hunter-gatherer lithic production within the context of standardisation and specialisation in a hunter-gatherer society.

To interpret the evidence for relative homogeneity, metrical analyses of 141 axes located on the quarries and 91 axes from the reduction floors at Moondarra were undertaken to define reduction behaviour. These data sets are different to those used by Hiscock (forthcoming) however they are consistent in suggesting that regular strategies were in place at varying workstations in the axe reduction sequence. Technical standardisation is based on the examination of 255 axes produced at Moondarra, Boulia and northwest New South Wales.

10.2 **Estimating the degree of standardisation**

Technological standardisation is principally argued here by the employment of two separate methods. First, comparative analyses are made with lithic production systems by relatively few artisans from several sources. Arguments suggesting that a degree of standardisation existed in an Aboriginal production systems can be supported by comparative analyses with other lithic production systems.

The second method involved the metrical analyses of 507 axes (91 located at Moondarra) produced at three separate locations. In addition, axes produced at

Moondarra are categorized and analysed in three sections, 1. those remaining on Moondarra 2. the axes produced and used more generally in the region, and 3. those artefacts exchanged from Moondarra. This approach to analyses allows comparative analysis for the same tool from various production centres to be compared with results from numerous lithic studies (see Eerkens and Bettinger 2001, Gallagher 1977, Hiscock 2005, Longacre 1999, White and Thomas 1972, Jones and White 1988).

10.3 **Defining standardisation**

Innes (1991) suggestion of standardisation at Moondarra has been further explored by Hiscock (forthcoming) and more extensively in this thesis. In archaeology the term standardisation is applied in two different ways that can be defined as the standardisation hypothesis and a state of relative homogeneity (Rice 1991:279). The standardisation hypothesis or technological standardisation is based on the assumption that products produced by specialists have less morphological variation compared with items produced by more generalised producers. Arnold (1984, 1987), Blackman *et al*. (1993). Longacre *et al*. (1988) and others believe that the organisation of prehistoric craft production can be identified by quantifying the scale of morphological variation within prehistoric assemblages. The standardisation hypothesis has been used in lithic studies by Hiscock (forthcoming), Torrence (1986) and Vanpool and Leonard (2002) while Arnold and Nieves (1992), Longacre *et al*. (1988), Eerkens (2000), and Nelson (1987) have applied it to studies of ceramic production.

Hiscock (forthcoming) has described relative homogeneity as: '…the degree to which the manufacturing process involves well defined routines such as the regular application of particular strategies to the reduction of many stone nodules'. He also argues that uniformity between production sequences, regardless of the level of complexity, represents a standardised technology (Hiscock forthcoming).

Vanpool and Leonard (2002:5) have suggested that the terms 'standardisation' and 'relative homogeneity' have sometimes been amalgamated in the literature resulting in some confusion.

10.4 **Measuring standardisation**

Eerkens and Bettinger (2001) used the coefficient of variation (CV), which is the Standard Deviation ÷ Mean x 100, as an independent scale to indicate highly variable or highly standardised assemblages. They also used the Weber fraction for line-length estimation to describe the minimum differences humans can perceive through unaided visual inspection and argued that this method provided a robust statistical technique to compare variation between different kinds of assemblages. The Weber fraction is random data used to estimate a second constant of the CV that represents variation expected when production is random (CV= S7.7 %). These two constants (CV= 1.7 % and CV =S7.7 %) can be used to assess the degree of standardisation in artefact assemblages.

Expressed as a CV, Eerkens and Bettinger (2001) hypothesised that the minimum amount of variance attainable by humans for length measurements possible is 1.7 % and that the maximum CV possible under random conditions is 57.7 % (see also Ogle 1950:236). Eerkens and Bettinger (2001) claim that any variation above 57.7 % may represent intentional inflation of variation and may indicate production where individual producers are endeavouring to differentiate their products from others, thereby increasing variation.

According to Eerkens and Bettinger (2001), variation may reflect the degree of tolerance for deviation from a standard size, shape, form or method of production. They considered standardisation as a relative measure of the degree to which artefacts are produced to be the same. It is therefore related to the life cycles of the artefacts being studied, reflecting concerns such as production costs, consumers preference, replication and learning behaviour, numbers of producers, quality control, skill of producers, and access to resources (Eerkens and Bettinger 2001).

10.5 **Factors affecting standardisation**

Eerkens and Bettinger (2001) argued that four central issues affect standardisation in an assemblage. First, the level of variation in an assemblage may differ due to the acceptance of some margin of error when the artefact is close to the ideal. The idea here is that time and energy spent in modification is unprofitable as the imperfect artefact may be good enough (Eerkens and Bettinger 2001). Aldenderfer (1990) and Bleed (1986, 1987) have referred to this as design constraint or tolerance. On the other hand, artefacts requiring exact or a specialised task are more likely to have high design constraints during production, resulting in a lower CV compared with specialised tools (Eerkens and Bettinger 2001).

Second, production by numerous knappers may result in an increased CV as there may have been different perceptions of an ideal shape and size for a particular artefact type. Eerkens (1997, 1998) compared general site contexts for Later Mesolithic microliths, (possibly produced by numerous knappers) with 'hoard' or 'cache' finds (possibly representing an individual's production) and found that the CV for the latter was significantly less.

Third, they considered *routinisation* where large quantities of artefacts are produced over a short time-span using similar and well-remembered mental images. This is likely to result in lower CV values than artefacts produced over a longer period of time. However, higher CV's for assemblages could be also the result of grouping artefacts into one type category where the producer considered them as distinct types (two or more categories).

Finally, standardisation and design tolerance are relative to different technologies and intended artefact function (Aldenderfer 1990 and Bleed 1987). Therefore comparing technological standardisation between stone artefacts and clay pots may not be relevant as clay is easier to shape. According to Eerkens and Bettinger (2001), each technology will have an empirically derived CV to represent standardisation.

These central issues raised by Eerkens and Bettinger (2001) outline some of the human and material factors influencing standardisation, however Berg (2004) has suggested that the term standardisation might refer to a range of intentional strategies and unintentional factors. By comparing conical cup production centres at Phylakopi on Melos and Ayia Irini on Kea, Berg (2004) suggested that the Ayia Irini conical cups were produced for local consumption only and not exchanged over vast distances. She suggested that external competition was not the reason for increasing standardisation on Kea, but exposure to a more efficient technology may have amplified internal competition between different pottery producing groups at Ayia Irini. Conversely, at Phylakopi the production of clay conical cups for exchange remained variable in their dimensions. She argued that this could be due to a lack of competition, negligible or no change in the production organisation, a greater variety of functions, limited customer demand or cultural resistance against standardisation (Berg 2004).

Costin and Hagstrum (1995:622-3) noted that attributes influencing tool function that are useful in relation to specific tasks may be standardised, regardless of the organisation of production, simply due to the necessity to make functional tools. This functional effect may result in data similar to that associated with increased standardisation associated with specialisation. They maintained that the standardisation in attributes affecting specific tasks may not, therefore, be an accurate reflection of organised production. This argument is similar to Eerkens and Bettinger’s (2001) first issue affecting standardisation.

Costin and Hagstrum (1995) believed that performance and standardisation attributes should be distinguished during analyses. In their opinion, mechanical standardisation or unintentional standardisation is the result of repetitive behavior of the artisan and intentional standardisation is conscious performance that results in limited variation or standardisation. In addition, they assume that the standardisation hypothesis can be used to assess the organisation of production by using the attributes affected by mechanical standardisation, but this hypothesis should not be applied to attributes that are intentionally standardised.

VanPool and Leonard (2002) concurred with Costin and Hagstrum (1995) that a certain amount of morphological and compositional standardisation is required simply to create usable tools. They did not question the notion of intentional standardisation of attributes or that morphological and compositional standardisation is required simply to produce utilitarian tools. Nevertheless, they contend that ‘… attributes that are intentionally standardised can and frequently will become more standardised with increased specialisation’ (VanPool and Leonard 2002:4)

They assume that groups of people who seldom fabricate complex or difficult items will most likely be unable to produce a standardised product, and repetition coupled with increasing skill creates the potential for increased standardisation. VanPool and Leonard (2002) also hypothesised that specialists may focus on increasing the amount of standardisation around an *optimal value* that might result in particularly useful tools when compared to the entire range of variation that can result in useful tools. This would persuade others that their products are worth obtaining (Benco 1987, Longacre *et al*. 2000, Rice 1991:268). In other words, the range of acceptable variation in attributes influencing the usefulness of tools may be less when specialists produce tools for exchange to meet consumer demand than the range of variation when individuals produce tools for their own use (VanPool and Leonard 2002). Moreover, they cited empirical studies by Crown (1995) and Mills (1995) who convincingly applied the standardisation hypothesis to attributes such as vessel height, volume, and maximum diameter and that affect the performance characteristics of ceramics.

10.6 **Technological standardisation at Moondarra**

Hiscock (forthcoming) and Innes (1991) have suggested that a high degree of standardisation occurred in the production of stone axes at Moondarra. Hiscock (forthcoming) compared his Moondarra data with standardisation results of Eerkens and Bettinger (2001), White and Thomas (1972), White and Jones (1988), Gallagher (1977) and Torrence (1986).

Comparative analyses with similar lithic tools produced in other locations is required to establish the degree of similarity and or differences in assemblage standardisation for the same tool type produced at various production centres by different knappers (e.g. Roux's ceramic study 2003). A sample of 486 stone axes (231 axes from Moondarra, 58 axes in museum collections provenanced to Moondarra and 197 axes originating from other quarries was analysed to identify technological standardisation in axe production. This approach tests comparable technology using similar and different raw materials.

The finished form of the axes in the Moondarra production sequence show significant attempts to obtain standardisation. This is supported by the axe blanks discarded during various stages of reduction that are usually below one of the major variables of length, width and thickness. For smaller axes, weight is also an important issue as this can increase markedly with minimal increases in linear measurements. However, if the previous three variables are suitable then weight is often within acceptable limits. Conversely, for 'ceremonial' axes, weight seems to be of minimal importance.

Larger ceremonial axes are possibly heavier axes. Plate 10.1 shows a large stage two axe, which is possibly an unfinished ceremonial axe. Histograms of axes produced at Moondarra and exchanged into the Lake Eyre Basin shows that the majority of axes are below 1099gms and 160mm in length (Figures 10.1 and 10.2).

The presence of 'ceremonial' and 'utilitarian' axes complicates assessments for standardisation in production. Furthermore, the majority of utilitarian axes in the archaeological record (provenanced to Moondarra) have possibly undergone various amounts of use, thus reducing length that is the variable most prone to wear by general use and resharpening. Some of these remaining artefacts at the production site are at the lower limits of size compared with those found elsewhere. This size difference might have a limited or no relationship with the CV as this statistical method measures variation by proportion. This assemblage located at Moondarra is analysed separately to those used more generally in the Mt Isa district to detect any differences in standardisation.

Plate 10.1. Clinton Percy holding a large stage two axe.

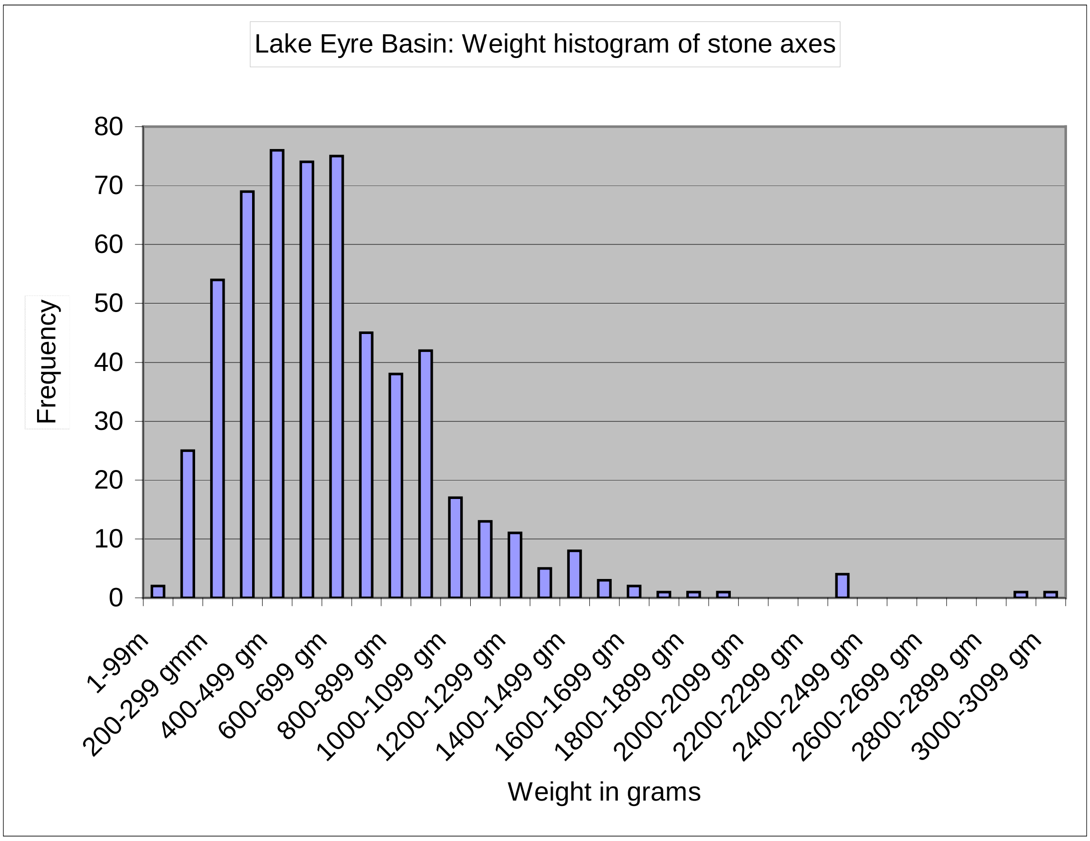


Figure 10.1. Lake Eyre Basin: Weight histogram of stone axes (from Tibbett 2000: Figure 3.3).

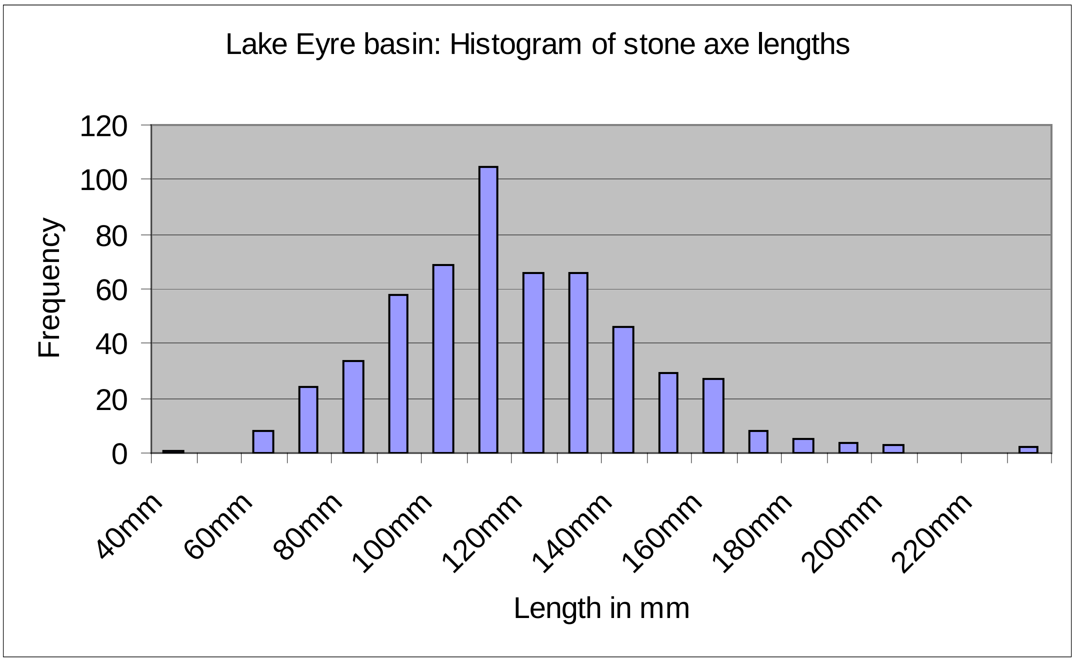


Figure 10.2. Lake Eyre Basin: Histogram of stone axe lengths (from Tibbett 2000:Figure 3.6).

To deal with issues of both wear and 'ceremonial' axes in archaeological assemblages when assessing the degree of standardisation a 10% trim is applied to all assemblages to remove outliers. The full data sets are shown in Appendix A. This approach to analysis may seem contradictory, especially when coefficient of variations is used to suggest standardisation, however it eliminates some outliers including significantly larger 'ceremonial' axes and those excessively worn by resharpening and use-wear. To ignore the presence of these could result in an inaccurate assessment of standardisation in the production process.

Ceremonial axes can be identified in museum collections (very large axes up to three kilos in weight, extensively polished and no scratches or chips to suggest their use as axes, and as large stage two axes located at Moondarra. This type of axe was probably produced in minimal numbers compared with utilitarian tools. However, they have the potential to be over-represented if they are not as prone to breakage during their use-life, thus remaining in the archaeological record for longer periods of time. Behaviourally, these larger axes may represent the ceremonial and ritual aspects of exchange and the smaller axes the utilitarian and/or economic characteristic of exchange.

The CV measurements for length, width and thickness and the mean length for axes from various quarries are presented in Tables 10.1, 10.2 and 10.3 and summarised in Table 10.4. The axes remaining on the reduction floor at Moondarra have not been worn by use-wear and larger ‘ceremonial’ axes are not present in the assemblage. Nevertheless, a 10% trim was also applied to this assemblage to achieve statistical consistency. The geographic locations of places referred to in Table 10.4 are shown in Figure 10.3.

Reduction floor axes	**Length mm**	**Width mm**	**Thickness mm**
Mean	112	110	41
Standard Error	1.58	1.811	0.81
Median	111	109	41
Mode	110	104	40
Standard Deviation	14	16	7
Sample Variance	204.43	265.76	53.79
Kurtosis	-0.762	-0.26	-0.84
Skewness	0.22	0.52	0.254
Range	57	70	28
Minimum	84	80	29
Maximum	141	150	57
Sum	9085	8896	3353
Count	81	81	81
CV	**12.75**	**14.84**	**17.73**

Table 10.1. Coefficient of variation for reduction floor axes at Moondarra.

Mt Isa axes	**Length**	**Width**	**Thickness**
Mean	125	100	34
Standard Error	5.81	4.73	1.17
Median	120.5	91	34.5
Mode	101	79	37
Standard Deviation	25	20	5
Sample Variance	609.62	402.87	24.82
Kurtosis	-0.75	0.17	-1.28
Skewness	0.57	1.08	0.13
Range	76	64	15
Minimum	92	79	28
Maximum	168	143	43
Sum	2255	1801	618
Count	18	18	18
CV	**19.7**	**20.05**	**14.5**

Table 10.2. Coefficient of variation for Mt Isa axes.

Glenormiston axes (Moondarra)	**Length mm**	**Width mm**	**Thickness mm**
Mean	134	110	36
Standard Error	3.90	2.86	1.27
Median	134	111	34
Mode	109	102	29
Standard Deviation	22	16	7
Sample Variance	502.82	270.70	53.24
Kurtosis	-0.21	0.13	-0.41
Skewness	0.39	0.24	0.58
Range	93	70	26
Minimum	96	80	26
Maximum	189	150	52
Sum	4427	3639	1201
Count	33	33	33
CV	**16.71**	**14.92**	**20**

Table 10.3. Coefficient of variation for Glenormiston axes.

The argument for standardisation in production appears to be supported by the CV (Table 10.7). The axes remaining at the reduction floors have slightly higher levels of standardisation. These axes are also smaller than axes found in the Mt Isa precinct or exchanged beyond the region. In effect, a quality control system may be in place to remove smaller axes from the exchange network.

Location	**CV Length**	**CV Width**	**CV Thickness**	**Mean Length *(mm)***	***n* *(after 10% trim)***
Moondarra, reduction floor	12.8	14.8	17.73	112.2	81
Mt Isa region	19.7	20.1	14.5	121	18
Glenormiston region	16.7	14.9	20	134.2	33
Boulia region *	14.0	12.7	15.8	107.6	79
Northwest NSW *	24.1	20.1	25.8	99.5	104

Table 10.4. Coefficient of variations for stone axes produced at various quarries. Note* Boulia and northwest NSW axes are produced at separate quarries to Moondarra.

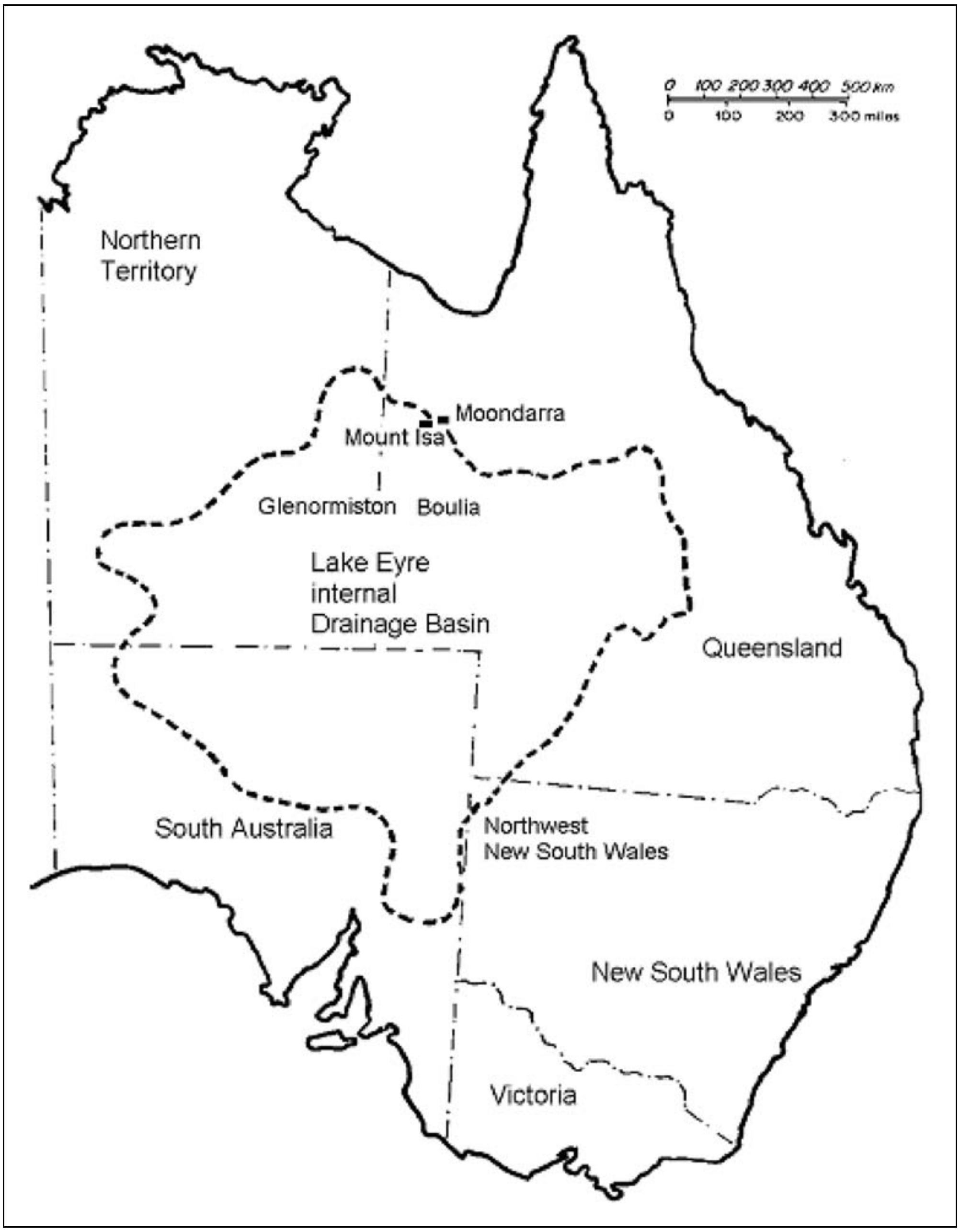


Figure 10.3. Locations mentioned in the text.

10.7 Estimating the degree of standardisation

Technological standardisation is principally argued here by the employment of two separate methods. First, comparative analyses are made with lithic production systems by relatively few artisans from several sources. Arguments suggesting that a degree of standardisation existed in an Aboriginal production systems can be supported by comparative analyses with other lithic production systems.

The second method involved the metrical analyses of 507 axes (91 located at Moondarra) produced at three separate locations. In addition, axes produced at Moondarra are categorised and analysed in three sections, 1. those remaining on Moondarra 2. the axes produced and used more generally in the region, and 3. those artefacts exchanged from Moondarra. This approach to analyses allows comparative analysis for the same tool from various production centres to be compared with results from numerous lithic studies (see Eerkens and Bettinger 2001, Gallagher 1977, Hiscock 2005, Longacre 1999, White and Thomas 1972, Jones and White 1988).

10.8 **Analysis of standardisation**

The data shown in Table 10.7 illustrates the CV for axes produced at Moondarra, but used in three localities to be compared with axes provenanced to Boulia and northwest New South Wales. Table 10.7 shows the level of standardisation of axes produced at Moondarra but: 1. left at Moondarra 2. used in the broader Mt Isa region, and 3. exchanged into the Lake Eyre Basin (Glenormiston). The categorisation of axes from three regions into five assemblages enables comparative analysis of same artefact type. In addition, lithic assemblages produced at different quarries (with both few and numerous artisans) can also be compared with this data (Eerkens 1997, 1998, Eerkens and Bettinger 1997, 2001, Gallagher 1977, Hiscock forthcoming, Longacre 1999, Torrence 1986, White and Thomas 1972, White and Jones 1988).

Machine produced tools and specialist potters working with the plasticity of clay are capable of producing items that show an extremely low CV that is probably unobtainable in lithic tool production. Nonetheless, the three axe assemblages from Moondarra possess varying degrees of standardisation that are comparable with lithic assemblages produced by a few specialist knappers (see Table 10.8).

The correlation of coefficients for axes remaining at Moondarra (Hiscock forthcoming and this study) are similar. Minor differences in variation may be explained by different samples and the application here of a 10% trim to limit the affect of any larger ceremonial axes in the assemblage. The CV for length, width and thickness for the axes remaining at Moondarra indicate that the variation within this assemblage is comparable with specialist flake production at Ngilipitji (Arnhem Land) and well below the variation expected in stone artefacts assemblages created by numerous knappers.

The axes found at Moondarra and in the Mt Isa region are considerably smaller than those exchanged to Glenormiston and have greater variation in the CV for length and width (see Table 10.5). Withholding smaller axes from the market place might serve two purposes. First, the known quality of exchange goods is ensured. Second, these otherwise utilitarian tools could be used for the producer's own requirements. This would also reduce the extent of losses in raw materials, time and effort for tools that were outside the requirements for exchange. In essence, these actions make a distinction between tools for the producers' own use and the demands of market exchange.

The degree of standardisation for Moondarra axes exchanged to Glenormiston is generally comparable with those remaining at Moondarra. However, with the Glenormiston axes have the highest CV for thickness at 20. This increased variation in thickness may be intentional, although it conflicts with VanPool and Leonard (2002) who suggest that increasing standardisation results in an *optimal value,* which is particularly useful in order to persuade others that the products are worth obtaining.

The effect of purposely increasing thickness may also achieve optimal status when the first exchange transaction may not be to the end user, and when there are different preferences for the finished form. Evidence to support this is the reduced thickness of hammer dressed axes in the southern regions of the Lake Eyre Basin (see Tibbett 2003). Tibbett (2000) argued that Glenormiston was a node of distribution for axes in the down-the-line exchange network that operated in the Lake Eyre Basin. The style of dressing on the dorsal and distal edges of axes changed from mostly grinding in northwest Queensland to principally hammer dressing in the southern regions of the Lake Eyre Basin (Tibbett 2002b). These hammer dressed axes are significantly reduced in thickness possibly to enhance resharpening (Tibbett 2003).

It is possible that the Moondarra artisans knew that slightly thicker axes were satisfactory for initial exchange connections, as these axes were potentially traded to regions further south where hammer dressing appears to reduce thickness. Hammer dressing enables the end-user to reduce thickness and consequently weight according to particular preferences.

Subsequent changes to the finished form of axes as a result of hammer dressing may result in more tolerance being acceptable in the variation of thickness compared with length and width. In effect, the slightly thicker axes produced at Moondarra were capable of meeting the requirements for a smooth ground finish or hammer dressing. By producing slightly thicker axes for a particular market, the producers at Moondarra are also catering for specialised markets.

The axes produced from numerous quarries in the Boulia district show a similar degree of standardisation as Moondarra axes (Table 10.5). However, a significant difference between these and those produced at Moondarra relates to axe size. The mean length for Boulia axes is 108mm in comparison with 134mm for the Moondarra axes exchanged to Glenormiston. The Boulia axes have been statistically determined as being different to the Glenormiston collection by a double t test (also termed the student t-test) assuming unequal variance (see Table 10.6). This statistical test was used to evaluate if two groups are significantly different according to their means. The null hypothesis of a *t-test* always proposes that the two groups do not differ significantly. The t-test found that there was a significant statistical difference in the two samples and the null hypothesis is rejected (Table 10.6).

Serial	Type of production	Class of objects	Average CV (%)	Reference
1	Specialist production	Machine produced tools	0.1	Eerkens and Bettinger 2001
		Pots, Philippines	4	Longacre 1999
2	Specialist production, possibly few artisans	Duna hafted flakes	10	White and Thomas 1972
		Ngilipitji flake production	15	White and Jones 1988 Gallagher 1977
		Ethiopian hide scrapers (used)	19	
3	Regular artefacts produced by numerous artisans	Chaco Canyon Manos	17	Eerkens and Bettinger 2001
		Mesoamerican prismatic blades	18	Torrence 1986
		English Mesolithic microliths	19	Eerkens 1997, 1998
		Great Basin points	22	Eerkens and Bettinger 1997
		Agean prismatic blades	29	Torrence 1986
4	Possibly produced by specialist knappers	Lake Moondarra (axe elongation).	12	Hiscock forthcoming. *n* 12 * elongation is calculated by dividing length by width.
		Lake Moondarra (length)	16	Hiscock forthcoming. *n*12
		Surrounding axes (axe elongation)	10	Hiscock forthcoming. *n* 69
		Surrounding areas (length)	22	Hiscock forthcoming. *n* 69
5	Produced by specialist knappers	Moondarra axes		
		Length	12.75	This study
		Width	14.84	This study
		Thickness	17.73	This study
6	Produced by specialist knappers	Mt Isa axes (Moondarra)		
		Length	19.70	This study
		Width	20.05	This study
		Thickness	14.50	This study
7	Produced by specialist knappers	Glenormiston axes (Moondarra) Length	16.71	This study
		Width	14.92	This study
		Thickness	20	This study
8	Possibly produced by numerous artisans	Boulia axes. Length	13.97	This study
		Width	12.68	This study
		Thickness	15.77	This study
9	Probably produced at various quarries by numerous artisans	Northwest New South Wales. Length	24.13	This study
		Width	20.08	This study
		Thickness	25.79	This study

Table 10.5. Comparative analysis of standardisation in different assemblages.

Serial	**Locations compared**	**Mean length (mm)**	**Variance**	**n**	**df**	**P (T<=t) two tail**
1	Boulia with Glenormiston	108.64 134.15	224.32 502.82	85 33	45	3.19862E-07

Table 10.6. A 5% trimmed two-sample t test assuming unequal variance (data from Tibbett 2003).

The standardisation of axe production at Boulia may have been influenced by a situation similar to that described by Berg (2004). She hypothesised that external competition was not the reason for increasing standardisation on Kea (late Bronze Age Aegean), but rather that exposure to a more efficient technology might have amplified internal competition between different pottery producing groups at Ayia Irini. In the present study, the Moondarra axes would have been recognizable by the Boulia groups, as they and the groups from Glenormiston and Moondarra were probably exchange partners. A distributional study as presented here cannot estimate the time scale involved. It is possible that some Moondarra and Boulia axes were produced at different times.

Axes sourced from northwest New South Wales demonstrate the lowest degree of standardisation with CV measurements of 24, 20 and 26 for length, width and thickness respectively (Table 10.5). This may be partly related to raw material type. These axes were produced from various raw materials whereas basalt is the stone used in the production of Moondarra and most Boulia axes. Raw material type and availability may have an impact on artefact size but decreased size does not necessarily impact on the degree of standardisation. For example, the Boulia axes are significantly smaller than those from Moondarra, however both assemblages have similar levels of standardisation.

The axes provenanced to northwest New South Wales were sourced to an expansive region covering eight 1:250,000 map grids. They are from numerous quarries of various stone types and were presumably produced by many knappers from many Aboriginal groups. The degree of standardisation for this collection therefore provides an excellent benchmark for comparative analysis.

The axe data in Table 10.5 enabled axe production from three regions to be compared with other case studies of lithic production. More importantly, this data indicated that axe production for specialisation or exchange might be distinguished from those produced for solely domestic purposes. Furthermore, these results suggesting specialised axe production are comparable with lithic assemblages known to have been produced by a small number of specialists.

Eerkens (1997, 1998) has supported this concept of fewer artisans producing more standardised tools by comparative analysis of English Mesolithic microliths produced by many knappers with specialised hoard assemblages possibly produced by one individual. Furthermore, the results from Moondarra suggest that a number of specialists can produce (within the constraints of lithic production) artefacts with a high degree of standardisation.

10.9 **Conclusion**

The definition proposed by Rice (1991:179) has been used here to establish the degree of standardisation in axe assemblages and relative homogeneity at Moondarra. Analyses of these different assemblage types enabled correlation of variations to be established for non-specialist production of utilitarian tools (northwest New South Wales), and for those items produced by specialists for exchange (Moondarra). The latter are also principally utilitarian but are exposed to the competitive forces of the market place (compare also the significantly smaller but similarly standardised axes from Boulia).

The correlation of variation of length, width and thickness for those axes produced by specialists for exchange is significantly less than those produced by many knappers for their own use (see Table 10.5). This supports VanPool and Leonard’s (2002) suggestion that standardisation may focus on optimal values to produce useful tools, and that attributes deliberately standardised can and frequently do become more standardised with increasing specialisation.

Eerkens and Bettinger 2001 suggest that the presence of more than one type of artefact in an assemblage, where the producer considered the artefacts as separate types may result in a higher CV. The effects of both large ceremonial and extremely worn axes in the assemblages were limited by the application of a 10% trim to limit the influence of outliers.

Relative homogeneity in the production of axes at Moondarra is strongly supported by the archaeological evidence. Two comparable reduction processes can be identified, one for the majority of utilitarian artefacts and a second for a minority, but considerably larger axes.

The examination of 486 axes from Moondarra and two other regions enabled the correlations of variation for the same tool type with two different production systems to be defined. This approach allowed comparative analysis of the degree of technological standardisation between specialist production essentially for exchange and production by numerous knappers using various raw materials to manufacture domestic tools. The empirically derived results showed significant variations in technological standardisation between the two production systems with specialist production being noticeably more standardised in form.

The CV for length, width and thickness for the axes found at Moondarra and those found elsewhere from the site (presumably exchanged) are similar to the specialist flake production at Ngilipitji and significantly lower than for assemblages produced by numerous knappers. The axes produced and used more generally in the Mt Isa district possess marginally higher variations in standardisation. Withholding axes with marginally increased variation from the exchange network may preserve the regular quality and form of exchange goods. Secondly, this type of behaviour would reduce the loss of time, energy and raw materials in the production of otherwise functional tools in situations when the knapper realises (during the production process) that the artefact is outside the margins required for exchange. In these situations, continued reduction of the axe to completion of the tool could fulfill the requirement for axes in their subsistence tool-kit.

The assemblages from Boulia and northwest New South Wales were used for comparative analysis with Moondarra axes to gauge two different issues. First, if production for exchange by fewer specialist knappers increases the degree of standardisation in an assemblage and second, was the degree of standardisation observed in the Moondarra assemblage be observed in other axe assemblages? The Boulia axes show remarkable standardisation in comparison with the axes produced at Moondarra. While, their significantly reduced size compared to axes found in the Lake Eyre Basin may suggest that these axes were not exchanged outside of the immediate region (Tibbett 2000). However standardised production at Boulia may have been an attempt to exchange axes or as Berg (2004) suggests exposure to a more efficient technology may amplify internal competition between different producing groups.

The correlation of variation is a robust tool for measuring standardisation as it calculates the standard variation as a percentage of the mean size and enables differences in these for separate assemblages to be expressed as percentages. However, in providing an accurate measurement of variation within an assemblage, variations in the mean size of assemblages can be overlooked. Therefore, in the comparative analyses of Moondarra and Boulia axes an apparent similarity in standardisation may be overshadowed by the ability of some groups of people to produce larger axes with equivalent measures of standardisation thus out competing potential exchange rivals. The attributes of larger axes may be important when the artefacts are exchanged into the Lake Eyre Basin where the sedimentary stone is unsuitable for manufacturing axes. In this arid environment, the opportunity for replacement axes may be at best an annual event depending on sufficient rainfall to allow travel and therefore exchange to occur.

The New South Wales axes are most likely utilitarian artefacts produced from a range of stone types from an expansive area by a large number of knappers. These axes have significantly increased variation compared with Moondarra axes and this result seems to partly support the hypothesis of Eerkens (1997, 1998) that fewer artisans are more likely to produce more standardised tools.

On the basis of a comparative analysis of correlations of variation in lithic production a high levels of standardisation is suggested at Moondarra. These degrees of standardisation suggest that axes were deliberately produced for exchange at Moondarra. The correlation of variation for the axes produced at the site are significantly reduced in comparison with stone axes produced from the northwest of

New South Wales and similar to those for a few specialist artisans producing lithic objects in other contexts.

Chapter 11 Community specialisation and production in northwest Queensland

11.1 Introduction

In the previous chapter it was demonstrated that a high standard of standardisation existed in axe production at Moondarra. Standardisation in production has significant implications for interpretations of hunter-gatherer risk minimisation strategies and exchange, procurement of raw materials and social behaviour. This chapter commences with an interpretation of specialisation.

On the basis of evidence presented here, a model is advanced suggesting that two types of raw material procurement operated simultaneously, in northwestern Queensland from the late Holocene. Embedded procurement for subsistence is clearly demonstrated in the hunter-gatherer tool kit at Moondarra (see Binford 1979). In addition, it is argued that a specialised procurement system for exchange also operated. It is also suggested that specialisation and standardisation were present to achieve collective or group economic benefit in obtaining both social and utilitarian items. This thesis suggests that in northwest Queensland, hunter-gatherers increased production for exchange and the quality of exchange items, and this behaviour was linked with both short and longer-term strategies. This study relates to specialised tool and drug production as a method of obtaining short-term economic and social gain, and as a long-term risk-minimization strategy to limit the effects of stress during times of severe drought.

The following section of this chapter reviews the archaeological evidence used to interpret the material culture of the Kalkadoons in the light of specialisation and emerging complexity. However, while socially progressive propositions are discussed and the inference for an emerging complex, hunter-gatherer society is rejected. This is similar to White and Pigott (1996) who argued that from 2,000 BP to 300BP an agricultural-based society in Thailand produced specialised copper items without political or social control by elites. In the light of their study and the archaeological and ethnographic evidence from Moondarra, this study proposes that community craft specialisation can exist in an egalitarian, mobile hunter-gatherers society. This tests accepted notions that the production of specialised and standardised items is an indicator of an emergent complex society.

11.2 **Degrees of specialisation**

According to Brumfiel and Earle (1987:5), specialisation is a complex notion relating to a number of dimensions of variation. These included: (1) the affiliation of either attached or independent specialists; (2) the nature of the items produced, subsistence, wealth or services; (3) the intensity of specialisation which can be part-time or full time; (4) the scale of production e.g. individual industry, household industry, village, or large scale industry, and finally (5) the volume of output per individual specialist.

Shafer and Hester (1991) used the term craft specialisation to define an individual who repeatably manufactures a craft product for exchange, and production in craft specialised communities exceeds the requirements for household use. Costin (2001:273) articulated that the idea that specialisation was related to the rise of complex societies could be traced to the studies by Childe (1981) [1956] and Service (1982:148). Earle (1987:64) has described specialisation as the essence of a complex society.

Earl and Brumfiel (1987) viewed the distinction between independent and attached specialists as being that independent specialists produce goods and services for an unspecified demand that varies according to economic, social and political conditions. On the other hand, attached specialists produce goods or provide services for a patron, typically either a social elite or a governing institution.

11.3 **Risk and technology**

This examination of risk and technology is founded on the argument that hunter-gatherers in northwest Queensland produced standardised axes for exchange to areas where suitable raw material for these was unavailable. Technological standardisation linked to axes of significantly larger size (than Boulia) is seen as a method of producing desired goods thereby maintaining and perhaps increasing the number of exchange partners. Competition between different sub-groups of the one language group and the archaeological evidence for similarly standardised but significantly smaller basalt axes in the Boulia region is possibly the result of competition between different groups to protect and maintain market share at the inter-group level. At numerous quarries in northwest Queensland there is an abundance of quality raw material suitable for axe production, as previously noted for the basalt quarries near Gunpowder.

It is argued that a ceremonial explanation for exchange (Stanner 1933-34, Thompson 1949) might not require the necessity for a standardised item. Ceremonial exchange that subsumes economics in comparison to social obligations may not require notions of an idealistic tool form.

This proposition involves significant elements of Torrence’s (1983, 1989) studies involving technology and risk but varies in that tool production essentially for exchange may comprise two elements. First, production for exchange may fulfil the requirements for utilitarian items and ritual ceremonial goods such as pituri. Second, this type of exchange may impart a method of delayed return in the form of a risk minimization strategy by the establishment of a social network, which may be called upon in times of food resource scarcity (after Gould 1980, Gould and Saggers 1985). Kalkadoon country is a semi arid region with unpredictable rainfall that cause frequent, extended periods of drought (Chapter 2).

Invisible returns was another concept used to explain future expectations from the exchange of material items (Altman 1982). Inherent in both of these explanations is the notion of delayed return. Technology is applied to provide future gain, one comparatively short-term, at the point of material exchange and the second delayed until required. This technological solution to risk minimisation associates material items directly with group survival.

Hiscock (1994:276) has argued that the benefits of risk reduction strategies may only occasionally be realised, however they are permanently in place. The economic aspects of axe exchange may be realised at the point of exchange, however the social aspects must be maintained to counter potential risks to group survival.

Despite the emphasis on standardised axe production at Moondarra, it is acknowledged that in Aboriginal exchange systems both economic and ceremonial relationships are most likely inexplicitly entwined. Ethnographic observations of inter-group reciprocity and associated obligations to return gifts are forms of social networking. In these instances, the social aspects of exchange may become a form of banking for times of need. However, when drought occurs the social relationships developed may be called upon to ensure group survival, by enabling a group of people whose lands are famine stricken, access to the lands of their exchange partners. Gould (1991) in Western Desert, Australia, has noted that strategy switching involving changing group structure, high mobility and a detailed knowledge of resource distribution as methods of risk minimization. Gould's (1991) strategies refer to social rather than technological responses to risk minimization. Nonetheless, they support the argument presented here, in that they make explicit the long-term planning strategies involved in Aboriginal risk-minimization strategies in these arid zones.

Hiscock (1994:273) has argued that new toolkits comprising points, backed blades, and tulas reduced risks in the mid-Holocene. He viewed these artefacts as a technological response to organizational difficulties imposed by a particular system of settlement and mobility, and that this new toolkit was created in response to scheduling uncertainty (Hiscock 1994). This explanation of a risk minimization strategy involves the subsistence tool kit whereas it is suggested here that the people at Moondarra used exchange to achieve a similar outcome.

It is argued that tool production for exchange occurred at certain times of the year for economic and delayed returns in addition to continual embedded procurement for subsistence tools associated with obtaining food resources in the immediate and/or short term return. In this scenario, survival or social replication is viewed as operating at two levels. First, on home estates when group survival is not threatened, and second on the lands of their exchange partners to access food resources when the group is vulnerable.

The archaeological evidence for standardisation from Moondarra may well suggest that this group applied technological advantage most likely achieved through group solidity and organisation to achieve both economic profits and potential delayed returns. This delayed return may take months or years to materialize. The marginal and unpredictable environment of northwest Queensland may require a continuing risk minimization strategy to counter extreme threats to group survival as documented by Gould (1980, 1991) and Gould and Saggers (1985) in the drought-prone environment of the Central Desert.

High-risk low probability strategies involving tool production in hunter-gatherer societies may not align precisely with Torrence's (1989) idea of shorter-term results contained in her optimisation theory. The strategies presented here are viewed as inter-group delayed returns over months or years related to complex planning and implementation, not immediate or forecasted intra-group subsistence activities.

11.4 **Exchange in hunter-gatherer societies**

In the production of stone axes, raw materials, curation and time stress are in an ambiguous relationship in the light of debates on these subjects (Andrefsky 1994, Bamforth 1986, Bleed 1991, Binford 1979, Torrence 1983, Wiessner 1982). Most theoretical and ethnographic studies presuppose that specialised production for exchange is not associated with mobile hunter-gatherer societies. The principle of exchange where one group purposely fabricates standardised items on a considerable scale to trade with people from outside of their immediate social group does not conform with contemporary theories of mobile hunter-gatherer exchange**.**

The proposition of specialisation combined with standardisation in egalitarian, mobile hunter-gatherer communities has not been previously examined. White and Pigott (1996:169) argue that in even in agricultural societies *'The implication of a strong economic basis in community-based specialisation as characterizing a pre-state economy has not yet been addressed in theories of the development of social complexity'*. Complex hunter-gatherer societies like the Northwest Coast Indians and Californian groups produced standardised materials in the context of 'prestige' items (including lithics), but these are hierarchical societies.

Essentially, specialisation at Moondarra arises due to the sheer abundance of raw material at Moondarra (and at least another major site in northwest Queensland) and its complete absence from the areas to which these axes were traded, such as the Gulf of Carpentaria, the west of Cape York and the Lake Eyre Basin. This uneven distribution of raw material combined with a high demand for suitable artefacts has implications for the relationship between raw material availability, curation and time stress in a hunter-gatherer society. Most of these tools produced at Moondarra were not utilised by the producers but passed through down-the-line exchange (McCarthy 1939) to regions up to 1,200km from the source.

In the case of Moondarra, the principles of raw material availability, curation and time stress cannot be perceived as factors operating within one social group for immediate or longer term needs. However, this closed circuit approach to tools seems to be inferred in most anthropological and archaeological studies. Once a hunter-gatherer group commences to exchange items on a significant and regular basis, external social influences are implicated in group behaviour. Unavoidably, external factors begin to influence internal social behaviour to meet these additional requirements thus changing hunter-gatherer behaviour towards obtaining raw material, curation and time stress, and subsequently tool production strategies.

Exchange and reciprocity may possibly infer curated production. However, interpretations of tool production in hunter-gatherer societies that only envisage artefacts as a means of subsistence and tool maintenance may limit the range of behaviour associated with hunter-gatherer tool production, as suggested by the data from Moondarra.

11.5 **Embeddedness and specialised procurement**

It is proposed that a dual procurement system operated simultaneously in Kalkadoon society and perhaps in other Aboriginal language groups in northwest Queensland at the time of contact with settlers. These are an embedded system used in the procurement of the subsistence tool-kit and specialised procurement for exchange.

The term embeddedness as applied by Binford (1979) could incorporate specialised procurement of subsistence items for exchange. However, to expand the meaning of embeddedness to include or exclude the production of specialised and/or subsistence tools for exchange might underestimate the full spectrum of Australian hunter-gatherer social behaviour relating to material culture. Binford (1979:259) explained embedded and direct raw material procurement strategies in the following way:

> Raw materials used in the manufacture of implements are normally obtained incidentally to the execution of basic subsistence tasks. Put another way, procurement of raw materials is embedded in basic subsistence schedules. *Very rarely, and then when things have gone wrong, does one go out into the environment for the express and exclusive purpose of obtaining raw materials for tools.*

There are ethnographic cases where parties of mobile hunter gatherers set out on trips from a central camp or temporary base to procure special goods and materials (Gould 1977:164, Gould and Saggers 1985:121) and this method of procurement does not fit Binford's (1979) 'logistical' model. However, Binford (1979) made the valid point that these items may be hard to detect archaeologically. The problem here is that Binford's (1979:259) proposition cannot be detected archaeologically and remains an assertion rather than an empirical fact.

Archaeological evidence of embedded procurement can be seen on some reduction floors at Moondarra in the variability of raw material used in the subsistence tool kit. Quartzite and quartz that represent the majority of non-axe producing raw materials at Moondarra are locally available. Chert is a foreign raw material and comprises a minimal percentage of the assemblage however, importation of this material might still be embedded procurement.

The presence of a relatively small andesite axe quarry near Lagoon Creek about 20km southwest from Moondarra may represent embedded behaviour in reprovisioning axes. The location of this axe quarry, relatively close to Moondarra suggests that axes were obtained on an as required basis when suitable raw material was available. The relatively small volume of debris at the site compared with Moondarra suggests a small-scale production centre and the absence of andesite axes provenanced to the Lake Eyre Basin (in museum collections) support this view. The presence of foreign axes at Moondarra supports an argument for embedded procurement (Chapter 6).

Some archaeologists who have studied hunter-gatherer procurement behaviour (Bergsvik 2002, Gould 1978:288, Gould and Saggers 1985, Hiscock 1989, Innes 1991, McBryde 1997:605**,** Simmons 1991**,** and Wiessner 1982) have questioned this approach to the embedded nature of raw material procurement. The central issue of disagreement has been the restrictive use of the term embeddedness to the subsistence tool kit and exclusion of the maintenance tool kit.

Gould (1978:288) documented the presence of inferior exotic chert at Puntujarpa rock shelter when superior quality chert was available in the nearby area. He considered that the effort to obtain these foreign cherts represented an extraordinary effort, and that some other factors may have influenced their acquisition. Binford (1979:261) dismissed Gould’s (1978) inference that some other factors were influencing procurement, proposing that these exotic cherts may simply be a result of wide ranging mobility.

Under Binford’s (1979) definition of embeddedness, the archaeological evidence for the exotic chert may represent tool procurement behaviour not directly associated with subsistence (extractive tool) as both the exotic and local chert was used for adzes, which are maintenance tools (Gould 1985). In rejecting Gould’s (1978) interpretation for exotic chert at Puntujarpa rock shelter on the grounds of extended group mobility, Binford (1979) is also refuting the possibility for a group’s external social relationships influencing the composition of their subsistence tool-kit.

In 1979, Gould emphasised the importance of distinguishing between stone materials procured from sources of useable material at definite quarries that were re-visited, and raw material gathered at or near a location on an ‘as required’ basis. The latter sources are non-localised and may only be visited once (Gould 1979:163). He noted that most quarry sites in the Central Desert region are not named unless they have specific mythological associations and/or a water source nearby. On the other hand, most generalised surface material is unnamed but can be re-located by reference to nearby landmarks.

Different types of procurement behaviour were observed at quarry sources compared with generalised sites (Gould 1979:164). At the quarries, cores were taken away and subsequently trimmed into tools for specific use, while at the general non-quarry sites, material was used for immediate tasks to hand. Gould observed that procurement activities were combined with other activities such as hunting and visits to sacred sites. Later, Gould and Saggers (1985) de-emphasised the importance of visiting sacred places during journeys to gather suitable lithics when discussing the ‘exotic chert hypothesis’. These observations of Gould (1979) even though differentiating between embedded and direct procurement strategies clearly align with Binford’s description of varying situational strategies used in obtaining raw materials which states that ‘Raw materials used in the manufacture of implements are normally obtained incidentally to the execution of subsistence tasks’ (Binford 1979:289).

Simmons (1991) argued that the application of the terms ‘embeddedness’, inadequately explained the archaeology of the quarry. He states that:

> The Mt Isa quarry shows a forager societies [sic] which travels directly to a quarry for the express purpose of making axes for trade. The embeddedness discussion highlights some of the short comings to be found with Binford’s attempts to develop universal laws of discard. They have in this study proved to be unsuccessful. (Simmons 1991:115)

Simmons (1991) has correctly identified the theme of direct procurement for exchange but as noted by Gould and Saggers (1985), if axes were considered as exclusively maintenance tools rather than extractive implements, then Binford’s (1979) embedded procurement argument is untested. It is suggested that these artefacts were used in both subsistence and maintenance tasks. Mulvaney (1975) has suggested that axes were used in woodworking, and Smyth (1878) articulated the value of axes in maintaining Aboriginal subsistence activities as such:

> The tomahawk… is one of the most useful implements possessed by the Aborigines. A man never leaves his encampment without his hatchet… Its

> uses are so many and so various that one cannot enumerate them. It is sufficient to say that a native could scarcely maintain existence in Australia if deprived of this implement. (Smyth 1878:**I** 379)

Innes (1991) cited the Ngilipitji spearhead quarry in Arnhem Land as an example that challenged Binford's claim for embeddedness. Thompson (1949) and Jones and White's (1988) ethnography demonstrated the production of artefacts for own use and exchange, which are directly related to food gathering activities.

Hiscock (1989:311) has argued that insofar as they were independent variables, stone-working technology in the Lawn Hill region was not embedded in food procurement strategies. He believed that the abundant food resources in the immediate region during the Holocene resulted in the economic, social and stone working activities being independent variables to subsistence, and that the archaeological debris indicated that stone working was a direct reflection of the economics of procurement and not an indirect reflection of scheduling or food procurement (Hiscock 1989:312). To support the leisurely nature of food gathering in hunter-gatherer societies he cited the studies of Lee (1975), McCarthy and McArthur (1960) and Sahlins (1975).

The common theme in Hiscock (1989), Innes (1991) and Simmon's (1991) critique of Binford (1979) is the concept that raw material procurement can be separated from subsistence activities. While this viewpoint is acceptable, it is suggested that grounds for challenging Binford's argument can be seen in terms of the social consequences of these technological actions.

The challenges to embeddedness by Bergsvik (2002) and McBryde (1997) referred to social factors as being connected to lithic materials. In explaining hunter-gatherer long-distance exchange systems, McBryde (1997:605) raised the question of procurement of raw materials for artefact production. She acknowledged that in normal circumstances procurement would be embedded in daily subsistence activities (1997:605). She argued that the symbolic values of the items involved are vital determinants of their distribution (1997:605). In expressing this argument differently, she proposed that the exchange system was not embedded in the economic or subsistence regimes of the societies concerned, but in their social and ceremonial life in which these material goods and exchange play substantial roles.

The interpretation of long-distance exchange as advanced by McBryde (1997) clearly recognized social factors as influencing raw material procurement behaviour among hunter-gatherers. The types of material goods exchanged also challenges Binford's connection between extraction and subsistence. Some of the items exchanged in northwest Queensland were subsequently used by the end-user in the exchange network as extractive tools in gathering food resources. Roth observed (1897:232) boomerangs, hook-boomerangs, wommeras, short wommera-spears and long spears being exchanged at markets in northwest Queensland. The production for exchange of extractive tools normally used in subsistence activities is fertile ground for testing Binford's (1979) embedded argument.

Gould and Saggers (1985) focused upon the comparative technological qualities of both exotic and local chert to argue for an inferior quality of the imported useable stone, but they also suggested that social factors were involved in procurement behaviour. In evaluating Binford's concept of embeddedness, Gould and Saggers (1985:117) applied a technological approach by conducting field surveys and experimental tests on lithic materials from sites in central Australia. Their experimental results demonstrated that the local cherts had superior edge-holding attributes when compared with the exotic chert. In other words, people were going to considerable efforts to obtain raw materials with inferior mechanical properties in a situation where superior quality chert was available nearby (Gould and Saggers 1985:120).

Gould and Saggers (1985) essentially agreed with Binford's view that raw material procurement by mobile hunter-gatherers occurred incidentally in relation to subsistence activities. However, they suggested that Binford's argument could not account for the patterning of raw material procurement based on the utilitarian qualities of various types of chert (Gould and Saggers 1985:117). They considered the presence of exotic chert at the Puntujarpa rock shelter as evidence of long-distance social networks to overcome or mitigate stress imposed by droughts (Gould and Saggers 1985:118). The presence of exotic chert up to 400km from its source was considered by them to be congruent with a risk-minimisation strategy of hunter-gatherer adaptation that depended on long-distance networks in drought-prone localities where temporary abandonment of the home estates may be necessary

(Gould and Saggers 1985: 118). They perceived these expansive social networks as a kind of 'envelope' of social space that expanded according to the degree of stress imposed by the severity of drought (Gould and Saggers 1985:122).

Gould and Saggers (1985:122) technological analysis indicated that lithic procurement occurred in both day-to-day foraging and resource activities, and in relation to special long-distance social trips. However, they agreed that:

> One cannot distinguish archaeologically between either special purpose lithic resource procurement or long-distance transport and/or exchange of lithic materials, on one hand, and the distribution of lithic materials in the context of the normal range of foraging by highly mobile Australian hunter-gatherers, on the other hand.

The fundamental point of disagreement between them and Binford (1979) in relation to his concept of embeddedness, was Binford's dismissal of lithic procurement and technological factors of tool use and manufacture in accounting for the relative occurrence of these materials. They argued that one cannot assume embeddedness of the lithic technology solely in relation to the subsistence economy, as Binford expressed, even though, in the Puntujarpa case, this is a logically parsimonious argument. They believed that Binford had overstated his position on embeddedness to the point where parsimony approached reductionism and argued for a more inclusive concept of embeddedness based on Binford's earlier (1962) arguments inferring various levels of integration within extinct cultural systems (Gould and Saggers 1985:117).

It is argued that the insertion of maintenance items to Binford's (1979) concept would include all types of procurement behaviour within the notion of embeddedness. However, this expanded interpretation is too general and does not distinguish between two different types of procurement, which Gould and Saggers (1985) were attempting to categorize.

Binford's (1979) embedded concept may not provide a universal explanation for all types of procurement, however it is widely accepted within the studies of subsistence behaviour. Arguments challenging the notion of embeddedness as being 'limiting' or 'too inclusive' or 'restrictive' have concentrated on the role of maintenance tools. The insurmountable issue in these instances is the absence of a definition that is transferable between subsistence and maintenance tools.

Moreover, the embedded subsistence argument of Binford (1979) cannot effectively explain the production of subsistence and maintenance items for exchange, particularly where items were produced with the ‘intent’ of exchange and not the exchange of personal equipment or tools at meeting places. Intentionally produced items for exchange might also include social goods such as pituri, ochre, shells, and ritual objects.

A dual procurement model that incorporates Binford’s (1979) argument for embedded behaviour and identifies external social factors is required to identify different procurement systems. This solution does not remedy the problems associated with maintenance tools, but if maintenance tools were specifically produced for exchange, this would also be considered as specialised procurement.

This second procurement system is founded on technological actions resulting from external social relations. For example, at Moondarra the evidence for standardisation in production strongly suggests that external social issues have influenced the procurement system. The items produced were subsequently exchanged to people outside the producing group.

Specialised procurement in a hunter-gatherer society may or may not be directly associated with specialised production. It is argued that the archaeological evidence for raw material procurement at Moondarra suggested that two procurement systems have operated simultaneously in northwest Queensland hunter-gatherer societies since the late Holocene.

Although, scale of economy does not automatically suggest labour specialisation, there are several issues that imply a dual procurement system. Factors supporting a theory of specialised production for exchange are: archaeological evidence for specialisation and standardisation, volume of production, scale of the quarry and reduction areas, the regions they were distributed to and the number of axes attributed to Moondarra.

11.6 Craft specialisation and complexity

The arguments for the existence of craft specialisation and standardisation in production at Moondarra could be misconstrued to suggest the presence of an emergent complexity in a hunter-gatherer society during the late Holocene. This argument is not supported here. Nonetheless, it is argued that in an egalitarian hunter-gatherer society, independent part-time specialists can produce a standardised utilitarian item. Costin (1991) holds that the production of utilitarian items appears more consistent with independent rather than attached specialists.

The case study of exchange in the Trobriands (Malinowski 1922) was cited by Brumfiel and Earle (1987:4) as an example where inter-regional exchange on an impressive scale occurred with no corresponding complexity in social structure. They argued that 'just as is no single relationship between food production and social complexity there is no single relationship between specialisation, exchange and social complexity'. Furthermore, they postulated that meaningful statements about these three terms can only be made if the variables covered by these terms are explicitly recognised and taken as the unit of study (1987:4).

Service (1962:148) described the relationship between specialisation and chiefdoms, stating that:

> One of the most striking things about the evolution of culture is the rapid improvement in the products of craft specialisation at the point of the rise of chiefdoms.

The relationship between the emergence of powerful elites and craft specialisation was examined by Peregrine (1991). He suggested that this relationship was connected to strategies that elites use to maintain or increase political authority. In explaining this approach, he argued that elites often increase the labour and technological sophistication required to produce certain items in order to readily control access to these products (Peregrine 1991:8).

This argument cannot effectively explain the production of axes at Moondarra. Raw materials suitable for axe production are scattered throughout northwest Queensland

and axes were produced at other smaller quarries. In this situation, elites would have been hampered by two factors: the technological ability of others and the availability of raw materials at other quarries which enabled the production of functional tools.

The argument for independent specialists producing the axes at Moondarra conforms with ethnographic observations from the region recorded just two decades after contact with settlers. In the late nineteenth century, the type of hunter-gatherer social organisation in northwest Queensland is best described as egalitarian, although Roth (1897) did not actually use this term when he described Aboriginal social systems. He documented the process in which individuals progressed through several phases to increase their social status and the operation of a similar social system elsewhere in Queensland (Roth 1897: 65-66). In an egalitarian society, the division of labour and status is based on age, sex, personal attributes, with dominance and status being mostly negotiable and contextual (Seymour-Smith 1986:268).

The advantages of independent specialisation are potentially great and can be expected when natural resources are unevenly distributed, when production requires acquired skills or significant economies of scale (Brumfiel and Earle 1987:5). The complete absence of raw materials suitable for axe production in the Lake Eyre Basin, the Gulf of Carpentaria and the west of Cape York exemplify the uneven distribution of resources. Specialised production of these items can be inferred from their relatively high degree of standardisation. Economy of scale cannot be effectively demonstrated, but the sheer volume of northwest Queensland axes that were exchanged into the Lake Eyre Basin may allow us to assume that a higher level or scale of production was in operation to gain a competitive advantage.

A second potential source of axes entering the Lake Eyre Basin was from the northwest of New South Wales. McBryde (1997:604) noted that the Aboriginals from the Flinders Ranges and from Cooper Creek spoke of the ‘green axes’ coming from the north and that they also mentioned axes coming from the southeast (northwest New South Wales). She suggested that lithic material from the southeast is not represented in the archaeological assemblages of these two regions. This suggestion is supported by comparative statistical and geological evidence, which has demonstrated significant differences in morphology and raw material types between axes from the Lake Eyre Basin and northwest New South Wales (Tibbett 2000).

Part time specialisation is argued to occur when fluctuations in supply and demand exist (Brumfiel 1986). The degree of specialisation is adjusted by the stability of exchange institutions with full-time specialisation only functioning in an environment of large aggregate demand and stable exchange mechanisms, to provide subsistence for the specialist producers (Brumfiel and Earl 1987:5).

Part-time specialisation in axe production at Moondarra is possibly due to fluxes in food resource availability at both the axe-producing region and at the exchange locations. The provision of long-term food resources to the artisans in this semi-arid environment is highly unlikely. Roth (1897) observed markets near rivers and large waterholes on the borders of Kalkadoon country. Riverine environments could sustain larger gatherings of people for a limited time, which is certainly linked to the size of the group and the quantity of food resources available. According to Watson (1983:44), along the Mulligan River which is about 200-300kms to the south of Moondarra pulses in the level of exchange between various groups was directly connected to the association between floods and an abundance of food. During times of severe drought, large gatherings of people at these traditional meeting places would have been severely restricted. By necessity, the scale of production was varied with fluctuations in production related to rises and falls in annual rainfall associated with changing food resource availability.

It is advanced that the level of organisation at the axe quarries was conducted at the family level and that numerous such like groups operated on Moondarra and perhaps other significant quarries in the region. The principle archaeological evidence supporting this argument for family-orientated production is the marked differences in the types of raw materials used in the subsistence tool kits on reduction floors and/or habitation sites. These are not related to the proximity of raw materials, but rather imply that restrictions of access were in place in relation to various parts of the quarry complex.

Ethnographic observations of Smyth (1878) for the existence of controlled access to major sources of raw material support the interpretations presented here. It may well be that several groups owned and controlled access to different parts of the quarries and the items produced primarily remained the property of each group. This type of control does not entail a hierarchal or political structure.

McBryde (1984:272) appears to support a notion of family based ownership rather than social group or clan rights to access valuable materials. Site ownership is supported by archaeological observations at Moondarra. Embedded subsistence tool production (not including axe production) using the nearest available raw materials can be observed at the majority of reduction sites, but exceptions to this do occur. For instance some habitation sites/reduction floors that are near quartz quarries have a limited amount of quartz in their assemblage compared to other sites that are a greater distance from the quartz outcrop. Natural barriers and geology cannot readily explain this diversion from an embedded procurement system in the subsistence tool kit.

The presence of stockpiles of axes and the presence of large ceremonial blanks at Moondarra seems to partly support concepts of restricted access as a safeguard against misappropriation (Plates 5.2 and 6.9). Tacon (1991:201) has argued that local stone sources were often given heightened significance by associating it with powerful, dangerous sources. He suggested that this assisted in the control and use of the site and reinforced the power and prestige of the site, its owners and the tools made from it (1991:201). These incomplete artefacts left at the site represent a significant expenditure in time, energy and raw materials.

Ownership rights and mythological stories associated with sites (McBryde 1997 and Tacon 1991:201) suggest that control of some sites could be monopolised and access restricted. In conjunction, these issues may have enabled a regular and experienced pool of craftsmen to produce items with high degrees of standardisation for exchange by preventing less experienced knappers from participating in axe production.

In Thailand, White and Pigott (1996:157) hold that several lines of archaeological evidence substantiate the view that organisation at the copper quarries was by independent specialists or communities producing for regional consumption. A similar idea, based on archaeological and ethnographic evidence is the preferred option to explain the organisation of production at Moondarra.

Any goods obtained by an individual from exchange would possibly involve obligations to members of the family group who constitute the economic group. Group and individual exchange in this region was documented by Watson (1983:53) who suggested that pituri was traded at markets after the 20th century and possibly before with groups or individuals haggling for themselves. Nevertheless, the possibility exists that those individuals who possessed effective social skills in the organization of production, and maintaining and acquiring successful exchange relationships may have increased their social status.

Competition between different family groups for exchange goods with similar levels of access to suitable raw materials, albeit in different parts of the same extensive quarry possibly increased the level of competition in production systems and thus a highly standardised exchange item may have became a necessity to promote and maintain market share. Moreover, community production was perhaps partly driven by the desire to obtain among other items, the narcotic drug pituri. The special relationship that existed between exchange and this drug in northwest Queensland is reviewed in this context.

The Mulligan River was the principle source of pituri production and the Selwyn Ranges (Kalkadoon country) was one of four regions that had a direct exchange relationship with the Mulligan River (Watson 1983). The Kalkadoon people most likely consumed some of the pituri they obtained and exchanged the remainder to their neighbours. As documented by Watson (1983), pituri was the gold standard in Aboriginal exchange mechanisms.

Brumfiel and Earle (1987:6) observed that one of the most important conclusions to be drawn from their work was the lack of importance of specialisation in subsistence goods for political development. They noted that either the specialisation is absent, as among the Mississippi chiefdoms or as among the Hawaiian chiefdoms, or as in the Inca Empire it is conducted with minimal control by elites. They used the Valley of Mexico as another example where a reasonably efficient system of part-time specialisation in subsistence goods and exchange existed without state unification. When a state did develop in this region, exchange intensified, but remained part-time (Brumfield and Earle 1987:6). They agreed with other suggestions in the literature that political elites do not function as promoters of economic efficiency.

It is suggested that at Moondarra, part-time specialists working at the community level produced standardised axes from the late Holocene. Although, Brumfiel and Earl (1987) hold that subsistence specialisation does not necessarily demonstrate emerging complexity in a society, their paper does not explicitly discuss empirical evidence for specialised production in an egalitarian society.

White and Pigott (1996) argued for the existence of a community based production system in the absence of a complex society. This is similar to Moondarra in that specialisation does not involve foodstuffs, although their study focused an agriculturally based society. The main hypothesis in White and Pigott’s (1996) suggest that craft specialisation has existed since prehistoric periods in Thailand and that this operated at a community based level of production from 3,000-300 B.C. After Costin (1991:8), they defined this mode of production as:

> Autonomous individual or household-based production units, aggregated within a single community producing for unrestricted regional consumption.

Their archaeological evidence suggested a community-based model of production from about 3,000-300B.P. with intensification at about the first millennium B.C., before the development of political centralization. For most of this there was direct archaeological evidence for copper production. Some of copper goods produced during this period were spear-points, arrow-points, fishhooks, socketed adzes, bracelets and anklets. They based their inferences regarding craft specialisation upon archaeological, ethnographic and historical evidence (White and Pigott 1996:153). Their archaeological evidence did not indicate any significant differentiation in grave assemblages, which suggested that individual qualities such as age, sex and social and economic roles were more significant in relation to social differentiation. Brumfiel and Earle (1987:1) have argued that cases of social complexity originating through commercial development must be relatively few. White and Pigott (1996:170) have suggested that the combination of specialised communities and decentralized exchange of the items, prior to political centralization would have been a difficult environment for elites to control or in which to accumulating power. Controlling such an economy may require considerable coercive force and a substantial investment in administration to regulate production and they proposed that specialisation and inter-regional exchange developed before the state controlled economy (White and Pigott 1996:170). They suggested that society may have become more differentiated and complex, but not necessarily along rigid hierarchical control lines. In an earlier paper, White (1995) had proposed a heterarchical model of social complexity be applied to this region.

The arguments postulated by White and Pigott (1996) have many similarities with the archaeological and ethnographic evidence from Moondarra including community specialisation, community production, product standardisation, centralized production with decentralized exchange networks and the absence of political control or elites in the production process. In dealing with the issues of economic and social complexity it seems that these variables are not necessarily correlated. White and Pigott (1996) state that:

> The implications for a strong economic basis in community-specialisation as characterizing a pre-state economy have not been addressed in theories of the development of social complexity. White and Pigott (1996:170)

They suggested that ‘ … even the presence of industrial levels of activity need not correlate with over-arching production controls or pronounced levels of social complexity among the producers’ (White and Pigott 1996:169).

The data from a prehistoric hunter-gather society from northwest Queensland seems to have many similarities with the archaeological evidence from an agricultural society from Thailand (White and Pigott (1996). These case studies test the explicit connection between emerging complexity and economics. However, it must be stressed that Kalkadoon wealth was not accumulated by a sector of society that allowed a transformation into hierarchical social relations. Kalkadoon society may have been egalitarian, but the presence and utilization of the axe quarries on the scale documented suggests that they may have been more affluent than their neighbours.

The argument that there is an association between specialisation and standardisation and social complexity is not disputed. The point being made here is that both specialisation and standardisation have occurred in an egalitarian, hunter-gather society. Therefore, specialisation and standardisation cannot be exclusively linked to the concept of an emerging complexity in society.

11.7 Previous suggestions for specialisation and standardisation

McBryde (1997) and Watson (1983), who have researched Aboriginal exchange in northwest Queensland have commented on the specialised nature of production while others such as Hiscock (forthcoming) and Innes (1991) have suggested the presence of standardised items. Watson's (1983) monograph was a seminal study of the production and exchange of pituri along the Mulligan River region. She reviewed and analysed the available data on the production, distribution and consumption of this psychoactive drug.

Watson (1983:37) has described the difference between Aiston's (1937) accounts of pituri exchange and conventional hunter-gatherer economics as striking. Aiston 1937:372-7 documented that pituri exchange did not occur along a chain of trade linking group A with B and so on, but at markets such as Kopperamanna and Birdsville, and that these locations attracted Aborigines from long distances. Watson (1983:53) documented two methods of pituri distribution. The first being where groups like the Dieri traveled up to 450km to exchange red ochre for pituri along the path described by McCarthy (1939) as the 'Red Ochre Route'. The second system involved local exchange where the pituri was exchanged through haggling and non-partnered exchange for prestige foreign items. Moondarra axes were probably one of the items the Kalkadoons used to obtain quantities of pituri (Watson 1983:55). She argued that the special qualities of 'this precious foliage' influenced trade. Whereas traditional Aboriginal exchange is characterized by formality and reciprocity she proposed that the demand created by an addictive drug may have altered the mechanism of trade, resulting in haggling (Watson 1983:54).

There seems to be a direct association between axe production at Moondarra and pituri production along the Mulligan River. McBryde (1984:273) recognized that the owners of the pituri appeared to organize production on a commercial basis. The standardised production of larger axes may have a similar effect as pituri production in that highly valued items such as a drug or a utilitarian item would increase demand in a competitive market place. The specialised production tasks in harvesting and curing the pituri plants, the development of a complex curing process, seasonal part-time production, restricted access, and hereditary control of resources have relevant similarities with axe production at Moondarra.

Innes (1991) and Hiscock (forthcoming) and have questioned Torrence's (1986:82-3) notion that only commercial or partially commercial exchange systems have evidence for standardisation. Hiscock (forthcoming) has cited Burton (1984a) to demonstrate standardised production in an egalitarian society.

The argument for the specialised production of standardised items in an egalitarian society does not inevitably question Torrence's (1986) notion linking standardisation to either part-time or full-time commercial exchange. The arguments in this thesis have incorporated the idea that in northwest Queensland, a commercial interest existed in an egalitarian, hunter-gatherer exchange system. Markets and haggling suggest the ascendancy of economics in exchange relationships. In this situation, the association between standardisation and partly commercial or commercial exchange is appropriate. For a connection between egalitarianism and commercialism to exist, social complexity may be immaterial. In northwest Queensland, pan continental notions of ceremonial exchange cannot subsume the economic aspects of egalitarian hunter-gather exchange.

11.8 **Conclusion**

The archaeological and ethnographic evidence for specialised and standardised production for inter-group exchange has many implications for previous interpretations of Aboriginal, hunter-gatherer behaviour in Australia. It appears that ceremonial and reciprocal interpretations of Aboriginal exchange cannot effectively explain standardised axe production at Moondarra and the specialised production of pituri along the Mulligan River.

Value adding by specialisation is possibly required due to the presence of external and internal competitors and unless goods can be produced to a highly standardised form or enhanced quality, then demand for these items would decrease. The highly standardised, but significantly decreased size of the axes from Boulia would be an external competing source for axes. The presence of numerous Kalkadoon family groups on two major quarries in the Mount Isa possibly represented internal competition. For axes, this argument assumes synchronous production at Gunpowder and Boulia and this is possibly the case before contact with settlers in the late 19th century.

It may be impossible to completely separate the social and economic intentions in exchange transactions, as these issues appear to be inexplicitly entwined. However, the argument presented in this thesis for increased value as a method of out-competing rivals seems to have an economic or commercial purpose rather than reciprocal. The requirement for pituri may have resulted in the standardisation of larger axes in comparison to those produced at Boulia. Markets or haggling at exchange centres may not completely absolve the exchange partners of future obligations. The economic part of the transaction may be finalized at the point of material exchange, but future obligations in the form of a risk minimisation strategy may commence. Nevertheless, the economic role of exchange in northwest Queensland cannot be subsumed under the ceremonial aspects.

A model of embedded procurement for subsistence and a specialised procurement system for exchange is proposed. Within this model, Binford’s (1979) argument that procurement is essentially explained by embeddedness is contested. Specialised procurement includes both subsistence and maintenance items when they are specifically produced for exchange. Exchange of items without intentional production for that purpose, does not represent specialised procurement within this interpretation.

While changes in societies over time can be can be associated with increased complexity, inferences of impending complexity or chiefdoms in the egalitarian, Kalkadoon hunter-gatherer society are not supported. This study proposes that community craft specialisation and standardisation can also exist in egalitarian hunter-gatherers societies, and that these variables are not items on a checklist for emerging complexity.

Chapter 12 Nature of archaeological sites at Moondarra

12.1 **Introduction**

This research has focused on archaeological surveys, excavations and other techniques to examine the quarry complex. It has concentrated on defining the commencement of stone axe manufacturing at Moondarra, changes in the intensity of site use and the technological organisation of the prehistoric Aboriginal miners and traders. The survey is the basis for a spatial analysis of quarries and reduction floors, providing insights into the relationship between these sites.

12.2 **Spatial relationships**

The survey revealed 23 basalt quarries, two quartzite quarries, one quartz quarry and six axe reduction floors. All quarries and four of the reduction floors are located on the eastern side of Stone Axe Creek while the remaining reduction floors are on the western side. The survey resulted in the expansion of the previously known western and northern boundaries and the inclusion of two reduction sites and two quartzite quarries. One of these leilira blade quarries was a two-kilometre section in the bed of Stone Axe Creek. Lake Moondarra is an expansive site with a total area of almost 175 hectares. The basalt quarries cover an area of 98.25 hectares and the reduction floors 76.7 hectares. The 32 sites are spread over a distance of 3,705m from north to south and 1,764m from east to west.

Based on the number and size of the basalt quarries it seems that axe production was the principle activity conducted at Moondarra. The two-quartzite quarries provide archaeological evidence for leilira blade production and the quartz quarry possibly reflects the embedded nature of tool-kit reprovisioning in a hunter-gatherer society.

An understanding of the spatial relationships between sites has provided a foundation for advancing arguments relating to: 1. levels of access to and control of particular sites, 2. the relationship between site use and water availability, 3. the times of the year when specific sites were used and why, and 4. the possibility of seasonal axe production.

12.3 **Excavations**

The length, width, thickness and weight of the basalt thinning flakes appeared to be uniform with increasing depth during the excavations. This consistency indicates that the practice of moving axes to ‘reduction floors’ for the removal of smaller thinning flakes has operated for an extended time.

Numbers of both basalt and quartzite flakes increased noticeably at about 500-600 years at which time basalt flake production began to outstrip quartzite. Prior to this acceleration in production quartzite flake quantities were similar to basalt. The descriptive analysis of artefacts suggested that throughout R4, basalt and quartzite flake size and edge angles are essentially unchanging. A few larger outliers were noted, but these flakes were within the range of the upper deposits suggesting that trimming flakes size has remained similar for an extended period of time.

Basal dates for R4 at 1,170BP, which is calculated on geomorphic grounds suggest that Moondarra may not be associated with edge ground stone axe technology along the east coast of Australia. If axe technology was transferred from Arnhem Land or the Kimberley Ranges via northwest Queensland to the eastern seaboard, evidence of axes could be expected to appear earlier in the archaeological record at Moondarra. Axes have been dated to 5,000 BP on the east coast (Morwood and Hobbs 1995). Rock to the north, south and east of Mt Isa are sedimentary rocks formed in an inland sea and unsuitable for axe production. The closest axe quarry to the east of Moondarra is near Charters Towers, about 700 kilometers distant. The northwest Highlands appear to be a geological artery that stone axe technology would have to flow through to enter eastern Australia.

12.4 **Mining techniques used at Moondarra**

Aboriginals used mining at Moondarra to extract suitable basalt for the production of axes. Archaeological evidence for a range of techniques such as firing raw material, the use of wedging to split boulders, the use of grindstones and the use of grinding agents in the production process at Moondarra were also examined.

Excavation of a mining pit at Q12, one of the quarries in the complex, demonstrated that most of the stone surrounding the excavation had not been excavated from pit. Calculations suggested that if this was the case, the original excavation would have been 3.47m deep. The maximum possible depth of the mining pit was 33cm, thus the volume of rock exceeded the amount excavated by about 10.5 times. This suggests that not only were these people mining, they also collected large quantities of stone and carried it to a central place for knapping.

The AMS date from the charcoal sample collected from the Aboriginal mining pit EXP1 was 414 ± 47 years BP. This is within a century of the intensification of axe production that occurred at about 500 to 600 BP at R4. Aboriginal mining may be therefore associated with a change in production techniques to meet the rising demand for raw materials for an expanding exchange market.

Evidence for the use of fire (determined by the presence of charcoal) to split stone is somewhat ambiguous in the absence of ethnographic observations. An independent test not based on the presence or absence of charcoal was developed to determine if fire was used to break stone in preparing suitable blocks of raw material at Moondarra. Firing stone results in fracturing along planes, along which suitable flakes are removed by percussion. Evidence for this would include negative percussion scars along some edges indicating the removal of axe flakes from the remaining core or block of stone.

A survey of three 60 square metre sections at two hardstone quarries revealed a complete absence of flake removal by percussion along fractured planes (nor formed by percussion). Fractured stone was identified in one section. However, these breaks were interpreted as being natural arrangements on inferior rock quality as there was an absence of negative percussion scars along the edges of these broken basalt boulders. In the three sections surveyed, hundreds of negative scars were present where flakes had been removed, but none were apparent along fractured planes. Archaeological evidence at Moondarra does not support suggestions that firing was used to purposely break up stone into smaller pieces.

Stone wedges were definitely used at Moondarra and rocks were prepared prior to wedging. Another method to break stones was to support larger boulders with smaller stones so that percussion blows could have maximum effect.

Anvils were commonly used at Moondarra and two different methods of breaking stone were employed. First, a conventional anvil was used where suitable blocks of stone were hammered while resting on the anvil and second, stone was hurled from an extended height onto an anvil. The first method may be more controlled, but the second method may be more suitable for applying additional force to break larger boulders into two or more pieces, which can then be reduced by more controlled percussion methods. Hammerstones are widespread on the quarries and reduction floors at Moondarra as would be expected on a major axe factory. Surprisingly, basalt hammerstones can only be found at quarries and only quartzite hammerstones only at reduction floors.

Grindstones made from local siltstone and quartzite from Stone Axe Creek may have been used for both food processing and for edge grinding axes at Moondarra. The presence of basalt blocks at Gunpowder to the north of Moondarra and numerous quartzite rocks on the reduction floors with abrasions and shallow indentations on the surface suggest that activities other than seed grinding were being performed at these axe quarries.

The presence of leilira blade production at Moondarra extends the known archaeological distribution of these artefacts from eastern Arnhem Land to northwest Queensland (Tibbett submitted). The absence of large blades from the six reduction and habitation sites on Moondarra is consistent with the observations of Allen (1991) and Paton (1994) that the production of this type of blade is associated with long distance exchange networks. This is generally supported by the fact that they are also absent on habitation sites in the region.

12.5 **Measuring standardisation**

The standardisation hypothesis or technological standardisation is founded on the assumption that goods produced by specialists have less morphological variation than those items produced by more generalised producers (Arnold 1984, 1987; Blackman *et al*. 1993; Longacre *et al*. 1988). Hiscock (forthcoming) has described relative homogeneity as a production process that exhibits uniformity between different stages, regardless of complexity.

The examination of 486 axes from Moondarra, Boulia and northwest NSW has enabled the correlation of variations for the same tool type with two different production systems to be determined. This approach permitted comparative analysis of the degree of technological standardisation between specialist production possibly for exchange and production by numerous knappers using various raw materials to manufacture functional tools. The empirically derived results showed significant variations in technological standardisation between the two production systems.

The axes produced and used in the Mt Isa district possess marginally higher variations in standardisation compared with the axes exchanged from Moondarra. Withholding these axes with marginally increased variation from the exchange network might serve two important purposes. First, axes at the higher ranges of variation are kept from the exchange system thus preserving the regular quality and form of their exchange goods. Second, this type of behaviour would reduce the loss of time, energy and raw materials in the production of otherwise functional tools in situations when the knapper realises during the production process that the artefact is outside the margins required for exchange. In these situations, continued reduction of the axe to completion of the tool could fulfil the requirement for axes in their subsistence tool-kit.

The Boulia axes show remarkable standardisation in comparison with the axes produced at Moondarra, although their reduced size suggests that they were not exchanged into the Lake Eyre Basin (see Tibbett 2000, 2002). Several ethnographers and archaeologists support the assumption that stone axes were exchanged from northwest Queensland into the Lake Eyre Basin (Horne and Aiston 1924, McCarthy 1939, McBryde 1997, McConnell 1976, Roth 1897). The argument by Berg (2004) that exposure to a more efficient technology may amplify internal competition between different producing groups seems to provide an answer for the highly standardised functional axes produced by numerous knappers in the Boulia district.

The correlation of variation is a robust tool for measuring standardisation as it calculates the standard variation as a percentage of the mean size and enables differences in standard deviation and mean size for separate assemblages to be expressed as percentages. However, in providing an accurate measurement of variation within an assemblage, variations in the mean size of assemblages can be overlooked. Therefore, in the comparative analyses of Moondarra and Boulia axes an apparent similarity in standardisation may be overshadowed by the ability of some groups to produce larger axes with equivalent measures of standardisation thus out competing potential exchange rivals.

The northwest New South Wales axes are produced from a range of stone types from an expansive area by a large number of knappers. These axes have significantly higher variation compared to Moondarra axes.

The suggestion of specialisation in production is suggested based on comparative analyses for correlation of variations in lithic production advanced by other archaeologists (Eerkens 1997, Eerkens and Bettinger 2001, Hiscock (forthcoming), Gallagher 1977, Longacre 1999, Torrence 1986, 1998, White and Jones 1988, White and Thomas 1972) and the analysis of data presented here on the levels of standardisation for axes produced by numerous knappers at various quarries using a range of raw materials.

12.6 **Dual production systems**

In this thesis, a model is advanced that a dual procurement systems operated simultaneously in Kalkadoon society at contact and perhaps also in other Aboriginal language groups in northwest Queensland. These are an embedded system used in the procurement of the subsistence tool-kit (after Binford 1973, 1979), and specialised procurement principally for exchange.

Gould (1979), Gould and Saggers (1985), Hiscock (forthcoming), Innes (1991), and Simmons (1991) have questioned Binford’s (1979) theory regarding the embedded nature of raw material procurement. The central issue of disagreement has been the restrictive use of the term embeddedness in relation to the subsistence tool kit and exclusion in terms of the maintenance tool kit.

The challenges to embeddedness by Bergsvik (2002) and McBryde (1997) referred to social factors as being connected to lithic materials. McBryde argued that the exchange system was not embedded in the economic or subsistence regimes of the societies concerned, but in their social and ceremonial life in which these material goods and exchange play substantial roles. The interpretation of long-distance exchange as advanced by McBryde (1997) recognises social factors as influencing raw material procurement behaviour among hunter-gatherers. However, the large-scale production and relatively high correlation of variations for lithics indicating significant degrees of standardisation at Moondarra suggest a more pronounced economic aspect in conjunction with social obligations. The nature of Kalkadoon axe exchange certainly tests assumptions that hunter-gatherer economics in Australia can be readily subsumed under the ceremonial role. Economic and social factors are certainly inexplicitly entwined, but in northwest Queensland emphasis appears to have been placed on lithic production.

It is suggested here that the insertion of maintenance items to Binford’s (1979) would include all types of procurement behaviour with the notion of embeddedness. This expanded interpretation may be misleading by being too general and unable to distinguish between two different types of procurement, which Gould and Saggers (1985) seem to have been attempting.

The embedded subsistence argument of Binford (1979) cannot effectively explain the production of subsistence and maintenance items for exchange. Specialised exchange is distinct in the sense that these items are produced primarily for exchange and not the exchange of personal tools and equipment at meeting places, which may be incidental activities.

A dual procurement model that incorporates Binford’s (1979) argument for embedded behaviour and identifies external social factors is required to identify different procurement systems. In this thesis, I propose that embedded procurement is related to the subsistence tool kit and specialised procurement is related to exchange. Specialised procurement occurs when external issues influence a group's internal procurement system.

12.7 Craft specialisation and complexity

Arguments for specialisation and standardisation in production at Moondarra could be misconstrued to suggest the presence of an emergent complexity in a hunter-gatherer society. Despite the archaeological evidence suggesting specialisation in Kalkadoon society at contact, the argument for an emerging complexity is firmly rejected. Nonetheless, it is argued that in an egalitarian hunter-gatherer society, independent part-time specialists produced highly standardised utilitarian items.

It is advanced here that social organisation at the axe quarries was at the family level and that numerous such like groups operated on Moondarra and perhaps other significant quarries in the region. There are two principle arguments to support this notion. First, the stockpiles of axes kept on the quarries and reduction floors represent a considerable investment of raw materials, time and energy invested in their production. This storage suggests that a system of ownership inferring restricted access and control was in place to safeguard resources. Second, the marked differences in the types of raw materials used in the subsistence tool kits at some reductions floors is not associated with proximity to raw material types.

It is suggested that at Moondarra, part-time specialists working at the local level produced standardised axes from the late-Holocene onwards. White and Pigott (1996) similarly argued for the existence of a community-based specialised production system in the absence of a complex society.

The argument that specialisation and social complexity both occur in complex societies is not questioned here. The point here is that both specialisation and standardisation can also occur in an egalitarian, mobile, hunter-gather society. Therefore, specialisation and standardisation cannot be exclusively linked to the concept of emerging social complexity.

12.8 **Conclusion**

During this research, the Moondarra complex was mapped and 32 separate archaeological sites were identified. Three archaeological excavations were conducted and AMS dates suggest that of axe production began in northwest Queensland around 1200BP, with intensification of production at about 500-600 years ago. Axe production was the principle activity on the site, but the presence of leilira blade production has expanded the known archeological distribution of these artefacts from the Northern Territory into northwest Queensland.

This research has contributed to understanding hunter-gatherer material culture and in particular, procurement systems. The archaeological evidence suggests that production of specialised and standardised axes was principally for exchange and that leilira blade production was exclusively for exchange. This challenges the notion that standardisation is exclusively associated with complex societies. It is argued that two procurement systems operated simultaneously in northwest Queensland from the late-Holocene.

The strength of this research is the timing for the commencement of Aboriginal axe production for exchange in northwest Queensland, and the description of mining techniques used. In addition, arguments for standardisation, elements of commercialism, and dual procurement systems in a mobile, hunter-gatherer society have challenged some assumptions concerning hunter-gatherer behaviour.

Glossary

Andesite	A fine-grained igneous rock in the diorite family that is intermediate in colour between the light end of the spectrum (rhyolite) and the dark end of the spectrum (basalt).
Artefact Length	Callipers were used to measure the length from the ring-crack to the distal margin, and measurements were recorded to the nearest millimetre. According to Hiscock (1988:366), the surface area of the fracture can be calculated, by multiplying the length and width of an artefact. In addition, the relationship of the flake to the core, the amount of force used in the flake detachment, and the technique of knapping can be determined. It also enables a calculation of consistency in reduction techniques (Hiscock 1988:366).
Basalt	A fine-grained usually dark coloured igneous rock, which is made up essentially of plagioclase and pyroxene (usually augite) minerals, with or without olivine. Basalt is characterised by a low silica content (45-50%), but has a very high content of ferromagnesian minerals. It is a fine grained volcanic equivalent of the coarse grained (plutonic) rock garbo, and the median grained (hypabyssal) rock dolerite (Whittow 1984) The Moondarra basalts mostly possess olivine which, gives it a distinctive green colouring and the colloquial term greenstone.
Bevelled	Usually refers to a tool edge that has been modified by the removal of a series of flakes to produce a desired edge angle (Andrefsky 2002).
Biface	A flake tool modified on both the dorsal or ventral side.
Blade	A long slender prismatic flake manufactured by indirect percussion or pressure from a prepared core. At least twice as long as it is wide.
Blank	A detached piece potentially modifiable into a specific tool (Andrefsky 2002).
Bulb of	The bulbar location on the ventral surface of a flake that was formed as a force result of the Hertzian cone turning toward the outside of the objective piece.
Chert	A compact cryptocrystalline or microcrystalline variety of quartz originating from a sedimentary context.
Colluvium	Unconsolidated material at the bottom of a cliff or slope, generally moved by gravity alone. It lacks stratification and is usually unsorted; its composition depends upon its rock source, and its fragments vary greatly in size. Such deposits include cliff debris and talus. Slope wash occurs when gravity is aided by non-channelled running water.
Conchoidal Flake	A flake having the properties of conchoidal fracture. These flakes have a dorsal and ventral surface and often a bulb of force.

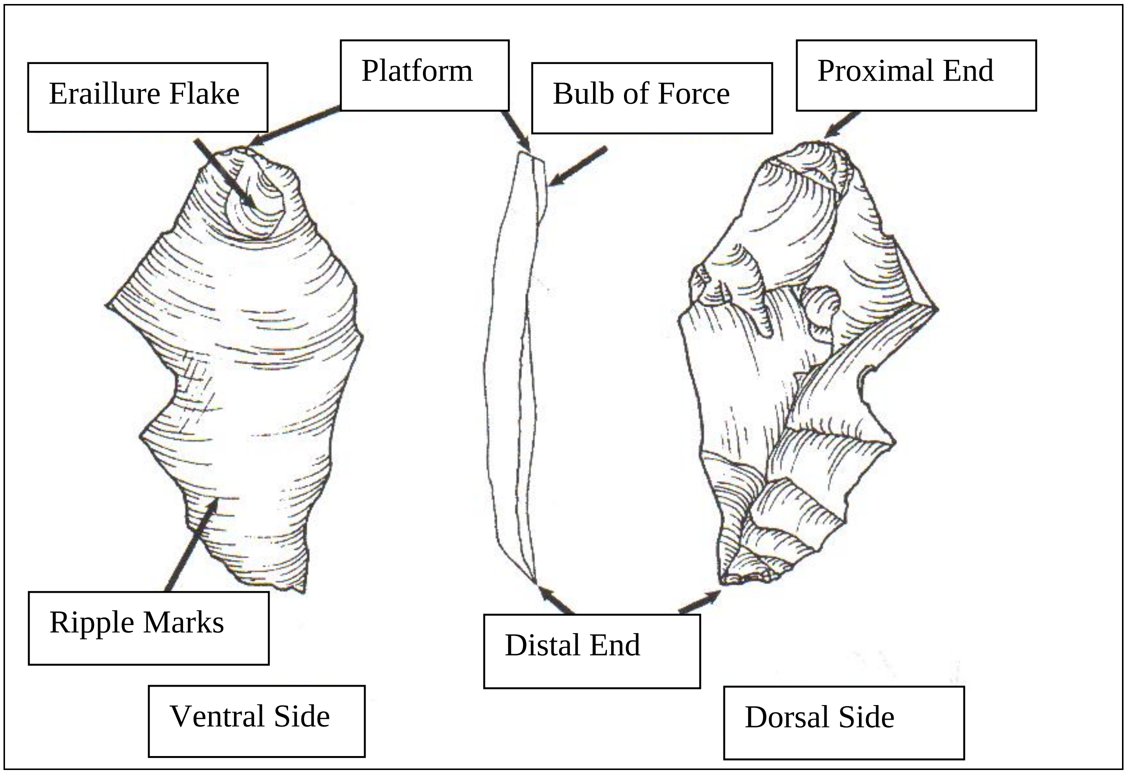
Core	A nucleus or mass of rock that shows signs of detached piece removal. A core is often considered an objective piece that functions primarily as a source for detached pieces.
Cortex	Chemical or mechanical weathered surface of a rock.
Debitage	Detached pieces that are discarded during the reduction process. Waste products from tool manufacture.
Distal end of a flake	The location on a flake that shows the type of termination, opposite the striking platform.
Dorsal ridge	A line or ridge formed on the dorsal surface by the previous removal of detached pieces from the objective piece. Also referred as the dorsal arris.
Dorsal Surface of a flake	The side of a flake or detached piece that shows evidence of previous flake removals or the original surface of the rock.
Elasticity	The property of stone to return to its former state after being depressed by the application of force.
End shock	transverse fracture due to stone exceeding its elastic limits.
Excavation	The principle method of data acquisition in archaeology, involving the systematic uncovering of archaeological remains through the removal of the deposits of soil and the other material covering them and accompanying them.
Exchange	A concept closely linked to reciprocity. Exchange may be equal or unequal, equivalent or non-equivalent.
Expedient Tools	Stone tools made with little or no production effort.
Fissures	Radii usually originating at the margins of detached pieces on the ventral surface and directed toward the point of applied force.
Flakes	Flakes are described by Shott (1994) as an object detached from a larger stone mass such as a core or tool. The width of artefacts was measured with callipers to the nearest millimetre. This measurement was taken at the mid point between the ring-crack and the distal margin.
Formal tools	Stone tools made as a result of extra effort in their production. These tools are in contrast to expediently made tools with little or no effort expended in their production.

Generalised Reduction Sequence	A description of the set of knapping behaviour common to, and characteristic of, a number of Reduction Sequences in an assemblage or region (Hiscock 1988:322).
Geomorphology	A sub-discipline of geography, concerned with the study of the form and development of landscape, it includes such specialisations as sedimentology**.**
Grid System	A system of rectangular excavation or sampling units laid over a site by strings and stakes.
Habitation site	A location where a human group has lived and conducted normal daily activities for a significant period.
Hafted	Attached with binding to a shaft or handle.
Hammer-stone	A rock used as a percussor to detach flakes from an objective piece. These usually show signs of impact damage such as crushed edges.
Hertzian cone	The cone formed as a result of conchoidal fracture in brittle solids.
Hinge fracture	The scar left by a previously removed flake detached by hinge fracture.
Hinge termination	The distal end of a flake that is rounded or blunt.
Informal tools	Stone tools made in a casual manner with only minor design constraints. these tools are often called expediently made tools or tools made for the needs of the moment.
Intensification	An increase in the product derived from a unit of land or labour.
Lateral margins	Margins of detached pieces and objective pieces on either side of the longitudinal axis.
Model	A system of hypothetical principles that represents the characters of a phenomenon and from which predictions can be made.
Moving Analysis	The combination of data from more than one source combined into one data set. e.g. data from three excavations merged into one graph**.**
Mudstone	general term used to describe a very-fine grained sedimentary rock. Mud-sized particles that have solidified under water or underground are often identified as mudstone.

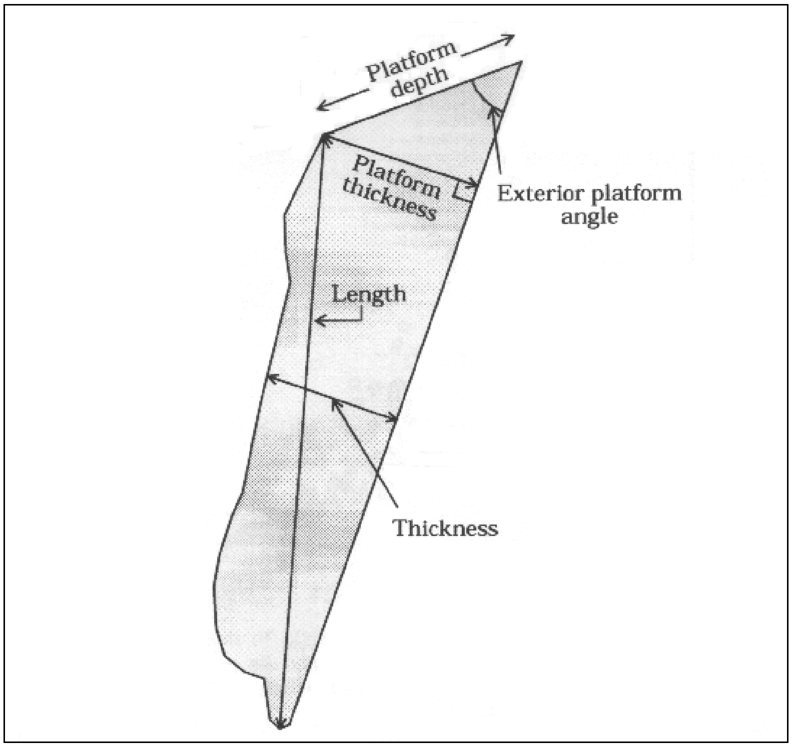
Percussion flaking	A method of striking with a percussor to detach flakes from an objective piece. Different methods of percussion flaking using different percussors tends to produce distinctive detached pieces.
Percussion width	Two methods were used to measure percussion width. Firstly, all artefact except for axes was measured at the right angles to the mid point along the percussion length. This measurement is not always the widest point of a flake but when calculated in conjunction with length provides a more accurate estimation of the ventral surface area. Secondly, axe width was measured at right angles to length axis but at the widest point. In most instances this variation would not significantly alter the measurements recorded, as the axes are generally discoid in shape. The widest width was recorded so that comparative analyses could be conducted with axes from the Lake Eyre Basin that have been sourced to Mt Isa (Tibbett 2000).
Platform Angle	A common definition for striking platform angle is the angle formed by the intersection of the striking surface and the ventral surface (Dibble and Whittaker 1981; Shott 1993).
Platform Width	The width of the platform was measured with callipers on the platform surface between the margins to the nearest millimetre.
Platform thickness	Platform thickness was measured with callipers to the nearest millimetre from the ventral to the distal faces in alignment with the ringcrack. Platform thickness measures the thickness of the flake at the ringcrack and the distance of the point of force from the core. Hiscock suggested (1988:371) that the location of the point of force is significant as it determines the area (size) of the fracture plane and ultimately the flake size. In conjunction with platform width, platform area can be measured. Hiscock (1988:371) also suggested, that similar to platform width, platform thickness may indicate increased control of the placement of blows, possibly related to overhang removal.
Radiocarbon dating	An absolute dating method based on the radioactive decay of Carbon 14 contained in organic materials.
Reduction Sequence	A description of the order in which reduction occurs within one block of stone. (Hiscock 1988:328).
Relative Dating	The determination of chronological sequences without recourse to a fixed time scale.
Reciprocity	A mode of exchange in which transactions take place between individuals who are symmetrically placed. i. e. they are exchanging as equals, neither being in a dominant position.

Platform Angle	The platform angles were measured using an engineer’s metal protractor that can measure solid angles to within one degree of accuracy. This degree of accuracy is possible as the solid angle being recorded is extended from the artefact being measured, to the graduated semicircular instrument or goniometer. When the relationship between the platform and ventral surface seemed irregular, two or more measurements were taken and the average angle recorded. Platform angles record the angle between the platform and core face on the producer immediately before the flake is struck (Hiscock 1988:373). He suggested that this angle might determine the amount of force required to create the flake (Hiscock 1988:373), but see Pelcin and Dibble (1994 for an alternative view).
Retouched Flake	A stone flake which has one or more edges modified by the deliberte removal of secondary chips.
Secondary Deposit	A body of natural or cultural sediments which have been disturbed and re-transported since their original deposition.
Statistical Analysis	The application of probability theory to quantified descriptive data.
Stratification	The laying down or depositing of strata or layers (also called deposits) one above another. A succession of layers should provide a relative chronological sequence, with the earliest at the bottom and the latest at the top.
Step termination	The distal end of a flake that terminates abruptly in a right-angle break. This creates a ‘step-like’ break, not to be confused with a hinge termination.
Stone tool	An artefact that has been intentionally modified by retouch or unintentionally modified by usewear. Examples of stone tools are projectile points, unifaces, scrapers, and microliths. Debitage would not be considered tools, but would be considered artefacts.
Striking platform	The surface area on an objective piece receiving the force to detach a piece of material. This surface is often removed with the detached piece so that the detached piece will contain the striking platform at the point of applied force.
Test Pit	a small exploratory “dig” designed to determine a site’s depth, and contents prior to major excavation.
Uniface	A flake tool modified on either the dorsal or ventral side only.

Ventral surface of a flake	The smooth surface of a detached piece that contains no previous removals except sometimes an eraillure flake scar on the bulb of force.
Weight	The force that gravity exerts on a body.



A conchoidal fracture showing common elements and terminology (from Andrefsky 2002.17).



Platform variables (from Dibble and Pelcin 1994 Figure 1).

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R3 Surface	Num	Length	Width	T/ness	P width	P t/ness	Weight	P angle	Mat	Type
A1	1	138	117	81			1447		2	8
A1	2	106	86	64			1044		2	8
A2	3	39	33	7	18	6	12	86	1	1
A2	4	28	32	5			7		2	2
A2	5	24	23	4			3		1	4
A2	6	147	112	77			1788		1	5
A3	7	25	15	4			1		1	2
A3	8	24	17	4			1		1	2
A3	9	18	18	3			1		1	2
A3	10	17	10	4			1		1	2
A3	11	8	14	3			1		1	2
A3	12	10	14	3	9	2	1	82	1	2
A3	13	16	14	2			1		1	4
A3	14	15	12	3			1		1	4
A3	15	14	15	3			1		1	4
A3	16	11	13	2			1		1	4
A3	17	12	12	2			1		1	4
A3	18	11	10	1			1		1	4
A3	19	15	12	3			1		1	4
A3	20	9	6	1			1		1	4
A3	21	12	10	2			1		1	4
A3	22	11	9	2			1		1	4
A3	23	8	6	1			1		1	4
A3	24	6	7	1			1		1	4
A3	25	7	8	1			1		1	4
A3	26	6	5	1			1		1	4
A3	27	7	4	1			1		1	8
A3	28	96	66	30			277		2	7
A4	29	98	54	16	29	11	1090	85	1	4
A5	30	11	5	2			2		1	4
A5	31	17	10	2			2		1	4
A5	32	6	10	2			2		1	4
A5	33	8	6	1			1		1	4
A5	34	11	7	1			1		1	4
A5	35	7	3	1			1		1	4
A5	36	8	4	1			1		1	4
A5	37	5	4	1			1		1	4
A5	38	3	2	1			1		1	8
A5	39	102	91	34			471		2	1
B1	40	35	29	7	24	6	8	76	1	1
B2	41	98	71	15	50	10	129	75	1	1
B2	42	42	45	9	24	4	24	91	1	1
B2	43	15	12	3	10	3	1	81	1	1
B2	44	6	7	1	6	1	1		1	2
B2	45	32	31	10	22	7	15	87	1	2
B2	46	29	41	10			13		1	2
B2	47	22	33	18	16	7	7	116	1	2
B2	48	26	34	9	23	9	9	98	1	2
B2	49	40	41	11	23	9	16	86	1	2
B2	50	41	28	7	20	6	10	81	1	2
B2	51	36	44	9			15		1	2
B2	52	36	40	7			19		1	2
B2	53	23	32	5	16	15	4	64	1	2
B2	54	26	37	5			6		1	2
B2	55	22	19	4	12	4	3	62	1	2
B2	56	18	20	6	15	4	3	93	1	2
B2	57	18	22	4	13	4	2	89	1	2
B2	58	40	48	8	16	5	22	76	1	4
B2	59	28	26	6			6		1	4
B2	60	29	24	9			4		1	4
B2	61	20	7	6			1		1	4

R3 Surface	Num	Length	Width	T/ness	P width	P t/ness	Weight	P angle	Mat	Type
B2	62	24	27	4			1		1	4
B2	63	30	26	4			5		1	4
B2	64	34	31	4			6		1	4
B2	65	27	14	4			3		1	4
B2	66	21	24	3			4		1	4
B2	67	16	15	3			2		1	4
B2	68	25	14	3			2		1	4
B2	69	60	52	9			45		1	4
B2	70	35	26	4			6		1	4
B2	71	22	14	6			2		1	4
B2	72	44	32	4			12		1	4
B2	73	18	17	5			2		1	4
B2	74	20	27	6			2		1	4
B2	75	28	12	5			2		1	4
B2	76	26	10	3			1		1	4
B2	77	21	20	2			2		1	4
B2	78	21	10	4			1		1	4
B2	79	14	11	2			1		1	4
B2	80	15	12	5			1		1	4
B2	81	16	12	3			1		1	4
B2	82	20	14	2			1		1	4
B2	83	12	9	2			1		1	4
B2	84	19	7	2			1		1	4
B2	85	19	10	3			1		1	4
B2	86	20	10	3			1		1	4
B2	87	11	14	4			1		1	4
B2	88	12	12	3			1		1	4
B2	89	14	12	3			1		1	4
B2	90	12	9	2			1		1	4
B2	91	17	16	2			1		1	4
B2	92	12	11	2			1		1	4
B2	93	10	12	2			1		1	4
B2	94	12	7	2			1		1	4
B2	95	16	9	2			1		1	4
B2	96	13	8	3			1		1	4
B2	97	12	14	2			1		1	4
B2	98	12	15	3			1		1	4
B2	99	15	9	5			1		1	4
B2	100	17	14	3			1		1	4
B2	101	11	7	1			1		1	4
B2	102	13	7	1			1		1	4
B2	103	13	6	2			1		1	4
B2	104	12	8	2			1		1	4
B2	105	9	7	2			1		1	4
B2	106	12	4	2			1		1	4
B2	107	6	5	1			1		1	4
B2	108	11	7	1			1		1	5
B2	109	104	99	66			1231		2	5
B2	110	112	106	63			935		2	5
B3	111	10	15	3	9	3	1	66	1	2
B3	112	8	8	1	5	1	1		1	4
B3	113	17	9	1			1		1	4
B3	114	14	11	2			1		1	4
B3	115	11	9	2			1		1	4
B3	116	11	7	5			1		1	4
B3	117	10	9	2			1		1	4
B3	118	10	7	3			1		1	4
B3	119	13	4	1			1		1	4
B3	120	11	7	1			1		1	4
B3	121	7	8	1			1		1	4
B3	122	6	7	1			1		1	4

R3 Surface	Num	Length	Width	T/ness	P width	P t/ness	Weight	P angle	Mat	Type
B3	123	11	7	2			1		1	4
B3	124	11	6	2			1		1	4
B3	125	6	10	2			1		1	4
B3	126	8	6	1			1		1	4
B3	127	7	7	1			1		1	4
B3	128	9	5	2			1		1	4
B3	129	9	6	1			1		1	4
B3	130	11	4	1			1		1	4
B3	131	4	4	1			1		1	4
B3	132	4	4	1			1		1	4
B3	133	5	3	1			1		1	4
B3	134	6	4	1			1		1	4
B3	135	5	3	1			1		1	4
B3	136	5	3	1			1		1	1
B4	137	6	7	1	6	1	1		1	2
B4	138	10	15	3	9	3	1	66	1	2
B4	139	8	8	1	5	1	1		1	4
B4	140	17	9	1			1		1	4
B4	141	14	11	2			1		1	4
B4	142	11	9	2			1		1	4
B4	143	11	7	5			1		1	4
B4	144	10	9	2			1		1	4
B4	145	10	7	3			1		1	4
B4	146	13	4	1			1		1	4
B4	147	11	7	1			1		1	4
B4	148	7	8	1			1		1	4
B4	149	6	7	1			1		1	4
B4	150	11	7	2			1		1	4
B4	151	6	10	2			1		1	4
B4	152	8	6	1			1		1	4
B4	153	7	7	1			1		1	4
B4	154	9	5	2			1		1	4
B4	155	9	6	1			1		1	4
B4	156	11	4	1			1		1	4
B4	157	4	4	1			1		1	4
B4	158	4	4	1			1		1	4
B4	159	5	3	1			1		1	4
B4	160	6	4	1			1		1	4
B4	161	5	3	1			1		1	4
B4	162	5	3	1			1		1	1
B5	163	52	31	14	24	5	44	74	1	2
B5	164	22	20	7			3		1	2
B5	165	13	12	2			2		1	4
B5	166	31	16	4			2		1	4
B5	167	10	8	2			1		1	4
B5	168	18	9	4			1		1	4
B5	169	11	9	2			1		1	4
B5	170	10	7	3			1		1	4
B5	171	11	7	2			1		1	4
B5	172	7	7	1			1		1	4
B5	173	7	6	1			1		1	4
B5	174	7	7	1			1		1	4
B5	175	8	6	1			1		1	4
B5	176	9	6	1			1		1	8
B5	177	173	61	46			907		2	1
C1	178	50	26	5	20	4	23	79	1	2
C1	179	32	21	2			8		1	2
C1	180	29	34	3			16		1	4
C1	181	12	20	1			1		1	4
C1	182	21	20	3			4		1	1
C2	183	29	20	2	9	1	5	70	1	1

R3 Surface	Num	Length	Width	T/ness	P width	P t/ness	Weight	P angle	Mat	Type
C2	184	42	55	9	19	3	34	65	1	1
C2	185	13	30	1			7	80	1	1
C2	186	12	6	2			1	64	1	1
C2	187	20	14	2	11	1	2	59	1	1
C2	188	6	6	1	4	1	1	83	1	1
C2	189	11	8	1	8	1	1		1	2
C2	190	80	22	11			44		1	2
C2	191	28	30	4			8		1	2
C2	192	48	27	4			12		1	2
C2	193	28	34	6			16		1	2
C2	194	28	19	6			10		1	2
C2	195	17	22	1			4		1	2
C2	196	57	11	4			17		1	2
C2	197	14	34	2			7		1	2
C2	198	11	12	3	10	1	2	80	1	2
C2	199	11	15	1			1		1	2
C2	200	19	9	1			1		1	2
C2	201	5	8	1			1	64	1	2
C2	202	6	19	1			1		1	2
C2	203	9	15	1			2		1	2
C2	204	12	12	1			2	84	1	2
C2	205	11	19	1			1		1	2
C2	206	9	4	1			1		1	2
C2	207	8	12	2			2		1	2
C2	208	35	24	4	12	2	12	90	1	4
C2	209	26	22	2			8		1	4
C2	210	41	22	4			15		1	4
C2	211	22	11	2			6		1	4
C2	212	32	24	4			11		1	4
C2	213	20	15	4			7		1	4
C2	214	38	33	2			9		1	4
C2	215	4	6	1			1		1	4
C2	216	9	6	1			1		1	4
C2	217	12	7	1			1		1	4
C2	218	11	10	1			1		1	4
C2	219	16	19	2			2		1	4
C2	220	14	5	1			1		1	4
C2	221	14	7	1			1		1	4
C2	222	14	7	1			1		1	4
C2	223	14	5	1			1		1	4
C2	224	15	8	2			1		1	4
C2	225	6	8	1			1		1	4
C2	226	4	6	1			1		1	4
C2	227	12	5	1			1		1	4
C2	228	8	6	2			1		1	4
C2	229	8	2	1			1		1	4
C2	230	10	4	3			2		1	4
C2	231	4	2	1			1		1	4
C2	232	6	4	1			1		1	4
C2	233	6	2	2			1		1	4
C2	234	4	2	2			1		1	4
C2	235	5	4	1			1		1	4
C2	236	5	2	1			1		1	4
C2	237	5	2	1			1		1	4
C2	238	3	3	1			1		1	4
C2	239	1	2	1			1		1	4
C2	240	2	2	1			1		1	4
C2	241	4	2	1			1		1	4
C2	242	4	2	1			1		1	4
C2	243	2	2	1			1		1	4
C2	244	6	2	1			1		1	4

R3 Surface	Num	Length	Width	T/ness	P width	P t/ness	Weight	P angle	Mat	Type
C2	245	6	2	1			1		1	4
C2	246	6	2	1			1		1	4
C2	247	6	2	1			1		1	4
C3	248	89	92	15	7	55	216	100	1	1
C3	249	38	69	9	ind		46		1	1
C3	250	32	22	3	18	1	6	92	1	1
C3	251	9	9	1	7	1	1	90	1	2
C3	252	10	20	3	3	14	2	91	1	2
C3	253	25	25	1			8		1	2
C3	254	9	14	1			2		1	2
C3	255	9	10	1	8	1	1	90	1	2
C3	256	9	11	1			1		1	2
C3	257	10	5	1			1		1	2
C3	258	3	5	1			1		1	2
C3	259	6	5	1			1		1	2
C3	260	18	22	3	15	2	4	90	1	2
C3	261	15	15	1	13	1	1	90	1	2
C3	262	10	10	1	8	1	1	85	1	4
C3	263	34	16	5			11		1	4
C3	264	25	22	3			7		1	4
C3	265	20	11	4			4		1	4
C3	266	21	18	2			4		1	4
C3	267	15	17	2			2		1	4
C3	268	23	5	1			1		1	4
C3	269	12	3	2			1		1	4
C3	270	10	5	1			1		1	4
C3	271	15	5	1			1		1	4
C3	272	15	3	1			1		1	4
C3	273	6	10	1			1		1	4
C3	274	15	4	1			1		1	4
C3	275	12	5	1			1		1	4
C3	276	11	6	1			1		1	4
C3	277	10	7	1			1		1	4
C3	278	7	5	1			1		1	4
C3	279	12	6	1			2		1	4
C3	280	8	7	1			1		1	4
C3	281	9	4	1			1		1	4
C3	282	7	7	2			2		1	4
C3	283	8	9	1			1		1	4
C3	284	10	4	1			1		1	4
C3	285	10	5	1			1		1	4
C3	286	11	2	1			1		1	4
C3	287	8	4	1			1		1	4
C3	288	8	6	1			1		1	4
C3	289	7	5	1			1		1	4
C3	290	10	5	1			1		1	4
C3	291	9	5	1			1		1	4
C3	292	5	5	1			1		1	4
C3	293	5	5	1			1		1	4
C3	294	9	2	1			1		1	4
C3	295	11	6	2			1		1	4
C3	296	3	2	1			1		1	4
C3	297	3	1	1			1		1	4
C3	298	3	2	1			1		1	4
C3	299	4	1	1			1		1	4
C3	300	4	1	1			1		1	4
C3	301	5	2	1			1		1	4
C3	302	2	2	1			1		1	4
C3	303	2	1	1			1		1	5
C3	304	122	85	63			990		2	4
C4	305	16	6	1			2		1	4

R3 Surface	Num	Length	Width	T/ness	P width	P t/ness	Weight	P angle	Mat	Type
C4	306	8	4	3			1		1	4
C4	307	8	4	1			1		1	4
C4	308	6	4	1			1		1	4
C4	309	6	3	1			1		1	4
C4	310	4	4	1			1		1	4
C4	311	1	1	1			1		1	4
C4	312	2	3	1			1		1	4
C4	313	4	2	1			1		1	4
C4	314	5	2	1			1		1	4
C4	315	4	1	1			1		1	4
C4	316	2	2	1			1		1	4
C4	317	3	2	1			1		1	1
C5	318	18	20	3			4		1	2
C5	319	31	30	2			3		1	4
C5	320	60	32	12			33		1	5
C5	321	140	87	40			647		2	5
C5	322	116	101	34			586		2	5
C5	323	150	75	30			718		5	1
D1	324	29	84	8	25	5	155	90	1	4
D1	325	20	14	3			2		1	8
D1	326	128	104	74			1640		2	1
D2	327	40	25	4	11	2	11	80	1	1
D2	328	51	49	7			33		1	1
D2	329	73	87	20			175		1	2
D2	330	33	44	6	37	7	21		1	2
D2	331	20	20	4	10	3	6		1	2
D2	332	75	76	23			150		1	2
D2	333	57	68	11			63		1	2
D2	334	46	34	4			17		1	2
D2	335	40	21	4			11		1	2
D2	336	28	19	5			11		1	2
D2	337	25	29	4			10		1	4
D2	338	95	84	13			110		1	4
D2	339	30	30	6			15		1	4
D2	340	5	6	1			1		1	4
D2	341	5	5	1			1		1	4
D2	342	7	5	1			1		1	4
D2	343	5	8	1			1		1	4
D2	344	14	10	2			1		1	4
D2	345	24	15	5			5		1	4
D2	346	19	11	1			2		1	4
D2	347	29	19	2			6		1	4
D2	348	11	8	3			2		1	4
D2	349	7	3	1			1		1	4
D2	350	14	11	3			3		1	4
D2	351	16	11	2			2		1	4
D2	352	11	5	1			1		1	4
D2	353	11	5	1			1		1	1
D3	354	64	68	10	21	4	76		1	2
D3	355	95	40	32			162		1	2
D3	356	68	62	7			78		1	2
D3	357	27	41	4			7		1	2
D3	358	26	30	4			5		1	2
D3	359	27	27	6			13		1	2
D3	360	23	23	2			2		1	2
D3	361	14	20	1			2		1	2
D3	362	12	15	1			1		1	2
D3	363	7	15	1			1		1	4
D3	364	35	17	6			8		1	4
D3	365	29	26	3			10		1	4
D3	366	25	25	4			7		1	4

R3 Surface	Num	Length	Width	T/ness	P width	P t/ness	Weight	P angle	Mat	Type
D3	367	12	18	2			2		1	4
D3	368	19	6	1			1		1	4
D3	369	19	10	3			2		1	4
D3	370	20	11	4			2		1	4
D3	371	14	4	4			2		1	4
D3	372	11	7	2			1		1	4
D3	373	12	5	1			1		1	4
D3	374	10	4	1			1		1	4
D3	375	4	4	1			1		1	4
D3	376	4	2	1			1		1	4
D3	377	6	2	1			1		1	8
D3	378	90	67	27			243		5	1
D4	379	84	51	9	11	1	77	80	1	1
D4	380	6	5	1			1		1	4
D4	381	4	2	1			1		1	4
D4	382	115	75	55			851		1	4
D4	383	21	104	60			899		1	2
D5	384	96	110	31			25		1	2
D5	385	16	19	2			3		1	2
D5	386	96	110	31			1		1	2
D5	387	16	19	2			3		1	4
D5	388	13	13	1			1		1	4
D5	389	2	1	1			1		1	4
D5	390	13	13	1			1		1	
E1	391									
E2	392									
E3	393	12	10	2					1	4
E4	394	3	2	1			1		1	4
E4	395	4	1	1			1		1	4
E4	396	5	2	1			1		1	1
E5	397	100	68	22	35	10	230		1	2
E5	398	22	9	3			2		1	4
E5	399	135	77	22			246		1	

R3B4	Num	Length	Width	Thickn	P Width	P T/ness	Weight	P Angle	Mat	Type
Surface	400	6	7	1	6	1	1		1	1
Surface	401	10	15	3	9	3	1	66	1	2
Surface	402	8	8	1	5	1	1		1	2
Surface	403	17	9	1			1		1	4
Surface	404	14	11	2			1		1	4
Surface	405	11	9	2			1		1	4
Surface	406	11	7	5			1		1	4
Surface	407	10	9	2			1		1	4
Surface	408	10	7	3			1		1	4
Surface	409	13	4	1			1		1	4
Surface	410	11	7	1			1		1	4
Surface	411	7	8	1			1		1	4
Surface	412	6	7	1			1		1	4
Surface	413	11	7	2			1		1	4
Surface	414	11	6	2			1		1	4
Surface	415	6	10	2			1		1	4
Surface	416	8	6	1			1		1	4
Surface	417	7	7	1			1		1	4
Surface	418	9	5	2			1		1	4
Surface	419	9	6	1			1		1	4
Surface	420	11	4	1			1		1	4
Surface	421	4	4	1			1		1	4
Surface	422	4	4	1			1		1	4
Surface	423	5	3	1			1		1	4
Surface	424	6	4	1			1		1	4
Surface	425	5	3	1			1		1	4
Surface	426	5	3	1			1		1	4
Spit 1	427	38	31	3	28	4	14	65	1	1
Spit 1	428	38	18	2			3		1	2
Spit 1	429	45	42	17			41		1	4
Spit 1	430	12	12	2			2		1	4
Spit 1	431	23	10	3			2		1	4
Spit 1	432	18	12	1			2		1	4
Spit 1	433	10	10	1			1		1	4
Spit 1	434	10	8	1			1		1	4
Spit 1	435	9	4	1			1		1	4
Spit 1	436	8	3	1			1		1	4
Spit 1	437	2	1	1			1		1	4
Spit 1	438	2	1	1			1		1	4
Spit 1	439	3	1	1			1		1	4
Spit 1	440	5	2	1			1		1	4
Spit 2	441	25	15	4			3		1	4
Spit 2	442	11	5	1			2		1	4
Spit 3	443	12	9	2			3		1	4
Spit 4	444									
Spit 5	445									

R3 C2	Num	Length	Width	Thickn	P Width	P T/ness	Weight	P Angle	Mat	Type
Surface	450	29	20	2	9	1	5	70	1	1
Surface	451	42	55	9	19	3	34	65	1	1
Surface	452	13	30	1			7	80	1	1
Surface	453	12	6	2			1	64	1	1
Surface	454	20	14	2	11	1	2	59	1	1
Surface	455	6	6	1	4	1	1	83	1	1
Surface	456	11	8	1	8	1	1		1	1
Surface	457	80	22	11			44		1	2
Surface	458	28	30	4			8		1	2
Surface	459	48	27	4			12		1	2
Surface	460	28	34	6			16		1	2
Surface	461	28	19	6			10		1	2
Surface	462	17	22	1			4		1	2
Surface	463	57	11	4			17		1	2
Surface	464	14	34	2			7		1	2
Surface	465	11	12	3	10	1	2	80	1	2
Surface	466	11	15	1			1		1	2
Surface	467	19	9	1			1		1	2
Surface	468	5	8	1			1	64	1	2
Surface	469	6	19	1			1		1	2
Surface	470	9	15	1			2		1	2
Surface	471	12	12	1			2	84	1	2
Surface	472	11	19	1			1		1	2
Surface	473	9	4	1			1		1	2
Surface	474	8	12	2			2		1	2
Surface	475	26	22	2			8		1	4
Surface	476	41	22	4			15		1	4
Surface	477	22	11	2			6		1	4
Surface	478	32	24	4			11		1	4
Surface	479	20	15	4			7		1	4
Surface	480	38	33	2			9		1	4
Surface	481	4	6	1			1		1	4
Surface	482	9	6	1			1		1	4
Surface	483	12	7	1			1		1	4
Surface	484	11	10	1			1		1	4
Surface	485	16	19	2			2		1	4
Surface	486	14	5	1			1		1	4
Surface	487	14	7	1			1		1	4
Surface	488	14	7	1			1		1	4
Surface	489	14	5	1			1		1	4
Surface	490	15	8	2			1		1	4
Surface	491	6	8	1			1		1	4
Surface	492	4	6	1			1		1	4
Surface	493	12	5	1			1		1	4
Surface	494	8	6	2			1		1	4
Surface	495	8	2	1			1		1	4
Surface	496	10	4	3			2		1	4
Surface	497	6	4	1			1		1	4
Surface	498	6	2	2			1		1	4
Surface	499	4	2	2			1		1	4
Surface	500	5	4	1			1		1	4
Surface	501	5	2	1			1		1	4
Surface	502	5	2	1			1		1	4
Surface	503	3	3	1			1		1	4
Surface	504	1	2	1			1		1	4
Surface	505	2	2	1			1		1	4
Surface	506	4	2	1			1		1	4
Surface	507	4	2	1			1		1	4
Surface	508	2	2	1			1		1	4
Surface	509	6	2	1			1		1	4
Surface	510	6	2	1			1		1	4

R3 C2	Num	Length	Width	Thickn	P Width	P T/ness	Weight	P Angle	Mat	Type
Surface	511	6	2	1			1		1	4
Surface	512	6	2	1			1		1	4
Spit 1	513	22	30	3			9		1	2
Spit 1	514	20	15	5			4		1	2
Spit 1	515	12	14	5			5		1	2
Spit 1	516	11	9	2			2		1	2
Spit 1	517	24	20	5			7		1	4
Spit 1	518	45	30	4			16		1	4
Spit 1	519	30	18	7			8		1	4
Spit 1	520	9	5	1			1		1	4
Spit 1	521	8	10	1			2		1	4
Spit 1	522	20	6	3			3		1	4
Spit 1	523	12	7	3			1		1	4
Spit 1	524	8	6	1			1		1	4
Spit 1	525	9	5	1			1		1	4
Spit 1	526	5	5	1			1		1	4
Spit 1	527	2	3	1			1		1	4
Spit 1	528	3	2	1			1		1	4
Spit 1	529	3	2	1			1		1	4
Spit 2	530	40	30	5			9		1	2
Spit 2	531	11	20	1			3		1	4
Spit 2	532	12	14	1			3		1	4
Spit 2	533	12	10	1			2		1	4
Spit 2	534	15	5	2			1		1	4
Spit 2	535	12	5	1			1		1	4
Spit 2	536	12	5	2			1		1	4
Spit 2	537	10	4	1			1		1	4
Spit 3	538	30	25	7	18	8	11	105	1	1
Spit 3	539	34	34	4	20	4	16	104	1	2
Spit 3	540	11	5	1			1		1	4
Spit 4	541	8	20	1			3		1	2
Spit 4	542	36	20	10			13		1	4
Spit 4	543	20	16	2			3		1	4
Spit 4	544	10	6	2			1		1	4
Spit 4	545	3	2	1			1		1	4
Spit 4	546	2	2	1			1		1	4
Spit 4	547	1	2	1			1		1	4
Spit 5	548	22	28	3	18	2	7		1	2
Spit 5	549	11	13	1			3		1	2
Spit 5	550	15	5	1			2		1	4
Spit 5	551	12	5	1			1		1	4
Spit 5	552	17	5	2			1		1	4
Spit 5	553	2	2	1			1		1	4
Spit 5	554	3	2	1			1		1	4
Spit 5	555	3	1				1		1	4

R3 D5	Num	Length	Width	Thickn	P Width	P T/ness	Weight	P Angle	Mat	Type
Surface	560	96	110	31			25		1	2
Surface	561	16	19	2			3		1	2
Surface	562	13	13	1			1		1	4
Surface	563	2	1	1			1		1	4
Spit 1	564	22	30	3			9		1	2
Spit 1	565	20	15	5			4		1	2
Spit 1	566	12	14	5			5		1	2
Spit 1	567	11	9	2			2		1	2
Spit 1	568	24	20	5			7		1	4
Spit 1	569	45	30	4			16		1	4
Spit 1	570	30	18	7			8		1	4
Spit 1	571	9	5	1			1		1	4
Spit 1	572	8	10	1			2		1	4
Spit 1	573	20	6	3			3		1	4
Spit 1	574	12	7	3			1		1	4
Spit 1	575	8	6	1			1		1	4
Spit 1	576	9	5	1			1		1	4
Spit 1	577	5	5	1			1		1	4
Spit 1	578	2	3	1			1		1	4
Spit 1	579	3	2	1			1		1	4
Spit 1	580	3	2	1			1		1	4
Spit 2	581	40	30	5			9		1	2
Spit 2	582	11	20	1			3		1	4
Spit 2	583	12	14	1			3		1	4
Spit 2	584	12	10	1			2		1	4
Spit 2	585	15	5	2			1		1	4
Spit 2	586	12	5	1			1		1	4
Spit 2	587	12	5	2			1		1	4
Spit 2	588	10	4	1			1		1	4
Spit 3	589	30	25	7	18	8	11		1	1
Spit 3	590	34	34	4	20	4	16		1	2
Spit 3	591	11	5	1			1		1	4
Spit 4	592									
Spit 5	593									

R4 Surface	Num	Length	Width	T/ness	P width	P t/ness	Weight	P angle	Mat	Type
A1	600	75	35	10			29		1	1
A1	601	103	53	11	25	7	101	55	1	1
A1	602	48	47	12	31	8	48	85	1	1
A1	603	54	30	11	11	3	19		1	1
A1	604	19	16	5	10	3	3	86	1	1
A1	605	25	16	7		6	4	73	1	1
A1	606	29	14	5	15	5	2	71	2	1
A1	607	23	10	4	9	3	1	68	2	1
A1	608	30	41	14			21		1	1
A1	609	66	36	11			27		1	1
A1	610	61	27	12			21		1	1
A1	611	41	40	13			23		1	1
A1	612	26	18	8			2		1	1
A1	613	19	22	7			2		2	2
A1	614	25	24	7			6		2	2
A1	615	39	32	6	21	5	14		1	2
A1	616	42	52	15	39	8	45	76	1	2
A1	617	60	32	8			24		1	2
A1	618	42	30	13	3	11	23		1	2
A1	619	41	47	8	33	9	27	82	1	2
A1	620	44	72	12	24	8	43	72	1	2
A1	621	32	34	9	34	7	16	84	1	2
A1	622	21	30	7	19	5	6	84	1	2
A1	623	28	32	7	22	4	6	76	1	2
A1	624	23	11	8			3		2	2
A1	625	28	8	8			1		2	2
A1	626	29	47	9	22	6	16	91	1	2
A1	627	38	33	6			9		1	2
A1	628	21	34	5			2		1	2
A1	629	33	59	8			24		1	4
A1	630	11	8	2	4	2	0.2		4	4
A1	631	8	2	2			0.2		4	4
A1	632	11	9	2			0.2		4	4
A1	633	11	10	2			0.2		4	4
A1	634	10	7	1			0.2		4	4
A1	635	24	19	3			0.2		1	4
A1	636	25	15	4	7	3	1	76	1	2
A1	637	25	15	5	9	3	1	77	1	2
A1	638	21	20	7			3		1	4
A1	639	34	20	10			6		1	4
A1	640	27	24	5			3		1	4
A1	641	24	16	3			1		1	4
A1	642	28	17	6			2		1	4
A1	643	18	17	3			1		1	4
A1	644	18	16	4			1		1	4
A1	645	29	14	6			2		1	4
A1	646	28	13	4			2		1	4
A1	647	26	19	4			3		1	4
A1	648	22	21	4			1		1	4

R4 Surface	Num	Length	Width	T/ness	P width	P t/ness	Weight	P angle	Mat	Type
A1	649	22	17	5			2		1	4
A1	650	33	31	5			6		1	4
A1	651	57	51	13			44		1	4
A1	652	28	27	6			5		1	4
A1	653	27	28	8			9		1	4
A1	654	32	20	10			6		1	4
A1	655	28	23	9			5		1	4
A1	656	26	23	4			3		1	4
A1	657	28	20	6			2		1	4
A1	658	22	43	4			4		1	4
A1	659	37	34	5			8		1	4
A1	660	23	21	6			2		1	4
A1	661	24	21	3			2		1	4
A1	662	14-25xn34					91		1	4
A1	663	27	8	5			1		2	4
A1	664	31	20	18			11		3	4
A1	665	25	19	11			7		3	4
A1	666	1x14xn 22					19		3	4
A1	667	15-25x n15					32		3	4
A1	668	1-14xn2					2		4	4
A1	669	15-25xn3					3		4	4
A1	670	115	105	65			1324		2	9
A1	671	111	73	49			546		2	9
A1	672	115	99	42			678		muds	9
A1	673	1-14xn258					130		1	
A2	674	47	21	7	17	5	10	68	1	1
A2	675	65	28	11	18	5	28	86	1	1
A2	676	34	21	4	9	2	4	76	1	1
A2	677	12	15	4	9	3	2	72	1	2
A2	678	27	32	11			9		1	2
A2	679	26	36	11			15		1	2
A2	680	39	24	6			26		1	2
A2	681	27	18	8	14	6	4	74	2	2
A2	682	24	13	7	6	4	3	76	2	2
A2	683	21	17	7			3		2	2
A2	684	36	24	9			7		1	4
A2	685	33	23	6			5		1	4
A2	686	37	28	11			12		1	4
A2	687	26	23	8			11		1	2
A2	688	45	29	5			16		1	4
A2	689	15-25n 20					76		1	4
A2	690	2-14 x 62					35		1	4
A2	691	24	12	7					3	4
A2	692	16	14	10			3		3	4
A2	693	16	8	3			0.2		3	4
A2	694	12	11	4			0.2		3	4
A2	695	10	10	4			0.2		3	4
A2	696	10	8	2			0.2		3	4
A2	697	4	4	1			0.2		3	4
A2	698	1-14xn2					1		4	4
A3	699	53	46	11			30		1	1
A3	700	14	22	4	18	5	2	86	1	1
A3	701	110	96	31			471		1	7
A3	702	44	28	8			10		1	1
A3	703	44	31	9			16		1	2
A3	704	45	42	8	34	6	26	90	1	2
A3	705	27	21	10	22	7	6	79	1	2
A3	706	38	32	7			15		1	2
A3	707	38	27	14			24		1	4
A3	708	31	27	6			3		1	4
A3	709	12	23	7			5		1	4

R4 Surface	Num	Length	Width	T/ness	P width	P t/ness	Weight	P angle	Mat	Type
A3	710	33	20	6			5		1	4
A3	711	25	23	3			3		1	4
A3	712	31	12	4			3		1	4
A3	713	3	14	8			3		1	4
A3	714	1-14n88					47		1	4
A3	715	15-25xn30					53		1	4
A3	716	19	9	5			0.5		2	4
A3	717	23	10	4			0.5		2	4
A3	718	19	10	4			0.5		2	4
A3	719	20	14	3			1		2	4
A3	720	15	7	5			1		2	4
A3	721	13	9	7			1		2	1
A3	722	14	12	4			1		2	2
A3	723	12	12	5			1		2	4
A3	724	13	7	4			1		2	4
A3	725	12	7	3			1		2	4
A3	726	12	4	2			1		2	4
A3	727	16	7	2			1		2	4
A3	728	13	5	2			1		2	4
A3	729	14	6	4			1		2	4
A3	730	22	3	4			1		4	4
A3	731	16	12	3					4	4
A3	732	16	10	3					4	4
A3	733	9	14	4					4	4
A3	734	13	7	4					4	4
A3	735	13	11	3					4	4
A3	736	10	8	1					4	4
A3	737	9	4	3					4	4
A3	738	11	13	2	10	1	1		4	4
A3	739	1-15n6					3		4	4
A3	740	29	16	12			6		3	4
A3	741	23	15	7			2		3	4
A3	742	24	17	9			2		3	4
A3	743	21	8	3			0.5		3	4
A3	744	19	12	4			0.5		3	4
A3	745	13	13	3			0.5		3	4
A3	746	14	11	4			0.5		3	4
A3	747	14	11	3			0.5		3	4
A3	748	19	7	4			0.5		3	4
A4	749	36	34	6	12	3	9	82	1	1
A4	750	78	50	14					2/ gri	1
A4	751	36	32	11					2/ gri	1
A4	752	45	38	13	18	5	29	88	1	1
A4	753	24	40	8	16	6	8	75	1	1
A4	754	27	34	9	15	5	11	86	1	1
A4	755	25	21	7	15	4	3	80	1	1
A4	756	33	32	6	16	6	11	83	1	1
A4	757	47	16	19	10	2	7	88	1	1
A4	758	26	25	7	6	3	6	87	1	1
A4	759	20	16	3	11	3	1	78	1	1
A4	760	30	15	7	13	5	3	78	2	1
A4	761	14	18	7	14	6	2	78	2	1
A4	762	35	36	8			16		1	1
A4	763	30	33	9			9		1	1
A4	764	45	21	6			9		1	1
A4	765	17	23	7			4		1	1
A4	766	42	24	8	15	4	18	82	1	2
A4	767	31	27	5	9	3		81	1	2
A4	768	26	25	11	18	6	10	84	1	2
A4	769	20	30	4	12	3	3	86	1	2
A4	770	29	18	7	14	7	4	74	2	2

R4 Surface	Num	Length	Width	T/ness	P width	P t/ness	Weight	P angle	Mat	Type
A4	771	24	14	4	12	4	2	74	2	2
A4	772	27	23	11			7		1	2
A4	773	29	29	9			8		1	2
A4	774	29	34	6	24	5	10		1	2
A4	775	24	21	7					1	2
A4	776	17	19	4	11	3	2		1	2
A4	777	21	16	6	6	2	2		2	2
A4	778	20	4	5			2		2	2
A4	779	33	25	11			7		1	4
A4	780	31	28	11			14		1	4
A4	781	27	34	9			11		1	2
A4	782	25	26	7			6		1	4
A4	783	35	24	12			11		1	4
A4	784	35	35	9			13		1	4
A4	785	25	17	12			5		1	4
A4	786	35	25	5			6		1	4
A4	787	23	20	9			3		1	4
A4	788	29	20	5			3		1	4
A4	789	17	19	4			1		1	4
A4	790	17	15	4			1		1	4
A4	791	24	13	4			2		1	4
A4	792	14	17	4			1		1	4
A4	793	20	14	3			1		1	4
A4	794	21	15	4			1		1	4
A4	795	19	13	3			1		1	4
A4	796	1-14xn54	W25						1	4
A4	797	1-25x30	W30						3	4
A4	798	18	7	4			1		2	4
A4	799	28	26	8			9		2	4
A4	800	26	14	4			2		2	4
A4	801	34	19	4			6		2	4
A4	802	21	11	9			2		2	4
A4	803	23	11	4			1		2	4
A4	804	21	12	3			1		2	4
A4	805	15-25xn6					6		2	4
A4	806	1-14xn8					7		2	4
A4	807	1x14n4					4		4	4
A4	808	15-25xn4					8		4	4
A5	809	72	55	17	51	19	82	74	1	1
A5	810	56	33	11			31		1	2
A5	811	42	38	11			33		1	2
A5	812	64	42	13	33	13	52	89	1	2
A5	813	29	18	8			6		1	4
A5	814	48	39	7			21		1	4
A5	815	44	25	8			17		1	4
A5	816	17	17	7	19	4	3	84	1	2
A5	817	15-25xn8					12		1	4
A5	818	1-14xn49					20		1	4
A5	819	32	37	6			15		1	4
A5	820	24	33	6			8		1	4
A5	821	22	27	4	7	3	4		1	2
A5	822	16	21	5	15	4	13		1	2
A5	823	27	24	4	10	2	2	82	1	4
A5	824	23	13	5	7	2	2		1	1
A5	825	20	11	4	9	3	2	62	4	4
A5	826	28	24	9	22	7	9		2	2
A5	827	32	19	10	19	8	5	83	2	2
A5	828	33	31	8	18	6	12	87	2	2
A5	829	29	21	7			5		2	4
A5	830	28	18	5			2		2	4
A5	831	20	18	8			2		2	4

R4 Surface	Num	Length	Width	T/ness	P width	P t/ness	Weight	P angle	Mat	Type
A5	832	25	12	6			2		2	4
A5	833	21	14	6			3		2	4
A5	834	14	14	3			1		2	4
A5	835	14	12	4			1		2	4
A5	836	1-14x21					8		2	4
A5	837	15-25x6					18		2	4
A5	838	1-14xn5					2		4	4
D1	839	48	45	13	33	8	37	82	1	1
D1	840	45	46	12	20	5	25	82	1	1
D1	841	42	43	13	32	15	29	65	1	1
D1	842	32	24	6	19	4	7	84	1	1
D1	843	30	33	5	11	4	5	87	1	1
D1	844	26	20	7	12	5	3		1	1
D1	845	35	24	7	20	6	6	89	2	1
D1	846	89	45	18			69		1	1
D1	847	52	41	8			20		1	1
D1	848	88	81	21	38	12	154		1	1
D1	849	48	35	10	31	4	25		1	1
D1	850	80	48	9	16	8	55		1	1
D1	851	45	38	11			21		1	1
D1	852	52	39	10	15	2	24		1	1
D1	853	66	29	12	13	9	28		1	1
D1	854	43	45	10			33		1	1
D1	855	27	18	5			2		2	1
D1	856	79	48	22			101		1	2
D1	857	51	40	11	18	7	33	86	1	2
D1	858	64	30	13	21	7	37	82	1	2
D1	859	55	61	12	42	12	60	82	1	2
D1	860	113	66	24	51	22	205	82	1	2
D1	861	38	45	13	20	12	27	76	1	2
D1	862	44	37	9	19	5	18	82	1	2
D1	863	60	45	9	29	5	30	87	1	2
D1	864	37	32	10	15	5	13	88	1	2
D1	865	29	28	11	11	4	9	82	1	2
D1	866	53	41	10	31	7	25		1	2
D1	867	55	62	14			75		1	2
D1	868	21	24	24	4		3		1	2
D1	869	21	19	19	5		2		1	2
D1	870	26	26	26	6		4		1	2
D1	871	26	29	29	6	25	4		1	2
D1	872	28	27	27	5		4		1	2
D1	873	27	20	20	6		3		1	2
D1	874	16	20	6	14	5	2	82	1	2
D1	875	22	25	5	17	5	21	83	1	2
D1	876	30	40	6			11		1	2
D1	877	33	34	4			5		1	2
D1	878	23	28	7	23	5	3	88	1	2
D1	879	28	27	5			4		1	2
D1	880	11	8	2			>1		4	2
D1	881	29	15	9			2		1	2
D1	882	23	18	4			4		1	2
D1	883	38	29	6			10		1	2
D1	884	37	29	13			16		1	2
D1	885	42	53	8			29		1	2
D1	886	47	42	6			14		1	2
D1	887	41	37	37	8		15		1	2
D1	888	34	21	4			3		1	4
D1	889	26	19	4			2		1	4
D1	890	27	21	4			2		1	4
D1	891	27	19	4			2		1	4
D1	892	54	41	8			24		1	4

R4 Surface	Num	Length	Width	T/ness	P width	P t/ness	Weight	P angle	Mat	Type
D1	893	31	35	7			13		1	4
D1	894	55	40	36			91		1	4
D1	895	24	32	7			7		1	4
D1	896	32	23	6			7		1	4
D1	897	34	24	4			5		1	4
D1	898	19	35	10			6		1	4
D1	899	15-25n31					65		1	4
D1	900	1-14n39					16		1	4
D1	901	28	30	12			14		2	4
D1	902	27	30	11			11		2	4
D1	903	1-10n4					1		4	4
D1	904	15-25n4					10		2	4
D1	905	1-14n15					7		2	4
D1	906	38	24	13			13		4	10
D2	907	46	17	7	22	4	10	84	1	1
D2	908	37	33	10	16	6	14	84	1	1
D2	909	57	27	10	17	6	14	79	1	1
D2	910	46	31	15			23	96	1	1
D2	911	23	22	5	17	4	21	78	1	1
D2	912	14	15	4	12	3	2	82	1	1
D2	913	14	16	4	15	4	3	64	1	1
D2	914	47	48	17	30	15	49	103	2	1
D2	915	35	22	10	15	7	5	73	2	1
D2	916	59	38	41	11	4	19		1	1
D2	917	42	27	7			10		1	1
D2	918	22	35	5			4		1	1
D2	919	45	36	41	31	12	21		1	1
D2	920	79	45	9	15	3	47		1	1
D2	921	21	11	3			1		4	1
D2	922	37	40	6	12	3	14	86	1	2
D2	923	25	30	11		8	9	75	1	2
D2	924	25	22	5			3	84	1	2
D2	925	31	24	8			9	69	1	2
D2	926	18	22	4	15	3	2	87	1	2
D2	927	28	16	4	9	2	2	86	1	2
D2	928	16	16	16	6	11	6	75	1	2
D2	929	57	32	9	21	4	23	83	2	2
D2	930	44	15	6	8	6	6	51	greer	2
D2	931	27	14	6	15	5	3	84	2	2
D2	932	28	34	7	11	5	8	81	2	2
D2	933	19	15	4			2		1	2
D2	934	18	29	6			4		1	2
D2	935	34	24	5			3		1	2
D2	936	19	24	5			3		1	2
D2	937	67	49	25	46	21	136		2	2
D2	938	21	20	10			4		2	2
D2	939	35	23	8			9		2	2
D2	940	21	16	3			2		2	2
D2	941	40	27	8			10		1	2
D2	942	26	25	4					1	2
D2	943	49	27	10	14	2	18		1	2
D2	944	40	31	10			27		1	2
D2	945	36	27	11			6		1	2
D2	946	35	25	10			16		1	2
D2	947	23	25	8		6	10		1	2
D2	948	23	14	4			3		1	2
D2	949	82	41	9			75		muds	4
D2	950	38	26	5			7		1	4
D2	951	40	27	11	22	6	15	77	1	2
D2	952	35	38	8	21	4	8		1	4
D2	953	27	37	7	17	4	8		1	2

R4 Surface	Num	Length	Width	T/ness	P width	P t/ness	Weight	P angle	Mat	Type
D2	954	14	13	7	8	2	2		1	4
D2	955	14	17	3	13	3	2	85	1	2
D2	956	16	18	4			2		1	4
D2	957	18	24	6			5		1	4
D2	958	26	25	5			3		1	4
D2	959	25	21	6			2		1	4
D2	960	18	16	4	8	4	2	74	1	2
D2	961	1-14xn55					24		1	4
D2	962	15-25xn26					62		1	4
D2	963	1-15xn8					3		4	4
D2	964	30	30	7			8		1	4
D2	965	54	28	8			20		1	4
D2	966	20	18	3			3		1	4
D2	967	50	45	8			36		1	4
D2	968	7	14	4			1		1	4
D2	969	30	24	11			10		2	4
D2	970	17	21	7			2		2	4
D2	971	24	14	6			2		2	4
D2	972	70	64	19			109		3	4
D2	973	27	30	12			7		3	4
D2	974	1-14xn51					27		3	4
D2	975	104	91	28			562		1	7
D3	976	40	47	13	24	7	25	78	1	1
D3	977	31	42	8	28	6	17	84	1	1
D3	978	13	15	5	10	4	1	89	2	1
D3	979	13	15	5	10	4	1	89	1	2
D3	980	47	38	6	17	3	16		1	2
D3	981	25	24	6	14	3	5		1	2
D3	982	31	47	11	26	6	15		1	2
D3	983	18	25	4			2		1	2
D3	984	22	30	5			5		2	2
D3	985	25	23	5			4		2	2
D3	986	11	11	4	6	2	1		2	2
D3	987	31	27	7			10		1	4
D3	988	18	34	4			3		1	4
D3	989	20	20	4			2		1	4
D3	990	21	13	4			1		1	4
D3	991	16	20	4			1		1	4
D3	992	30	12	5			2		1	4
D3	993	19	15	4			2		1	4
D3	994	1-15xn.19					7		1	4
D3	995	21	19	11			6		2	4
D3	996	16	12	9			2		2	4
D4	997	30	37	7	22	6	15	94	1	1
D4	998	18	15	4	9	4	2	82	1	1
D4	999	12	10	3	10	3	1		1	1
D4	1000	74	24	1	12	9	29	70	1	1
D4	1001	38	36	9		7			1	1
D4	1002	40	33	6	21	5	13		1	1
D4	1003	21	34	8	16	3	7		1	1
D4	1004	28	29	9	13	4	7		1	1
D4	1005	19	19	4	7	3	1		1	1
D4	1006	30	13	10			4		2	1
D4	1007	32	37	6	25	4	12	84	1	2
D4	1008	32	27	6	16	3	6	78	1	2
D4	1009	21	34	8	24	6	8	74	1	2
D4	1010	31	30	9	13	3	9		1	2
D4	1011	30	27	10	20	8	6	78	2	2
D4	1012	2	19	7	18	7	2	82	2	2
D4	1013	26	21	6			3		1	2
D4	1014	21	24	6			3		1	2

R4 Surface	Num	Length	Width	T/ness	P width	P t/ness	Weight	P angle	Mat	Type
D4	1015	21	16	7			2		1	2
D4	1016	55	49	11			29		1	2
D4	1017	23	25	10			6		1	2
D4	1018	32	18	8			4		2	2
D4	1019	27	10	5			2		2	2
D4	1020	29	24	4			4		1	4
D4	1021	24	29	3			2		1	4
D4	1022	22	21	4			4		1	4
D4	1023	22	21	7			3		1	4
D4	1024	28	29	4			2		1	4
D4	1025	20	19	4			2		1	4
D4	1026	21	15	8			3		1	4
D4	1027	22	16	8			2		1	4
D4	1028	22	16	4			1		1	4
D4	1029	22	14	4			1		1	4
D4	1030	17	14	4			1		1	4
D4	1031	22	12	4			1		1	4
D4	1032	24	20	10			3		2	4
D4	1033	20	14	8			2		2	4
D4	1034	1-15xn10					6		2	4
D4	1035	1-15xn48					4		1	4
D4	1036	110	107	34			592		1	7
D5	1037	102	93	54			not rec		1	7
D4	1038	115	119	64			996		1	7
D4	1039	158	127	42			1152		2	8/particle

R4 A3	No	Length	Width	T/ness	P width	P /ness	Weight	P angle	Mat	Type
surface	1050	53	46	11			30		1	1
surface	1051	14	22	4	18	5	2	86	1	1
surface	1052	44	28	8			10		1	1
surface	1053	44	31	9			16		1	2
surface	1054	45	42	8	34	6	26	90	1	2
surface	1055	27	21	10	22	7	6	79	1	2
surface	1056	38	32	7			15		1	2
surface	1057	38	27	14			24		1	4
surface	1058	31	27	6			3		1	4
surface	1059	31	12	4			3		1	4
surface	1060	33	20	6			5		1	4
surface	1061	1-14n90					55		1	4
surface	1062	15-25xn30					56		1	4
surface	1063	110	96	31			471		1	7
surface	1064	19	9	5			0.5		2	4
surface	1065	23	10	4			0.5		2	4
surface	1066	19	10	4			0.5		2	4
surface	1067	20	14	3			1		2	4
surface	1068	15	7	5			1		2	4
surface	1069	13	9	7			1		2	4
surface	1070	14	12	4			1		2	4
surface	1071	12	12	5			1		2	4
surface	1072	13	7	4			1		2	4
surface	1073	12	7	3			1		2	4
surface	1074	12	4	2			1		2	4
surface	1075	16	7	2			1		2	4
surface	1076	13	5	2			1		2	4
surface	1077	14	6	4			1		2	4
surface	1078	29	16	12			6		3	4
surface	1079	23	15	7			2		3	4
surface	1080	24	17	9			2		3	4
surface	1081	21	8	3			0.5		3	4
surface	1082	19	12	4			0.5		3	4
surface	1083	13	13	3			0.5		3	4
surface	1084	14	11	4			0.5		3	4
surface	1085	14	11	3			0.5		3	4
surface	1086	19	7	4			0.5		3	4
surface	1087	22	3	4			1		4	4
surface	1088	16	12	3			1		4	4
surface	1089	16	10	3			1		4	4
surface	1090	9	14	4			1		4	4
surface	1091	13	7	4			1		4	4
surface	1092	13	11	3			1		4	4
surface	1093	10	8	1			1		4	4
surface	1094	9	4	3			1		4	4
surface	1095	11	13	2			1		4	4
surface	1096	1-14n6					3		4	4
Spit 1	1097	31	45	8			14		1	1
Spit 1	1098	32	34	3	21	4	12		1	1
Spit 1	1099	34	22	7	11	4	4	72	1	1
Spit 1	1100	37	21	6	14	5	4	76	1	1
Spit 1	1101	35	20	5	16	5	6		1	1
Spit 1	1102	16	10	3	5	3	1	70	1	1
Spit 1	1103	29	21	5	12	3	2		1	1
Spit 1	1104	22	17	5			2		1	1
Spit 1	1105	21	16	5			3		1	1
Spit 1	1106	54	44	8	31	4	33	88	1	2
Spit 1	1107	16	16	5	16	5	4		1	2
Spit 1	1108	14	12	3			1		1	2
Spit 1	1109	13	19	4	7	1	3		1	2
Spit 1	1110	17	10	3	11	4	3		1	2

R4 A3	No	Length	Width	T/ness	P width	P /ness	Weight	P angle	Mat	Type
Spit 1	1111	10	15	3	5	2	2		1	2
Spit 1	1112	15	14	3			2		1	2
Spit 1	1113	11	12	5			1		1	2
Spit 1	1114	26	38	11	33	9	20	75	1	2
Spit 1	1115	51	29	8	25	5	20	54	1	2
Spit 1	1116	31	59	40	47	6	38	92	1	2
Spit 1	1117	49	32	8	27	10	13	88	1	2
Spit 1	1118	31	29	10	33	9	13	88	1	2
Spit 1	1119	35	29	10	24	8	12	74	1	2
Spit 1	1120	27	22	8			6		1	2
Spit 1	1121	22	34	10	25	9	11	71	1	2
Spit 1	1122	31	32	11	31	11	16	94	1	2
Spit 1	1123	24	32	8	14	1	9	89	1	2
Spit 1	1124	26	30	5	12	5	7		1	2
Spit 1	1125	23	21	7	25	7	5		1	2
Spit 1	1126	19	16	6	12	5	4	60	1	2
Spit 1	1127	16	17	6	12	4	2		1	2
Spit 1	1128	24	18	6	8	3	3	96	1	2
Spit 1	1129	20	20	5	10	1	2	82	1	2
Spit 1	1130	33	30	6	23	8	4		1	2
Spit 1	1131	16	17	3	10	1	2	82	1	2
Spit 1	1132	27	33	8	22	9	16	69	1	2
Spit 1	1133	15	21	8	16	7	4	73	1	2
Spit 1	1134	24	17	4			3		1	2
Spit 1	1135	31	14	6			3		1	2
Spit 1	1136	32	15	9	8	3	2	89	1	2
Spit 1	1137	24	14	6	12	5	2	67	1	2
Spit 1	1138	15	15	4	8	3	3	89	1	2
Spit 1	1139	55	48	10			32		1	2
Spit 1	1140	27	30	6			5		1	4
Spit 1	1141	32	31	8			15		1	4
Spit 1	1142	37	21	8			7		1	4
Spit 1	1143	1-14x198					120		1	4
Spit 1	1144	15-25x70					188		1	4
Spit 1	1145	38	19	11	13	8	6		2	1
Spit 1	1146	28	20	9	11	6	6	79	2	1
Spit 1	1147	32	19	13	14	7	9	78	2	1
Spit 1	1148	25	23	9	12	8	6	83	2	1
Spit 1	1149	23	9	8	7	6	2		2	1
Spit 1	1150	16	7	4			1		2	2
Spit 1	1151	17	8	4			1		2	2
Spit 1	1152	18	15	4			1		2	2
Spit 1	1153	17	8	3			1		2	2
Spit 1	1154	26	18	12			8		2	4
Spit 1	1155	26	13	12			2		2	4
Spit 1	1156	1-5x71					41		2	4

Appendix A Lake Moondarra

R4 A3	No	Length	Width	T/ness	P width	P /ness	Weight	P angle	Mat	Type
Spit 2	1160	20	19	4	6	2	1		1	1
Spit 2	1161	16	11	4	6	2	1		1	1
Spit 2	1162	19	10	3	5	1	1		1	1
Spit 2	1163	29	22	7	15	3	4	74	1	1
Spit 2	1164	30	21	5	8	3	3	78	1	1
Spit 2	1165	13	8	4	4	3	1	82	1	1
Spit 2	1166	13	23	7			3		1	1
Spit 2	1167	14	22	5			2		1	1
Spit 2	1168	16	22	5			2		1	1
Spit 2	1169	16	15	3			1		1	1
Spit 2	1170	14	11	3			1		1	2
Spit 2	1171	25	23	4	17	3	3	92	1	2
Spit 2	1172	34	25	1	12	3	9	82	1	2
Spit 2	1173	34	32	8	20	4		89	1	2
Spit 2	1174	21	20	5	17	4	2	83	1	2
Spit 2	1175	27	35	9	28	9	9	72	1	2
Spit 2	1176	24	18	5	11	4	21	77	1	2
Spit 2	1177	20	16	4	13	2	2	83	1	2
Spit 2	1178	15	17	3	10	3	2	86	1	2
Spit 2	1179	15	15	3	8	2	2	86	1	2
Spit 2	1180	26	13	4	5	3	1	83	1	2
Spit 2	1181	27	28	8			8		1	2
Spit 2	1182	35	28	7			8		1	2
Spit 2	1183	24	26	8	21	5	5		1	2
Spit 2	1184	29	20	8	10	3	8		1	2
Spit 2	1185	9	21	5	18	5	3		1	2
Spit 2	1186	25	20	6			2		1	2
Spit 2	1187	17	24	6	11	5	4		1	2
Spit 2	1188	17	15	3	16	2	2		1	2
Spit 2	1189	17	15	4	11	3	1	64	1	2
Spit 2	1190	30	18	5			4		1	4
Spit 2	1191	15-25xn24					45		1	4
Spit 2	1192	1-14xn169					63		1	4
Spit 2	1193	25	14	6	10	2	3	84	2	2
Spit 2	1194	22	21	7			2		2	2
Spit 2	1195	33	23	17			14		2	4
Spit 2	1196	29	16	15			8		2	4
Spit 2	1197	1-14xn51					17		2	4
Spit 2	1198	24	10	7			2		2	4
Spit 2	1199	20	7	7			4		2	4
Spit 2	1220	17	15	6			2		2	4

R4 A3	No	Length	Width	T/ness	P width	P /ness	Weight	P angle	Mat	Type
Spit 2	1221	13	19	4			1		2	4
Spit 2	1222	1-14xn10					3		2	4
Spit 2	1223	22	8	4			1		4	4
Spit 2	1224	1-14xn3					1		4	4
Spit 3	1225	26	17	3	8	2	2	121	1	1
Spit 3	1226	22	17	6	15	5	4	84	1	1
Spit 3	1227	16	10	3	5	2	1		1	1
Spit 3	1228	14	12	4	6	2	1		1	1
Spit 3	1229	44	37	11	29	7	18	64	1	1
Spit 3	1230	14	13	3	6	1	1		1	1
Spit 3	1231	11	11	2	7	2	1	40	1	1
Spit 3	1232	21	11	6	8	5	2	101	1	1
Spit 3	1233	27	21	9	21	6	6	91	1	1
Spit 3	1234	16	11	5	10	4	1	84	1	1
Spit 3	1235	17	27	5			4		1	2
Spit 3	1236	17	10	3			1		1	2
Spit 3	1237	14	11	2	4	1	1		1	2
Spit 3	1238	21	13	6			3		1	2
Spit 3	1239	19	13	5			1		1	2
Spit 3	1240	25	25	5			3		1	4
Spit 3	1241	24	10	6			1		1	4
Spit 3	1242	15-25xn11					16		1	4
Spit 3	1243	1-14xn128					47		1	4
Spit 3	1244	27	14	10			4		2	4
Spit 3	1245	15-25xn2					8		2	4
Spit 3	1246	1-14xn17					5		2	4
Spit 4	1247	28	24	7	10	2	6	88	1	1
Spit 4	1248	24	4	4	9	2	3	78	1	1
Spit 4	1249	16	15	6	11	2	2	86	1	1
Spit 4	1250	15	13	3	6	1	2		1	2
Spit 4	1251	1-14xn86					23		1	4
Spit 4	1252	16	15	3			1		4	2
Spit 4	1253	22	19	5			2		4	4
Spit 4	1254	25	18	11			5		4	10
Spit 4	1255	37	34	24			36		2	2
Spit 4	1256	12	10	3	9	2	1	64	2	2
Spit 4	1257	12	15	6	12	6			2	2
Spit 4	1258	1-14xn13					2		2	4
Spit 4	1259	15-15xn4					29		2	4
Spit 5	1260	21	23	6			3		1	2
Spit 5	1261	16	16	5	12	4	3		1	2
Spit 5	1262	1-14xn26					3		3	4
Spit 5	1263	15-25xn5					8		1	4
Spit 5	1264	1-14xn32					8		1	4
Spit 6	1265	14	18	7	15	7	2		1	2
Spit 6	1266	15-25xn5					6		1	4
Spit 6	1267	1-14xn20					3		1	4
Spit 6	1268	15-25xn1					4		2	4
Spit 6	1269	1-14xn15					2		3	4
Spit 6	1270	15-25xn1					2		3	4
Spit 7	1271	18	19	3	16	4	2	86	1	2
Spit 7	1272	1-14xn6					2		1	4
Spit 7	1273	1-14 xn4					2		3	4
Spit 8	1274									
Spit 9	1275									
Spit 10	1276	40	18	11	27	8	9	76	2	1
Spit 10	1277	16	14	4			1		2	4
Spit 10	1278	1-14xn2					1		2	4
Spit 11	1279	40	22	11			15		1	2
Spit 11	1280	17	9	4			2		2	4
Spit 12	1281									
Spit 13	1282									

Spit 14	1283
Spit 15	1284

R4D2	No	Length	Width	T/ness	P width	P /ness	Weight	P angle	Mat	Type
Surface	1290	42	27	7			10		1	1
Surface	1291	22	35	5			4		1	1
Surface	1292	19	17	5			2		1	1
Surface	1293	14	16	4	15	4	3	64	1	1
Surface	1294	26	25	4		25	4		1	2
Surface	1295	37	40	6	12	3	14	86	1	2
Surface	1296	49	27	10	14	2	18		1	2
Surface	1297	25	30	11		8	9	75	1	2
Surface	1298	25	22	5			3	84	1	2
Surface	1299	31	24	8			9	69	1	2
Surface	1300	18	22	4	15	3	2	87	1	2
Surface	1301	28	16	4	9	2	2	86	1	2
Surface	1302		16	16	6	11	6	75	1	2
Surface	1303	18	29	6			4		1	2
Surface	1304	34	24	5			3		1	2
Surface	1305	23	14	4			3		1	2
Surface	1306	19	24	5			3		1	2
Surface	1307	19	15	4			2		1	2
Surface	1308	79	45	9	15	3	47		1	2
Surface	1309	37	45	11			24		1	2
Surface	1310	35	25	10			16		1	2
Surface	1311	23	25	8			10		1	2
Surface	1312	40	31	10			27		1	2
Surface	1313	26	25	5			3		1	2
Surface	1314	40	27	10			10		1	2
Surface	1315	36	27	11			6		1	2
Surface	1316	38	26	5			7		1	2
Surface	1317	40	27	11	22	6	15	77	1	2
Surface	1318	35	38	8	21	4	8		1	2
Surface	1319	27	37	7	17	4	8		1	2
Surface	1320	14	13	7	8	2	2		1	2
Surface	1321	14	17	3	13	3	2	85	1	2
Surface	1322	16	18	4			2		1	2
Surface	1323	18	24	6			5		1	2
Surface	1324	25	21	6			2		1	2
Surface	1325	18	16	4	8	4	2	74	1	2
Surface	1326	30	30	7			8		1	4
Surface	1327	54	28	8			20		1	4
Surface	1328	20	18	3			3		1	4
Surface	1329	50	45	8			36		1	4
Surface	1330	1-14xn55					24		1	4
Surface	1331	15-25xn27					63		1	4
Surface	1332	104	91	28			562		1	7
Surface	1333	44	15	6	8	6	6	51	2	2
Surface	1334	57	32	9	21	4	23	83	2	2
Surface	1335	67	49	25	46	21	136		2	2
Surface	1336	27	14	6	15	5	3	84	2	2
Surface	1337	28	34	7	11	5	8	81	2	2
Surface	1338	21	20	10			4		2	2
Surface	1339	35	23	8			9		2	2
Surface	1340	21	16	3			21		2	2
Surface	1341	30	24	11			10		2	4
Surface	1342	17	21	7			2		2	4
Surface	1343	24	14	6			2		2	4
Surface	1344	70	64	19			109		3	4
Surface	1345	27	30	12			7		3	4
Surface		35	35	26			43		3	4
Surface	1346	1-14xn51					27		3	4
Surface	1347	21	11	3			1		4	2
Surface	1348	1-14xn8					3		4	4
Surface	1349	82	41	9			75		5	4

R4 D2	Num	Length	Width	T/ness	P width	P /ness	Weight	P angle	Mat	Type
Spit 1	1350	66	46	19			64		1	1
Spit 1	1351	20	28	5	22	4	3		1	1
Spit 1	1352	29	10	7	10	6	4	73	1	1
Spit 1	1353	23	15	4			2	85	1	1
Spit 1	1354	24	27	4			4		1	1
Spit 1	1355	13	17	4			1		1	1
Spit 1	1356	18	17	5			1		1	1
Spit 1	1357	37	27	5	14	3	6	101	1	2
Spit 1	1358	42	34	8	22	5	14	94	1	2
Spit 1	1359	38	27	7	13	4	12	94	1	2
Spit 1	1360	21	21	6	12	4	4	76	1	2
Spit 1	1361	17	22	3	10	2	3	90	1	2
Spit 1	1362	35	23	41	15	6	8	82	1	2
Spit 1	1363	28	22	6	11	5	3	82	1	2
Spit 1	1364	14	17	4	11	3	2	91	1	2
Spit 1	1365	15	15	3	9	3	1	69	1	2
Spit 1	1366	24	13	5	12	5	1	64	1	2
Spit 1	1367	37	26	7			9		1	2
Spit 1	1368	22	21	7			5		1	2
Spit 1	1369	20	21	5			3		1	2
Spit 1	1370	19	19	6			4		1	2
Spit 1	1371	34	31	7	19	2	10		1	2
Spit 1	1372	28	35	6	12	5	5		1	2
Spit 1	1373	22	22	7	16	5	6		1	2
Spit 1	1374	27	20	5			3		1	2
Spit 1	1375	15	19	5			3		1	2
Spit 1	1376	17	18	4			2		1	2
Spit 1	1377	16	20	4			2		1	2
Spit 1	1378	15	17	4			2		1	2
Spit 1	1379	29	36	8			11		1	4
Spit 1	1380	36	30	6			6		1	4
Spit 1	1381	30	18	6			4		1	4
Spit 1	1382	26	26	7			4		1	4
Spit 1	1383	31	8	4			3		1	4
Spit 1	1384	29	33	6			7		1	4
Spit 1	1385	24	21	4			3		1	4
Spit 1	1386	22	29	4			2		1	4
Spit 1	1387	28	14	4			4		1	4
Spit 1	1388	26	13	5			2		1	4
Spit 1	1389	26	18	5			2		1	4
Spit 1	1390	1--14x85					46		1	4
Spit 1	1391	15--25x61					83		1	4
Spit 1	1392	32	21	6			6		1	4
Spit 1	1393	35	20	8	14	5	3	81	2	1
Spit 1	1394	54	23	8	18	6	9	64	2	1
Spit 1	1395	49	20	8	22	10	11	75	2	1
Spit 1	1396	34	36	8	12	6	7		2	1
Spit 1	1397	28	17	6	15	5	2		2	1
Spit 1	1398	36	22	10	15	10	7	100	2	2
Spit 1	1399	36	18	10			6	81	2	2
Spit 1	1400	25	22	8	12	7	3	78	2	2
Spit 1	1401	18	7	6	12	5	3	72	2	2
Spit 1	1402	28	18	7	13	4	4	82	2	2
Spit 1	1403	22	24	10	23	10	4	61	2	2
Spit 1	1404	27	16	10	16	7	4	89	2	2
Spit 1	1405	19	19	6			2		2	2
Spit 1	1406	18	32	6			3		2	2
Spit 1	1407	26	31	9			7		2	4
Spit 1	1408	47	24	12			12		2	4
Spit 1	1409	28	14	7			3		2	4
Spit 1	1410	33	27	8			6		2	4
Spit 1	1411	50	14	5			4		2	4

Spit 1	1412	18	31	10	6	2	4
Spit 1	1413	32	17	7	2	2	4

R4 D2	Num	Length	Width	T/ness	P width	P /ness	Weight	P angle	Mat	Type
Spit 1	1414	28	16	7			2		2	4
Spit 1	1415	27	17	4			2		2	4
Spit 1	1416	27	10	3			2		2	4
Spit 1	1417	1--14n17	W16						2	4
Spit 1	1418	15-25n16	W42						2	4
Spit 1	1419	30	28	19			21		3	4
Spit 1	1420	32	21	13			9		3	4
Spit 1	1421	30	21	6			10		3	4
Spit 1	1422	25	24	10			6		3	4

Spit 1	1423	28	14	8			3		3	4
Spit 1	1424	31	23	7			5		3	4
Spit 1	1425	35	17	6			3		3	4
Spit 1	1426	1--14n58					39		3	4
Spit 1	1427	15--25n35					106		3	4
Spit 1	1428	1--14n9					3		4	4
Spit 1	1429	15--25n10					19		4	4
Spit 2	1430	41	21	7	13	4	9	80	1	1
Spit 2	1431	28	25	7			3		1	1
Spit 2	1432	33	23	5	8	2	3		1	1
Spit 2	1433	20	15	6			2		1	1
Spit 2	1434	24	9	4	12	4	3		1	2
Spit 2	1435	32	45	9			16		1	2
Spit 2	1436	44	36	8			7		1	2
Spit 2	1437	13	28	6			3		1	2
Spit 2	1438	23	35	5			4		1	2
Spit 2	1439	18	24	5			2		1	2
Spit 2	1440	17	14	4			2		1	2
Spit 2	1441	26	22	5			3		1	2
Spit 2	1442	27	30	5					1	4
Spit 2	1443	23	36	8			11		1	4
Spit 2	1444	50	17	8			9		1	4
Spit 2	1445	28	22	3			3		1	4
Spit 2	1446	19	12	3			1		1	4
Spit 2	1447	23	22	4			2		1	4
Spit 2	1448	1--14n15					10		1	4
Spit 2	1449	15--25n19					28		1	4
Spit 2	1450	34	31	7	24	7	9		2	2
Spit 2	1451	33	30	10	15	9	9	112	2	2
Spit 2	1452	23	21	7	13	4	4	84	2	2
Spit 2	1453	22	13	9	15	7	4	68	2	2
Spit 2	1454	26	13	7	13	7	3	92	2	2
Spit 2	1455	21	14	9	12	9	3	72	2	2
Spit 2	1456	24	10	3	9	3	2		2	2
Spit 2	1457	17	9	6			5		2	2
Spit 2	1458	37	32	11			5		2	4
Spit 2	1459	47	14	10			8		2	4
Spit 2	1460	29	25	7			6		2	4
Spit 2	1461	28	23	5			5		2	4
Spit 2	1462	39	26	4			4		2	4
Spit 2	1463	36	20	7			5		2	4
Spit 2	1464	29	23	5			4		2	4
Spit 2	1465	1--14n4					2		2	4
Spit 2	1466	32	30	16			20		3	4
Spit 2	1467	1--14n26					14		3	4
Spit 2	1468	15--25n25					59		3	4
Spit 2	1469	15--25n1					2		4	4

R4 D2	Num	Length	Width	T/ness	P width	P /ness	Weight	P angle	Mat	Type
Spit 3	1470	18	9	4			3		1	1
Spit 3	1471	30	42	13			13		1	2
Spit 3	1472	19	18	5			2		1	2
Spit 3	1473	45	17	6			7		1	4
Spit 3	1474	17	33	4			3		1	4
Spit 3	1475	27	41	5			8		1	4
Spit 3	1476	26	19	7			3		1	4
Spit 3	1477	1--14n18					7		1	4
Spit 3	1478	15--25n9					12		1	4

Spit 3	1479	38	27	7	13	7	4	82	2	1
Spit 3	1480	21	13	5	12	4	2		2	1
Spit 3	1481	17	10	5	7	3	2		2	1
Spit 3	1482	25	17	7	16	7	3	66	2	1
Spit 3	1483	24	18	6	14	4	2		2	1
Spit 3	1484	32	22	7	9	5	3	79	2	2
Spit 3	1485	21	13	5	12	4	2		2	2
Spit 3	1486	17	10	5	7	3	2		2	2
Spit 3	1487	25	17	7	16	7	3	66	2	2
Spit 3	1488	24	18	6	14	4	2		2	2
Spit 3	1489	15--25n19					43		2	4
Spit 3	1490	28	20	4			2		2	4
Spit 3	1491	33	14	5			3		2	4
Spit 3	1492	15--25n8					5		2	4
Spit 3	1493	1--14n6					6		3	4
Spit 3	1494	27	16	10			5		3	4
Spit 3	1495	15--25n6					12		3	4
Spit 3	1496	1--14n10					2		4	4
Spit 3	1497	15--25n2					3		4	4
Spit 3	1498	40	31	6			11		5	4
Spit 4	1499	29	9	5	12	4	4	77	1	1
Spit 4	1500	26	29	6			3		1	1
Spit 4	1501	37	18	7	17	7	6	80	1	2
Spit 4	1502	37	35	8	25	7	14		1	2
Spit 4	1503	23	25	10	21	9	5	62	1	2
Spit 4	1504	16	12	3	8	3	2	86	1	2
Spit 4	1505	24	15	5	12	5	2	79	1	2
Spit 4	1506	23	42	6			6		1	2
Spit 4	1507	25	40	4			5		1	2
Spit 4	1508	40	18	8			10		1	4
Spit 4	1509	22	20	3			2		1	4
Spit 4	1510	38	9	6			4		1	4
Spit 4	1511	34	10	5			3		1	4
Spit 4	1512	1--14n7					12		1	4
Spit 4	1513	15--25n15					9		1	4
Spit 4	1514	55	28	3	21	12	33	88	2	1
Spit 4	1515	15	16	5	8	4	2		2	2
Spit 4	1516	34	23	11	20	10	9	81	2	2
Spit 4	1517	21	23	13			7		2	4
Spit 4	1518	1--14n3					2		2	4
Spit 4	1519	15--25n4					2		2	4
Spit 4	1520	34	32	27			41		3	4
Spit 4	1521	28	20	8			5		3	4
Spit 4	1522	1--14n37					25		3	4
Spit 4	1523	15--25n13					38		3	4
Spit 4	1524	1--14n13					4		4	4
Spit 4	1525	15--25n1					3		4	4
Spit 5	1526	20	27	5	13	4	3	84	1	1
Spit 5	1527	33	29	6	23	11	19	78	1	1
Spit 5	1528	23	29	6	26	6	7	101	1	2
Spit 5	1529	13	32	3			2		1	2
Spit 5	1530	1--14n3					2		1	4
Spit 5	1531	15--25n11					1		1	4
Spit 5	1532	20	12	4	9	3	2	77	2	2

R4 D2	Num	Length	Width	T/ness	P width	P /ness	Weight	P angle	Mat	Type
Spit 5	1533	28	23	7			4		2	2
Spit 5	1534	43	13	9	17	6	6	67	2	2
Spit 5	1535	34	13	6			3		2	4
Spit 5	1536	15--25n2					4		2	4
Spit 5	1537	26	26	7			4		3	4
Spit 5	1538	1--14n9					4		3	4
Spit 5	1539	15--25n11					13		3	4
Spit 5	1540	15-25n2					2		4	4
Spit 6	1541	35	20	5	14	3	4		1	1
Spit 6	1542	23	12	3	13	4	2	54	1	2
Spit 6	1543	1--14n9					2		1	4
Spit 6	1544	18	20	5			2		1	4
Spit 6	1545	15--25n5					6		1	4
Spit 6	1546	32	16	5			3		2	2
Spit 6	1547	1--14n6					2		2	4
Spit 6	1548	15--25n2					4		2	4
Spit 6	1549	26	18	12			6		3	4
Spit 6	1550	1--14n18					5		3	4
Spit 6	1551	15--25n8					19		3	4
Spit 6	1552	1--14n20					2		4	4
Spit 6	1553	15--25n2					4		4	4
Spit 7	1554	50	25	7	21	5	13	86	1	1
Spit 7	1555	26	34	9	19	5	10	83	1	2
Spit 7	1556	15	21	5	16	4	3	90	1	2
Spit 7	1557	29	16	5			3		1	4
Spit 7	1558	27	10	5			2		1	4
Spit 7	1559	1--14n7					3		1	4
Spit 7	1560	1--14n2					2		2	4
Spit 7	1561	15--25n3					5		2	4
Spit 7	1562	32	20	10			5		3	4
Spit 7	1563	27	10	5			2		3	4
Spit 7	1564	1--14n16					4		3	4
Spit 7	1565	15--25n2					3		3	4
Spit 7	1566	1--14n5					3		4	4
Spit 8	1567	29	31	5			11		1	4
Spit 8	1568	32	15	8			3		1	4
Spit 8	1569	27	10	5			2		1	4
Spit 8	1570	1--14n5					2		1	4
Spit 8	1571	15--24n2					2		1	4
Spit 8	1572	1--14n2					2		2	4
Spit 8	1573	1--14n9					3		3	4
Spit 8	1574	15--25n3					4		3	4
Spit 8	1575	1--14n3					2		4	4
Spit 9	1576	15	23	5	14	3	8	74	1	1
Spit 9	1577	83	65	22			121		2	1
Spit 9	1578	31	27	15			7		2	1
Spit 9	1579	15--25n2					3		2	4
Spit 9	1580	1--14n1					1		4	2
Spit 9	1581	32	15	5	11	5	4	83	4	1
Spit 10	1582	47	44	15	37	14	49	73	1	1
Spit 11	1583	11	19	2			4		1	2
Spit 11	1584	36	19	7	11	4	5		2	1
Spit 11	1585	36	19	7	11	4	5		2	2
Spit 11	1586	37	23	11			11		2	2
Spit 11	1587	19	12	9	9	4	3	74	3	1
Spit 12	1588	57	27	9			22		1	2
Spit 13	1589									
Spit 14	1590									
Spit 15	1591									
Spit 16	1592									
Spit 17	1593									

Appendix A Lake Moondarra

R4 D4	Num	Length	Width	T/ness	P length	P t/ness	Weight	P angle	Mat	Type
Surface	1600	18	15	4	9	4	2	82	1	1
Surface	1601	12	10	3	10	3	1		1	1
Surface	1602	74	24	1	12	9	29	70	1	2
Surface	1603	32	37	6	25	4	12	84	1	2
Surface	1604	32	27	6	16	3	6	78	1	2
Surface	1605	21	34	8	24	6	8	74	1	2
Surface	1606	28	29	9	13	4	7		1	2
Surface	1607	19	19	4	7	3	1		1	2
Surface	1608	55	49	11			29		1	2
Surface	1609	38	36	9		7			1	2
Surface	1610	40	33	6	21	5	13		1	2
Surface	1611	21	34	8	24	16	8	74	1	2
Surface	1612	31	30	9	13	3	9		1	2
Surface	1613	26	21	6			3		1	2
Surface	1614	23	25	10			6		1	2
Surface	1615	21	24	6			3		1	2
Surface	1616	21	16	7			2		1	2
Surface	1617	29	24	4			4		1	4
Surface	1618	24	29	3			2		1	4
Surface	1619	22	21	4			4		1	4
Surface	1620	22	21	7			3		1	4
Surface	1621	28	29	4			2		1	4
Surface	1622	20	19	4			2		1	4
Surface	1623	21	15	8			3		1	4
Surface	1624	22	16	8			2		1	4
Surface	1625	22	16	4			1		1	4
Surface	1626	22	14	4			1		1	4
Surface	1627	22	12	4			1		1	4
Surface	1628	1-14xn48					26		1	4
Surface	1629	110	107	34			592		1	7
Surface	1630	30	13	10			4		2	1
Surface	1631	30	27	10	20	8	6	78	2	2
Surface	1632	32	18	8			4		2	2
Surface	1633	22	19	7	18	7	2	82	2	2
Surface	1634	27	10	5			2		2	2
Surface	1635	24	20	10			3		2	4
Surface	1636	20	14	8			2		2	4
Surface	1637	1-14xn10					6		2	4
Spit 1	1638	16	39	8	12	2	16	90	1	1
Spit 1	1639	31	22	7	15	6.0	12	75	1	1
Spit 1	1640	34	17	7	11	7	12	85	1	1
Spit 1	1641	23	27	7	16	4	7	78	1	2
Spit 1	1642	36	20	5	8	2	4	70	1	2
Spit 1	1643	35	20	8	15	8	8	74	1	2
Spit 1	1644	33	29	9	18	5	15	77	1	2
Spit 1	1645	41	16	8	13	3	5	80	1	2
Spit 1	1646	43	30	7	11	7	12		1	2
Spit 1	1647	27	27	7	12	6	7		1	2
Spit 1	1648	27	23	7	12	2	6		1	2
Spit 1	1649	35	20	5	12	3	10	73	1	2
Spit 1	1650	34	20	7	8	4	7		1	2
Spit 1	1651	11	17	5	11	6	3	70	1	2
Spit 1	1652	25	15	4	15	5	3	76	1	2
Spit 1	1653	42	38	9	27	3	9	80	1	2
Spit 1	1654	49	36	7			21		1	2
Spit 1	1655	31	22	5			6		1	2
Spit 1	1656	48	34	11			18		1	2
Spit 1	1657	44	29	7			21		1	2
Spit 1	1658	32	18	10			6		1	2
Spit 1	1659	23	30	5			8		1	2
Spit 1	1660	23	22	4			2		1	2
Spit 1	1661	20	18	4			2		1	2

R4 D4	Num	Length	Width	T/ness	P length	P t/ness	Weight	P angle	Mat	Type
Spit 1	1662	30	14	4			2		1	2
Spit 1	1663	27	33	3			4		1	2
Spit 1	1664	31	21	5			3		1	2
Spit 1	1665	16	24	3			2		1	2
Spit 1	1666	15	21	3			1		1	2
Spit 1	1667	24	15	4			3		1	2
Spit 1	1668	14	18	4			2		1	2
Spit 1	1669	16	10	4			1		1	2
Spit 1	1670	35	22	6			5		1	2
Spit 1	1671	29	21	7			7		1	3
Spit 1	1672	1-14n240					119		1	4
Spit 1	1673	15-25n74					235		1	4
Spit 1	1674	37	33	15			17	87	2	2
Spit 1	1675	48	25	11	10	3	12	70	2	2
Spit 1	1676	45	27	7	15	4	10		2	2
Spit 1	1677	38	29	13	22	10	18		2	2
Spit 1	1678	33	25	8	20	7	7		2	2
Spit 1	1679	32	30	9				87	2	2
Spit 1	1680	32	39	5			3	87	2	2
Spit 1	1681	29	21	9	12	6	7	76	2	2
Spit 1	1682	33	13	9	14	5	5	71	2	2
Spit 1	1683	31	19	7	13	4	6	75	2	2
Spit 1	1684	18	22	2	9	2	2	69	2	2
Spit 1	1685	55	35	12			29		2	2
Spit 1	1686	43	37	9			27		2	2
Spit 1	1687	31	28	10			14		2	2
Spit 1	1688	37	30	10			12		2	4
Spit 1	1689	43	22	7			9		2	4
Spit 1	1690	39	27	7			12		2	4
Spit 1	1691	37	27	6			10		2	4
Spit 1	1692	24	15	3			2		2	4
Spit 1	1693	22	22	3			4		2	4
Spit 1	1694	35	12	6			3		2	4
Spit 1	1695	31	25	8			9		2	4
Spit 1	1696	26	26	10			5		2	4
Spit 1	1697	29	12	5			3		2	4
Spit 1	1698	29	16	4			5		2	4
Spit 1	1699	31	28	10			14		2	4
Spit 1	1700	27	26	11			11		2	4
Spit 1	1701	1-14n6					10		2	4
Spit 1	1702	15-25n4					13		2	4
Spit 1	1703	40	17	23			8		3	4
Spit 1	1704	28	20	13			10		3	4
Spit 1	1705	35	28	13			8		3	4
Spit 1	1706	28	25	8			6		3	4
Spit 1	1707	23	24	17			7		3	4
Spit 1	1708	30	19	14			9		3	4
Spit 1	1709	33	16	13			7		3	4
Spit 1	1710	27	17	16			8		3	4
Spit 1	1711	28	27	9			5		3	4
Spit 1	1712	27	17	14			8		3	4
Spit 1	1713	1-14n168					92		3	4
Spit 1	1714	15-25n45					150		3	4
Spit 1	1715	20	8	8	18	5	5	82	4	1
Spit 1	1716	18	14	4	16	4	2	68	4	2
Spit 1	1717	20	22	4	8	5	2	85	4	2
Spit 1	1718	23	12	7	8	5	2		4	2
Spit 1	1719	22	10	6			2		4	4
Spit 1	1720	30	9	3			2		4	4
Spit 1	1721	23	21	12			7		4	4
Spit 1	1722	1-14n24					14		4	4

R4 D4	Num	Length	Width	T/ness	P length	P t/ness	Weight	P angle	Mat	Type
Spit 2	1723	82	39	10	25	5	68	84	1	1
Spit 2	1724	71	26	9	7	3	25		1	1
Spit 2	1725	35	43	10	14	7	14		1	1
Spit 2	1726	52	34	9	20	10	18	80	1	1
Spit 2	1727	40	24	5	13	5	8	86	1	1
Spit 2	1728	35	23	5	18	5	5	80	1	1
Spit 2	1729	40	19	7	19	4	10		1	1
Spit 2	1730	55	35	10			28		1	1
Spit 2	1731	53	51	13			49		1	1
Spit 2	1732	28	42	5			10		1	2
Spit 2	1733	50	21	8			9		1	2
Spit 2	1734	43	20	6			7		1	2
Spit 2	1735	31	21	5			5		1	2
Spit 2	1736	21	22	3			2		1	2
Spit 2	1737	13	28	5			2		1	2
Spit 2	1738	70	28	9	15	2	26		1	2
Spit 2	1739	84	42	15	24	4	72	62	1	2
Spit 2	1740	28	43	9	20	5	13	76	1	2
Spit 2	1741	21	22	7	19	6	2	71	1	2
Spit 2	1742	22	26	7	13	4	4	63	1	2
Spit 2	1743	25	18	4	13	6	3	86	1	2
Spit 2	1744	35	27	8	13	3	8	66	1	2
Spit 2	1745	36		42	10	7	1		1	2
Spit 2	1746	31	16	5	12	3	3	77	1	2
Spit 2	1747	30	26	5	15	1	9		1	2
Spit 2	1748	22	33	7	19	6	8		1	2
Spit 2	1749	50	36	8	18	9	19	75	1	2
Spit 2	1750	27	28	6	12	2	7	67	1	2
Spit 2	1751	42	20	5	8	1	6		1	2
Spit 2	1752	39	21	5	9	1	4		1	2
Spit 2	1753	42	22	5	14	3	6	64	1	2
Spit 2	1754	35	21	4	17	3	2	64	1	2
Spit 2	1755	70	28	9	15	2	26		1	2
Spit 2	1756	84	42	15	24	4	72	62	1	2
Spit 2	1757	28	43	9	20	5	13	76	1	2
Spit 2	1758	51	32	10			26		1	2
Spit 2	1759	73	34	14			32		1	2
Spit 2	1760	41	39	6			17		1	2
Spit 2	1761	35	27	10			8		1	2
Spit 2	1762	22	34	8			5		1	2
Spit 2	1763	19	34	5			5		1	2
Spit 2	1764	30	19	4			3		1	2
Spit 2	1765	46	26	5			10		1	2
Spit 2	1766	55	48	8			51		1	2
Spit 2	1767	41	18	7			4		1	2
Spit 2	1768	27	13	5			2		1	2
Spit 2	1769	49	20	7			9		1	2
Spit 2	1770	51	32	10			26		1	2
Spit 2	1771	73	34	14			37		1	2
Spit 2	1772	41	39	6			17		1	2
Spit 2	1773	25	25	7			6		1	4
Spit 2	1774	40	40	15			41		1	4
Spit 2	1775	37	24	11			12		1	4
Spit 2	1776	42	17	5			7		1	4
Spit 2	1777	49	35	5			12		1	4
Spit 2	1778	38	25	5			10		1	4
Spit 2	1779	42	21	10			6		1	4
Spit 2	1780	42	25	12			15		1	4
Spit 2	1781	39	16	6			5		1	4
Spit 2	1782	26	23	7			6		1	4

R4 D4	Num	Length	Width	T/ness	P length	P t/ness	Weight	P angle	Mat	Type
Spit 2	1783	26	21	4			4		1	4
Spit 2	1784	34	21	6			6		1	4
Spit 2	1785	23	25	3			3		1	4
Spit 2	1786	26	16	3			1		1	4
Spit 2	1787	25	20	5			3		1	4
Spit 2	1788	29	15	10			5		1	4
Spit 2	1789	27	19	6			4		1	4
Spit 2	1790	25	11	5			4		1	4
Spit 2	1791	23	27	5			4		1	4
Spit 2	1792	28	15	6			3		1	4
Spit 2	1793	28	22	5			4		1	4
Spit 2	1794	1-14n7					5		1	4
Spit 2	1795	15-25n11					31		1	4
Spit 2	1796	41	37	5			15		1	4
Spit 2	1797	39	22	5			4		1	4
Spit 2	1798	28	28	6			6		1	4
Spit 2	1799	31	27	5			5		1	4
Spit 2	1800	40	19	10	22	11	7		2	1
Spit 2	1801	27	13	3	4	1	1		2	1
Spit 2	1802	27	17	7	12	3	2	90	2	1
Spit 2	1803	70	35	13			38		2	1
Spit 2	1804	42	18	5	8	3	5	72	2	2
Spit 2	1805	27	44	9	21	8	11	103	2	2
Spit 2	1806	31	16	5	13	4	6	75	2	2
Spit 2	1807	25	19	5	8	5	4	90	2	2
Spit 2	1808	27	21	4	17	5	4		2	2
Spit 2	1809	21	15	4	9	5	3		2	2
Spit 2	1810	20	14	5	5	3	1	76	2	2
Spit 2	1811	48	22	7	10	5	11	78	2	2
Spit 2	1812	20	16	6	10	6	3		2	2
Spit 2	1813	26	24	7			2		2	2
Spit 2	1814	35	47	10			23		2	2
Spit 2	1815	24	22	5			7		2	2
Spit 2	1816	37	18	11			10		2	4
Spit 2	1817	51	52	40			120		2	10
Spit 2	1818	15	25	4	10	3	1	72	3	2
Spit 2	1819	26	15	4			4		3	4
Spit 2	1820	1-14n126					79		3	4
Spit 2	1821	15-25n27					112		3	4
Spit 2	1822	35	25	20			25		3	4
Spit 2	1823	30	18	12			9		3	4
Spit 2	1824	31	21	12			10		3	4
Spit 2	1825	29	19	10			7		3	4
Spit 2	1826	33	25	19			19		3	4
Spit 2	1827	31	10	6			6		3	4
Spit 2	1828	27	10	6			4		3	4
Spit 2	1829	30	30	11			12		3	4
Spit 2	1830	35	16	10			7		3	4
Spit 2	1831	39	19	7			6		3	4
Spit 2	1832	29	16	6			3		3	4
Spit 2	1833	32	28	32			31		3	4
Spit 2	1834	21	12	3			2		4	4
Spit 2	1835	19	15	5			4		4	4
Spit 2	1836	21	12	5			2		4	4
Spit 2	1837	20	16	7			2		4	4
Spit 2	1838	1-14n14					6		4	4
Spit 3	1839	40	34	13			35		1	1
Spit 3	1840	45	33	16	35	15	21	115	1	1
Spit 3	1841	45	34	12	41	12	24	112	1	1
Spit 3	1842	46	22	12	10	7	15	80	1	1
Spit 3	1843	52	16	10	11	7	9	81	1	1
Spit 3	1844	30	21	11	17	11	4	62	1	1

R4 D4	Num	Length	Width	T/ness	P length	P t/ness	Weight	P angle	Mat	Type
Spit 3	1845	36	12	5	12	3	2	58	1	1
Spit 3	1846	22	23	9	22	8	4	84	1	1
Spit 3	1847	21	23	7	18	7	5	76	1	1
Spit 3	1848	36	13	8	6	2	4		1	1
Spit 3	1849	39	17	7			4		1	1
Spit 3	1850	32	28	15			3		1	1
Spit 3	1851	32	28	15			4		1	2
Spit 3	1852	41	53	23	55	21	67	69	1	2
Spit 3	1853	32	31	11	32	11	17	82	1	2
Spit 3	1854	33	22	18	24	17	10	88	1	2
Spit 3	1855	38	15	10	9	5	5	78	1	2
Spit 3	1856	34	24	12	20	11	9	81	1	2
Spit 3	1857	24	30	8	13	5	5	74	1	2
Spit 3	1858	32	21	12	9	6	8	88	1	2
Spit 3	1859	22	21	5	14	5	2		1	2
Spit 3	1860	26	19	8	17	7	3	91	1	2
Spit 3	1861	20	35	9	17	9	7	74	1	2
Spit 3	1862	38	27	4	12	4	3	86	1	2
Spit 3	1863	24	13	5	15	12	3		1	2
Spit 3	1864	30	15	5	15	4	3	78	1	2
Spit 3	1865	19	15	4	9	3	3	85	1	2
Spit 3	1866	50	19	8			13		1	2
Spit 3	1867	31	23	8			6		1	2
Spit 3	1868	25	26	7			6		1	2
Spit 3	1869	37	10	7			3		1	2
Spit 3	1870	19	12	4			12		1	2
Spit 3	1871	16	34	24			17		1	4
Spit 3	1872	37	21	8			7		1	4
Spit 3	1873	28	27	11			7		1	4
Spit 3	1874	25	25	5			4		1	4
Spit 3	1875	12	22	4			2		1	4
Spit 3	1876	17	15	3			2		1	4
Spit 3	1877	1--14 n53					21		1	4
Spit 3	1878	15--25n48					53		1	4
Spit 3	1879	27	20	4	15	4	4		2	1
Spit 3	1880	25	16	8	14	9	2	115	2	1
Spit 3	1881	24	12	4	17	5	2	110	2	1
Spit 3	1882	29	15	12	20	14	7	102	2	2
Spit 3	1883	35	20	7	17	3	6		2	2
Spit 3	1884	34	19	7	12	7	4	84	2	2
Spit 3	1885	16	24	14	12	4	4	94	2	2
Spit 3	1886	39	28	7			9		2	2
Spit 3	1887	1--15n1					2		2	4
Spit 3	1888	28	7	6			2		3	2
Spit 3	1889	17	11	8			2		3	2
Spit 3	1890	23	18	10			4		3	2
Spit 3	1891	1--14n110					42		3	4
Spit 3	1892	1--14n10					2		4	4
Spit 3	1893	28	21	5			11		4	4
Spit 4	1894	45	38	13	24	6	19		1	1
Spit 4	1895	40	28	4	10	2	5		1	1
Spit 4	1896	15	8	3	13	2	2		1	1
Spit 4	1897	30	28	5	9	3	2		1	1
Spit 4	1898	46	41	10			16		1	1
Spit 4	1899	42	37	11			8		1	1
Spit 4	1900	36	26	10	24	9	12	64	1	2
Spit 4	1901	26	24	7	11	8	4	70	1	2
Spit 4	1902	23	28	7	18	4	3		1	2
Spit 4	1903	16	28	4			3		1	2
Spit 4	1904	35	21	6			5		1	4
Spit 4	1905	25	19	4			3		1	4
Spit 4	1906	15--25n20					37		1	4

Spit 4	1907	1--14n12	5	1	4

R4 D4	Num	Length	Width	T/ness	P length	P t/ness	Weight	P angle	Mat	Type
Spit 4	1908	36	21	10	20	5	14		2	1
Spit 4	1909	25	15	10	12	8	2	84	2	1
Spit 4	1910	36	27	7	9	4	7	79	2	1
Spit 4	1911	36	22	6	20	6	5	67	2	1
Spit 4	1912	23	16	5	16	6	2	82	2	1
Spit 4	1913	17	14	4	9	4	2	74	2	1
Spit 4	1914	48	20	10			11		2	1
Spit 4	1915	34	20	7			3		2	1
Spit 4	1916	23	27	6			6		2	1
Spit 4	1917	15	21	5			3		2	1
Spit 4	1918	23	16	7			3		2	1
Spit 4	1919	16	27	8	17	5	3	84	2	2
Spit 4	1920	32	21	7	17	4	5	79	2	2
Spit 4	1921	18	9	7			2		2	2
Spit 4	1922	34	17	8			5		2	2
Spit 4	1923	18	18	2			2		2	2
Spit 4	1924	39	29	7			14		2	2
Spit 4	1925	35	25	6			4		2	4
Spit 4	1926	36	23	5			7		2	4
Spit 4	1927	26	14	4			2		2	4
Spit 4	1928	36	33	16			16		2	4
Spit 4	1929	26	24	7			8		2	4
Spit 4	1930	28	24	8			5		2	4
Spit 4	1931	34	24	8			4		2	4
Spit 4	1932	16	22	6			3		2	4
Spit 4	1933	30	22	7			3		2	4
Spit 4	1934	25	24	7			7		2	4
Spit 4	1935	31	16	4			2		2	4
Spit 4	1936	27	18	4			4		2	4
Spit 4	1937	26	16	7			4		2	4
Spit 4	1938	26	16	10			4		2	4
Spit 4	1939	21	16	7			2		2	4
Spit 4	1940	30	25	12			8		2	4
Spit 4	1941	1--14n38					11		2	4
Spit 4	1942	15--25n8					22		2	4
Spit 4	1943	32	32	26			33		2	10
Spit 4	1944	1--14n15					6		3	4
Spit 4	1945	15--25n6					6		3	4
Spit 4	1946	27	23	12			8		4	10

R4 D4	Num	Length	Width	T/ness	P length	P t/ness	Weight	P angle	Mat	Type
Spit 5	1947	44	33	9	23	7	22	86	1	1
Spit 5	1948	19	27	5			3		1	1
Spit 5	1949	37	16	7			6		1	2
Spit 5	1950	15-25 n4					4		1	4
Spit 5	1951	44	22	10	20	8	12	107	2	1
Spit 5	1952	26	20	7		14	6	109	2	2
Spit 5	1953	18	20	6		19	6	88	2	2
Spit 5	1954	24	18	6	19	6	2		2	2
Spit 5	1955	1--14n 49					12		2	4
Spit 5	1956	15--25n18					25		2	4
Spit 5	1957	16	14	6			1		2	4
Spit 5	1958	15--25n11					22		3	4
Spit 5	1959	1--14n61					16		3	4
Spit 5	1960	1--14n2					1		4	4
Spit 5	1961	15--25n11					22		4	4
Spit 6	1962	56	35	9	15	4	22	90	1	1
Spit 6	1963	1--14n2					1		1	4
Spit 6	1964	15-25n1					1		1	4
Spit 6	1965	20	17	4			3		2	1
Spit 6	1966	15--25n2					3		2	4
Spit 6	1967	1--14n1					1		2	4

R4 D4	Num	Length	Width	T/ness	P length	P t/ness	Weight	P angle	Mat	Type
Spit 6	1971	1--14n1					1		3	4
Spit 6	1972	27	26	3			10		4	4
Spit 6	1973	1--14n6					2		4	4
Spit 7	1977	30	16	5			3		1	4
Spit 7	1978	20	13	7			2		3	4
Spit 7	1979	1--14n2					1		3	4
Spit 7	1980	1--14n21					3		4	4
Spit 8	1981	1--14n4					3		1	4
Spit 8	1985	28	14	5	12	5	2		2	2
Spit 8	1986	28	18	3			3		2	2
Spit 8	1987	1--14n4					1		2	4
Spit 8	1988	15--25n1					1		2	4
Spit 8	1982	1--15n1					1		3	4
Spit 8	1983	31	22	1			6		4	4
Spit 8	1984	1--14n6					3		4	4
Spit 9	1990	29	28	11	22	10	7	91	2	2
Spit 9	1991	26	19	6			2		2	2
Spit 9	1992	1--14n4					3		2	4
Spit 9	1989	1--14n5					2		4	4
Spit 10	1994	22	27	6	18	5	6	63	2	2
Spit 10	1995	16	8	3			1		2	2
Spit 10	1996	1--14n4					2		2	4
Spit 10	1997	15--25n1					2		2	4
Spit 10	1993	1--14n6					2		4	4
Spit 11	1998	28	29	3	13	2	4		2	2
Spit 11	1999	21	23	7			4		2	2
Spit 12	2000									
Spit 13	2002	26	22	4			2		1	4
Spit 13	2001	15	38	17			8		2	4
Spit 14	2003									
Spit 15	2004									
Spit 16	2005									
Spit 17	2006									
Spit 18	2007									

Q12	Num	Length	Width	T/ness	P width	P t/ness	Weight	P angle	Mater	Type
Surface	2008	69	97	22	64	17	240	74	basal	1
Surface	2009	97	105	21	37	24	210	70	basal	1
Surface	2010	99	73	11	24	14	125	81	basal	1
Surface	2011	59	54	15	22	10	49	77	basal	1
Surface	2012	52	52	10	35	10	39	83	basal	1
Surface	2013	81	49	21	50	19	92	71	basal	1
Surface	2014	52	51	9	32	7	29	70	basal	1
Surface	2015	47	42	13	34	19	51	90	basal	1
Surface	2016	77	52	10	22	3	44	57	basal	1
Surface	2017	46	37	13	22	8	18	62	basal	1
Surface	2018	44	48	8	27	7	16	70	basal	1
Surface	2019	23	29	9			12	70	basal	1
Surface	2020	79	82	24			182		basal	1
Surface	2021	89	73	30			236		basal	1
Surface	2022	67	82	8	20	6	87		basal	1
Surface	2023	75	80	21			107		basal	1
Surface	2024	59	51	12			32		basal	1
Surface	2025	86	74	9			83		basal	1
Surface	2026	50	64	12			11		basal	3
Surface	2027	166	198	93	ind	ind	4097	66	basal	7
Surface	2028	122	117	42			661		basal	7
Surface	2029	137	133	42	87	27	1098	50	basal	7
Spit 1	2030	34	33	5				9	1	2
Spit 1	2031	34	36	9	24	10	12	60	1	2
Spit 1	2032	37	34	8	36	6	25	76	1	2
Spit 1	2033	34	37	7	29	5	9	65	1	2
Spit 1	2034	34	22	11	21	11	2	68	1	2
Spit 1	2035	35	15	7	9	6	3	90	1	2
Spit 1	2036	38	19	9	17	10	7	61	1	2
Spit 1	2037	30	25	9	26	7	7	112	1	2
Spit 1	2038	26	32	8	13	6	5	82	1	2
Spit 1	2039	24	31	13	29	13	14	66	1	2
Spit 1	2040	25	24	5	19	4	2	71	1	2
Spit 1	2041	30	33	9	10	14	9	105	1	2
Spit 1	2042	24	25	6	20	4	6	80	1	2
Spit 1	2043	26	26	11	23	11	5	95	1	2
Spit 1	2044	31	40	10	27	3	8		1	2
Spit 1	2045	45	37	4			8		1	2
Spit 1	2046	43	42	11			36		1	2
Spit 1	2047	37	23	10	11	6	10		1	2
Spit 1	2048	64	12	9		6	14		1	2
Spit 1	2049	27	26	9			4		1	2
Spit 1	2050	29	19	12	6	1	1		1	2
Spit 1	2051	14	22	5			2		1	2
Spit 1	2052	11	22	4	21	4	1		1	2
Spit 1	2053	12	17	6	9	4	1	85	1	2
Spit 1	2054	20	30	6			2		1	2
Spit 1	2055	21	27	3	16	10	2		1	2
Spit 1	2056	8	13	5	6	1	1		1	2
Spit 1	2057	39	26	5	19	12	14		1	2
Spit 1	2058	19	24	4	15	4	2		1	2
Spit 1	2059	38	26	9	26	8	8		1	2
Spit 1	2060	12	18	5	17	4	2		1	4
Spit 1	2061	16	12	3			1		1	4
Spit 1	2062	21	17	4			1		1	4
Spit 1	2063	62	163	57			866		1	4
Spit 1	2064	15	12	3			1		1	4
Spit 1	2065	19	10	3			1		1	4
Spit 1	2066	14	22	1			1		1	4
Spit 1	2067	65	12	33			406		1	4
Spit 1	2068	7	17	3			1		1	4

Q12	Num	Length	Width	T/ness	P width	P t/ness	Weight	P angle	Mate	Type
Spit 1	2069	17	10	3			1		1	4
Spit 1	2070	20	11	2			1		1	4
Spit 1	2071	97	66	21			164		1	4
Spit 1	2072	8	13	5	6	1	1		1	4
Spit 1	2073	12	15	6			1		1	4
Spit 1	2074	13	15	3			1		1	4
Spit 1	2075	112	110	32			448		1	4
Spit 1	2076	22	12	7			1		1	4
Spit 1	2077	22	6	2			1		1	4
Spit 1	2078	63	58	22			59		1	4
Spit 1	2079	12	24	3			1		1	4
Spit 1	2080	13	12	2			1		1	4
Spit 1	2081	119	50	12			66		1	4
Spit 1	2082	14	22	3			1		1	4
Spit 1	2083	17	15	2			1		1	4
Spit 1	2084	122	57	22			194		1	4
Spit 1	2085	21	17	4			1		1	4
Spit 1	2086	26	12	3			1		1	4
Spit 1	2087	13	10	2			19		1	4
Spit 1	2088	14	23	3			1		1	4
Spit 1	2089	14	19	3			1		1	4
Spit 1	2090	15	14	3			19		1	4
Spit 1	2091	19	13	3			1		1	4
Spit 1	2092	15	15	2			1		1	4
Spit 1	2093	17	12	8			29		1	4
Spit 1	2094	14	13	3			1		1	4
Spit 1	2095	27	11	4			1		1	4
Spit 1	2096	11	24	4			2		1	4
Spit 1	2097	17	16	2			1		1	4
Spit 1	2098	13	12	2			1		1	4
Spit 1	2099	24	14	3			2		1	4
Spit 1	2100	13	18	2			1		1	4
Spit 1	2101	23	14	4			3		1	4
Spit 1	2102	20	9	4			2		1	4
Spit 1	2103	22	14	4			1		1	4
Spit 1	2104	19	19	2			1		1	4
Spit 1	2105	19	13	2			1		1	4
Spit 1	2106	11	22	2			1		1	4
Spit 1	2107	12	12	2			1		1	4
Spit 1	2108	20	12	2			1		1	4
Spit 1	2109	10	21	2			1		1	4
Spit 1	2110	8	27	3			1		1	4
Spit 1	2111	16	12	2			1		1	4
Spit 1	2112	13	24	2			1		1	4
Spit 1	2113	11	14	2			1		1	4
Spit 1	2114	12	11	4			1		1	4
Spit 1	2115	26	15	3			1		1	4
Spit 1	2116	14	18	2			1		1	4
Spit 1	2117	17	11	2			1		1	4
Spit 1	2118	10	12	3			1		1	4
Spit 1	2119	16	14	2			1		1	4
Spit 1	2120	15	14	5			2		1	4
Spit 1	2121	10	19	2			1		1	4
Spit 1	2122	11	12	4			1		1	4
Spit 1	2123	12	11	1			1		1	4
Spit 1	2124	9	17	2			1		1	4
Spit 1	2125	13	11	2			1		1	4
Spit 1	2126	12	10	2			1		1	4
Spit 1	2127	14	11	6			1		1	4
Spit 1	2128	19	13	4			3		1	4
Spit 1	2129	20	12	2			1		1	4

Q12	Num	Length	Width	T/ness	P width	P t/ness	Weight	P angle	Mate	Type
Spit 1	2130	13	18	2			1		1	4
Spit 1	2131	9	11	2			1		1	4
Spit 1	2132	17	14	3			1		1	4
Spit 1	2133	16	14	2			1		1	4
Spit 1	2134	10	9	3			1		1	4
Spit 1	2135	9	10	5			1		1	4
Spit 1	2136	9	12	2			1		1	4
Spit 1	2137	9	17	2			1		1	4
Spit 1	2138	26	11	3			3		1	4
Spit 1	2139	9	13	2			1		1	4
Spit 1	2140	11	15	2			1		1	4
Spit 1	2141	17	11	6			3		1	4
Spit 1	2142	9	22	2			1		1	4
Spit 1	2143	19	10	2			1		1	4
Spit 1	2144	24	12	5			4		1	4
Spit 1	2145	11	23	3			1		1	4
Spit 1	2146	19	11	2			1		1	4
Spit 1	2147	18	12	6			4		1	4
Spit 1	2148	17	11	4			1		1	4
Spit 1	2149	12	11	2			1		1	4
Spit 1	2150	16	17	4			3		1	4
Spit 1	2151	17	11	3			1		1	4
Spit 1	2152	25	15	1			1		1	4
Spit 1	2153	15	12	5			2		1	4
Spit 1	2154	32	8	3			1		1	4
Spit 1	2155	16	12	2			1		1	4
Spit 1	2156	59	44	9			36		1	4
Spit 1	2157	15	11	3			1		1	4
Spit 1	2158	14	17	3			1		1	4
Spit 1	2159	14	16	3			1		1	4
Spit 1	2160	12	13	2			1		1	4
Spit 1	2161	23	10	3			2		1	4
Spit 1	2162	12	8	6			2		1	4
Spit 1	2163	11	16	3			1		1	4
Spit 1	2164	16	14	2			1		1	4
Spit 1	2165	15	14	2			1		1	4
Spit 1	2166	18	14	3			1		1	4
Spit 1	2167	14	16	2			1		1	4
Spit 1	2168	11	10	2			1		1	4
Spit 1	2169	16	12	1			1		1	4
Spit 1	2170	16	13	2			1		1	4
Spit 1	2171	14	8	3			1		1	4
Spit 1	2172	14	12	5			1		1	4
Spit 1	2173	26	12	6			3		1	4
Spit 1	2174	14	11	2			1		1	4
Spit 1	2175	12	15	2			1		1	4
Spit 1	2176	10	16	5			1		1	4
Spit 1	2177	14	19	2			1		1	4
Spit 1	2178	11	9	2			1		1	4
Spit 1	2179	29	9	4			1		1	4
Spit 1	2180	12	26	3			1		1	4
Spit 1	2181	14	15	2			1		1	4
Spit 1	2182	9	20	3			1		1	4
Spit 1	2183	11	11	2			1		1	4
Spit 1	2184	12	8	5			1		1	4
Spit 1	2185	12	10	2			1		1	4
Spit 1	2186	8	18	5			1		1	4
Spit 1	2187	13	12	2			1		1	4
Spit 1	2188	16	12	2			1		1	4
Spit 1	2189	23	10	2			1		1	4
Spit 1	2190	20	10	2			1		1	4

Q12	Num	Length	Width	T/ness	P width	P t/ness	Weight	P angle	Mate	Type
Spit 1	2191	12	10	2			1		1	4
Spit 1	2192	8	18	3			1		1	4
Spit 1	2193	11	10	2			1		1	4
Spit 1	2194	9	13	4			1		1	4
Spit 1	2195	19	6	5			1		1	4
Spit 1	2196	14	10	4			1		1	4
Spit 1	2197	9	14	2			1		1	4
Spit 1	2198	26	9	3			1		1	4
Spit 1	2199	12	10	4			1		1	4
Spit 1	2200	13	15	2			1		1	4
Spit 1	2201	9	14	2			1		1	4
Spit 1	2202	10	13	2			1		1	4
Spit 1	2203	10	12	2			1		1	4
Spit 1	2204	12	11	2			1		1	4
Spit 1	2205	17	8	2			1		1	4
Spit 1	2206	17	11	2			1		1	4
Spit 1	2207	16	8	2			1		1	4
Spit 1	2208	10	15	4			1		1	4
Spit 1	2209	19	17	3			1		1	4
Spit 1	2210	10	10	2			1		1	4
Spit 1	2211	11	14	4			1		1	4
Spit 1	2212	10	11	2			1		1	4
Spit 1	2213	20	7	6			2		1	4
Spit 1	2214	10	10	2			1		1	4
Spit 1	2215	9	13	2			1		1	4
Spit 1	2216	18	15	2			1		1	4
Spit 1	2217	16	15	2			1		1	4
Spit 1	2218	18	8	2			1		1	4
Spit 1	2219	16	11	3			1		1	4
Spit 1	2220	19	9	2			1		1	4
Spit 1	2221	10	14	2			1		1	4
Spit 1	2222	15	9	4			1		1	4
Spit 1	2223	14	14	2			1		1	4
Spit 1	2224	18	17	2			1		1	4
Spit 1	2225	9	16	4			1		1	4
Spit 1	2226	10	12	2			1		1	4
Spit 1	2227	13	10	3			1		1	4
Spit 1	2228	15	11	3			1		1	4
Spit 1	2229	11	17	3			1		1	4
Spit 1	2230	12	14	2			1		1	4
Spit 1	2231	7	14	2			1		1	4
Spit 1	2232	14	16	1			1		1	4
Spit 1	2233	14	11	2			1		1	4
Spit 1	2234	14	10	3			1		1	4
Spit 1	2235	16	13	2			1		1	4
Spit 1	2236	11	12	3			1		1	4
Spit 1	2237	16	12	2			1		1	4
Spit 1	2238	11	13	3			1		1	4
Spit 1	2239	9	12	4			1		1	4
Spit 1	2240	12	11	2			1		1	4
Spit 1	2241	11	7	2			1		1	4
Spit 1	2242	13	11	1			1		1	4
Spit 1	2243	16	6	2			1		1	4
Spit 1	2244	9	10	2			1		1	4
Spit 1	2245	15	10	1			1		1	4
Spit 1	2246	14	14	2			1		1	4
Spit 1	2247	11	12	2			1		1	4
Spit 1	2248	13	12	3			1		1	4
Spit 1	2249	10	10	2			1		1	4
Spit 1	2250	9	11	3			1		1	4
Spit 1	2251	11	11	3			1		1	4

Q12	Num	Length	Width	T/ness	P width	P t/ness	Weight	P angle	Mate	Type
Spit 1	2252	7	11	1			1		1	4
Spit 1	2253	73	36	15			21		1	4
Spit 1	2254	47	50	13			12		1	4
Spit 1	2255	29	32	7			8		1	4
Spit 1	2256	32	34	7			4		1	4
Spit 1	2257	63	47	7			21		1	4
Spit 1	2258	85	53	12			27		1	4
Spit 1	2259	42	27	6			25		1	4
Spit 1	2260	52	37	8			18		1	4
Spit 1	2261	42	41	12					1	4
Spit 1	2262	41	47	17					1	4
Spit 1	2263	60	36	7			21		1	4
Spit 1	2264	60	37	8			18		1	4
Spit 1	2265	41	42	11			18		1	4
Spit 1	2266	55	35	12			12		1	4
Spit 1	2267	36	13	6			2		1	4
Spit 1	2268	30	8	2			1		1	4
Spit 1	2269	26	10	2			1		1	4
Spit 1	2270	22	19	4			1		1	4
Spit 1	2271	22	14	4			1		1	4
Spit 1	2272	16	10	2			1		1	4
Spit 1	2273	24	12	6			1		1	4
Spit 1	2274	20	11	4			1		1	4
Spit 1	2275	23	13	3			1		1	4
Spit 1	2276	18	11	2			1		1	4
Spit 1	2277	21	8	2			1		1	4
Spit 1	2278	34	30	3			12		1	4
Spit 1	2279	33	18	10			6		1	4
Spit 1	2280	42	21	8			9		1	4
Spit 1	2281	36	19	12			10		1	4
Spit 1	2282	64	31	7			16		1	4
Spit 1	2283	57	25	5			14		1	4
Spit 1	2284	24	36	5			5		1	4
Spit 1	2285	30	39	6			5		1	4
Spit 1	2286	63	36	25			31		1	4
Spit 1	2287	27	38	11			13		1	4
Spit 1	2288	49	21	6			8		1	4
Spit 1	2289	27	26	8			7		1	4
Spit 1	2290	32	29	9			6		1	4
Spit 1	2291	36	48	11			20		1	4
Spit 1	2292	11	19	9			4		1	4
Spit 1	2293	26	26	5			3		1	4
Spit 1	2294	40	27	10			11		1	4
Spit 1	2295	51	22	7			9		1	4
Spit 1	2296	22	9	4			1		1	4
Spit 1	2297	42	10	9			3		1	4
Spit 1	2298	10	33	4			1		1	4
Spit 1	2299	20	27	8			4		1	4
Spit 1	2300	19	25	7			1		1	4
Spit 1	2301	28	19	5			2		1	4
Spit 1	2302	26	19	2			1		1	4
Spit 1	2303	31	18	3			2		1	4
Spit 1	2304	22	18	3			1		1	4
Spit 1	2305	17	21	3			3		1	4
Spit 1	2306	27	19	6			2		1	4
Spit 1	2307	31	12	8			3		1	4
Spit 1	2308	28	22	6			3		1	1
Spit 2	2309	37	17	4	7	2	3	98	1	1
Spit 2	2310	33	17	6	15	10	6	132	1	1
Spit 2	2311	24	14	8	10	7	1	96	1	1
Spit 2	2312	84	63	24	63	22	135	86	1	1

Q12	Num	Length	Width	T/ness	P width	P t/ness	Weight	P angle	Mate	Type
Spit 2	2313	64	34	11			27	63	1	1
Spit 2	2314	42	27	4	24	14	15	63	1	1
Spit 2	2315	67	29	14	25	11	30	67	1	1
Spit 2	2316	54	34	15	34	14	24	49	1	1
Spit 2	2317	38	23	8	22	8	5	58	1	1
Spit 2	2318	21	24	4	12	4	2		1	1
Spit 2	2319	45	24	5	15	3	4		1	1
Spit 2	2320	26	22	6	11	5	3		1	1
Spit 2	2321	84	43	17	19	9	58		1	1
Spit 2	2322	87	34	21	28	16	79		1	1
Spit 2	2323	30	21	8	19	7	5	75	1	1
Spit 2	2324	29	25	11	25	10	13	78	1	1
Spit 2	2325	93	26	27			216		1	1
Spit 2	2326	64	50	15			60		1	1
Spit 2	2327	67	69	26			122		1	1
Spit 2	2328	69	79	15	27	3	74		1	1
Spit 2	2329	28	24	4	13	6	5		1	1
Spit 2	2330	23	15	3			1		1	1
Spit 2	2331	34	35	4			4		1	1
Spit 2	2332	27	26	5			5		1	2
Spit 2	2333	13	24	2	13	3	4	88	1	2
Spit 2	2334	2	15	6	14	4	1	74	1	2
Spit 2	2335	31	31	5	14	5	5	81	1	2
Spit 2	2336	15	24	4	16	2	1	72	1	2
Spit 2	2337	23	16	7	9	6	1	54	1	2
Spit 2	2338	83	80	29	77	31	79	83	1	2
Spit 2	2339	56	62	19	49	18	75	62	1	2
Spit 2	2340	76	60	26		11	144		1	2
Spit 2	2341	82	51	13	39	10	50	70	1	2
Spit 2	2342	69	47	15	47	17	37	64	1	2
Spit 2	2343	49	52	14	34	14	40	62	1	2
Spit 2	2344	61	44	7	17	4	17		1	2
Spit 2	2345	40	76	9	29	4	33	82	1	2
Spit 2	2346	47	43	6	16	4	12		1	2
Spit 2	2347	26	45	11	42	11	12	53	1	2
Spit 2	2348	60	39	14		15	43		1	2
Spit 2	2349	42	38	7	36	6	12	119	1	2
Spit 2	2350	29	54	14	29	15	18	55	1	2
Spit 2	2351	30	40	11		7	16		1	2
Spit 2	2352	52	34	19		3	18		1	2
Spit 2	2353	46	24	9		8	10		1	2
Spit 2	2354	38	36	7	17	4	11	94	1	2
Spit 2	2355	32	22	8		8	6		1	2
Spit 2	2356	38	45	8		6	12		1	2
Spit 2	2357	42	28	7	22	7	14	94	1	2
Spit 2	2358	32	16	9	14	9	3		1	2
Spit 2	2359	20	19	4	11	3	1	58	1	2
Spit 2	2360	23	22	8	22	7	3	108	1	2
Spit 2	2361	20	24	4	12	3	2	82	1	2
Spit 2	2362	124	105	51	99	50	980	86	1	2
Spit 2	2363	135	91	65	34	14	802	85	1	2
Spit 2	2364	89	47	16	20	4	68	94	1	2
Spit 2	2365	28	16	5	7	4	2	85	1	2
Spit 2	2366	19	16	4	12	3	1		1	2
Spit 2	2367	22	48	15	31	12	10		1	2
Spit 2	2368	23	47	17			14		1	2
Spit 2	2369	26	25	4			1		1	2
Spit 2	2370	19	22	4		4	2		1	2
Spit 2	2371	15	24	6			1		1	2
Spit 2	2372	115	114	36			433		1	2
Spit 2	2373	77	9	19			136		1	2

Q12	Num	Length	Width	T/ness	P width	P t/ness	Weight	P angle	Mate	Type
Spit 2	2374	20	14	5	12	7	2		1	2
Spit 2	2375	47	25	9			7		1	2
Spit 2	2376	35	41	15			16		1	2
Spit 2	2377	43	23	8			13		1	2
Spit 2	2378	60	20	11			16		1	4
Spit 2	2379	20	18	7			2		1	4
Spit 2	2380	30	20	3			3		1	4
Spit 2	2381	20	18	3			1		1	4
Spit 2	2382	27	18	6			2		1	4
Spit 2	2383	19	18	6			1		1	4
Spit 2	2384	22	20	7			2		1	4
Spit 2	2385	22	20	6			1		1	4
Spit 2	2386	26	20	4			1		1	4
Spit 2	2387	31	29	4			1		1	4
Spit 2	2388	18	21	2			1		1	4
Spit 2	2389	2	17	4			1		1	4
Spit 2	2390	24	17	10			2		1	4
Spit 2	2391	16	34	9			3		1	4
Spit 2	2392	24	17	9			2		1	4
Spit 2	2393	29	18	4			1		1	4
Spit 2	2394	17	14	3			1		1	4
Spit 2	2395	18	14	3			1		1	4
Spit 2	2396	22	19	6			3		1	4
Spit 2	2397	19	14	4			1		1	4
Spit 2	2398	24	16	3			1		1	4
Spit 2	2399	19	16	4			1		1	4
Spit 2	2400	14	13	4			1		1	4
Spit 2	2401	23	14	4			1		1	4
Spit 2	2402	27	18	7			2		1	4
Spit 2	2403	21	19	4			1		1	4
Spit 2	2404	21	16	3			1		1	4
Spit 2	2405	24	10	3			1		1	4
Spit 2	2406	16	13	3			1		1	4
Spit 2	2407	24	15	3			1		1	4
Spit 2	2408	25	15	3			1		1	4
Spit 2	2409	11	8	3			1		1	4
Spit 2	2410	21	10	3			1		1	4
Spit 2	2411	29	34	10			7		1	4
Spit 2	2412	33	29	5			6		1	4
Spit 2	2413	33	25	8			5		1	4
Spit 2	2414	19	14	4			1		1	4
Spit 2	2415	27	11	6			1		1	4
Spit 2	2416	27	14	5			1		1	4
Spit 2	2417	32	13	9			2		1	4
Spit 2	2418	15	17	3			1		1	4
Spit 2	2419	23	11	2			1		1	4
Spit 2	2420	21	19	4			1		1	4
Spit 2	2421	39	19	4			1		1	4
Spit 2	2422	21	22	3			1		1	4
Spit 2	2423	16	16	2			1		1	4
Spit 2	2424	14	18	4			1		1	4
Spit 2	2425	30	13	4			4		1	4
Spit 2	2426	17	15	3			1		1	4
Spit 2	2427	15	17	2			1		1	4
Spit 2	2428	19	12	3			1		1	4
Spit 2	2429	28	16	4			3		1	4
Spit 2	2430	28	14	3			1		1	4
Spit 2	2431	25	19	4			1		1	4
Spit 2	2432	24	12	2			1		1	4
Spit 2	2433	25	11	4			1		1	4
Spit 2	2434	26	14	6			1		1	4

Q12	Num	Length	Width	T/ness	P width	P t/ness	Weight	P angle	Mate	Type
Spit 2	2435	20	13	2			1		1	4
Spit 2	2436	21	12	3			1		1	4
Spit 2	2437	21	14	3			1		1	4
Spit 2	2438	29	8	2			1		1	4
Spit 2	2439	69	29	7			14		1	4
Spit 2	2440	52	34	21			34		1	4
Spit 2	2441	40	78	10			41		1	4
Spit 2	2442	52	31	8			11		1	4
Spit 2	2443	29	52	8			15		1	4
Spit 2	2444	42	25	17			16		1	4
Spit 2	2445	49	47	9			13		1	4
Spit 2	2446	47	25	11			13		1	4
Spit 2	2447	28	47	9			16		1	4
Spit 2	2448	30	34	11			11		1	4
Spit 2	2449	31	36	9			8		1	4
Spit 2	2450	41	34	9			19		1	4
Spit 2	2451	46	25	4			6		1	4
Spit 2	2452	24	19	6			2		1	4
Spit 2	2453	52	21	14			14		1	4
Spit 2	2454	27	42	7			7		1	4
Spit 2	2455	43	25	12			12		1	4
Spit 2	2456	43	35	11			14		1	4
Spit 2	2457	30	33	9			9		1	4
Spit 2	2458	48	15	14			7		1	4
Spit 2	2459	19	50	4			4		1	4
Spit 2	2460	45	52	11			19		1	4
Spit 2	2461	32	42	6			11		1	4
Spit 2	2462	30	41	4			6		1	4
Spit 2	2463	32	44	4			6		1	4
Spit 2	2464	25	24	8			8		1	4
Spit 2	2465	30	28	6			8		1	4
Spit 2	2466	29	27	3			7		1	4
Spit 2	2467	31	26	12			13		1	4
Spit 2	2468	45	21	4			6		1	4
Spit 2	2469	22	20	7			4		1	4
Spit 2	2470	29	47	9			16		1	4
Spit 2	2471	31	22	5			3		1	4
Spit 2	2472	42	21	7			7		1	4
Spit 2	2473	21	39	10			8		1	4
Spit 2	2474	33	27	7			7		1	4
Spit 2	2475	31	33	4			8		1	4
Spit 2	2476	37	18	4			2		1	4
Spit 2	2477	22	39	8			3		1	4
Spit 2	2478	37	24	6			4		1	4
Spit 2	2479	21	28	6			3		1	4
Spit 2	2480	17	22	7			2		1	4
Spit 2	2481	32	29	4			5		1	4
Spit 2	2482	32	20	7			3		1	4
Spit 2	2483	17	42	4			4		1	4
Spit 2	2484	21	12	3			1		1	4
Spit 2	2485	16	14	2			1		1	4
Spit 2	2486	27	19	8			2		1	4
Spit 2	2487	16	22	4			1		1	4
Spit 2	2488	26	17	2			1		1	4
Spit 2	2489	26	29	3			1		1	4
Spit 2	2490	13	17	2			1		1	4
Spit 2	2491	34	10	5			1		1	4
Spit 2	2492	24	16	5			1		1	4
Spit 2	2493	28	4	4			1		1	4
Spit 2	2494	29	12	4			1		1	4
Spit 2	2495	28	17	8			1		1	4

Q12	Num	Length	Width	T/ness	P width	P t/ness	Weight	P angle	Mater	Type
Spit 2	2496	19	18	3			1		1	4
Spit 2	2497	29	13	2			1		1	4
Spit 2	2498	20	19	3			1		1	4
Spit 2	2499	29	14	3			1		1	4
Spit 2	2500	20	10	1			1		1	4
Spit 2	2501	31	19	2			1		1	4
Spit 2	2502	29	12	4			1		1	4
Spit 2	2503	31	18	4			2		1	4
Spit 2	2504	33	17	4			2		1	4
Spit 2	2505	30	21	6			3		1	4
Spit 2	2506	31	17	4			1		1	4
Spit 2	2507	25	26	4			1		1	4
Spit 2	2508	34	16	4			2		1	4
Spit 2	2509	12	36	6			2		1	4
Spit 2	2510	29	16	5			4		1	4
Spit 2	2511	23	22	4			2		1	4
Spit 2	2512	22	22	6			1		1	4
Spit 2	2513	30	16	6			1		1	4
Spit 2	2514	16	21	5			1		1	4
Spit 2	2515	24	21	7			1		1	4
Spit 2	2516	26	30	3			2		1	4
Spit 2	2517	21	12	3			1		1	4
Spit 2	2518	24	16	4			1		1	4
Spit 2	2519	44	12	2			1		1	4
Spit 2	2520	30	17	5			1		1	4
Spit 2	2521	28	20	4			1		1	4
Spit 2	2522	28	22	4			1		1	4
Spit 2	2523	18	18	6			1		1	4
Spit 2	2524	12	26	3			1		1	4
Spit 2	2525	24	13	3			1		1	4
Spit 2	2526	15	14	7			1		1	4
Spit 2	2527	24	13	4			1		1	4
Spit 2	2528	13	25	3			1		1	4
Spit 2	2529	11	26	5			1		1	4
Spit 2	2530	16	14	4			1		1	4
Spit 2	2531	19	14	3			1		1	4
Spit 2	2532	22	11	3			1		1	4
Spit 2	2533	17	10	3			1		1	4
Spit 2	2534	21	11	4			1		1	4
Spit 2	2535	15	9	4			1		1	4
Spit 2	2536	17	8	1			1		1	4
Spit 2	2537	17	7	4			1		1	4
Spit 2	2538	19	9	2			1		1	4
Spit 2	2539	14	13	2			1		1	4
Spit 2	2540	14	11	2			1		1	4
Spit 2	2541	8	6	3			1		1	4
Spit 2	2542	19	5	3			1		1	4
Spit 2	2543	17	5	2			1		1	4
Spit 2	2544	14	5	3			1		1	4
Spit 2	2545	11	5	1			1		1	4
Spit 2	2546	117	81	33			266		1	4
Spit 2	2547	106	92	46			504		1	4
Spit 2	2548	68	68	24			114		1	4
Spit 2	2549	58	74	12			38		1	4
Spit 2	2550	48	68	16			56		1	4
Spit 2	2551	24	21	5			4		1	4
Spit 2	2552	25	17	3			1		1	4
Spit 2	2553	31	12	4			3		1	4
Spit 2	2554	24	40	6			1		1	4
Spit 2	2555	32	13	4			1		1	4
Spit 2	2556	29	11	6			3		1	4

Q12	Num	Length	Width	T/ness	P width	P t/ness	Weight	P angle	Mate	Type
Spit 2	2557	24	22	4			2		1	4
Spit 2	2558	26	24	3			2		1	4
Spit 2	2559	31	16	5			2		1	4
Spit 2	2560	31	27	7			5		1	4
Spit 2	2561	19	19	5			3		1	4
Spit 2	2562	24	12	7			1		1	4
Spit 2	2563	24	14	4			1		1	4
Spit 2	2564	34	12	6			1		1	4
Spit 2	2565	25	21	4			1		1	4
Spit 2	2566	24	19	31			1		1	4
Spit 2	2567	21	11	2			1		1	4
Spit 2	2568	25	12	4			1		1	4
Spit 2	2569	22	18	4			3		1	4
Spit 2	2570	30	24	6			6		1	4
Spit 2	2571	34	29	6			5		1	4
Spit 2	2572	17	40	10			4		1	4
Spit 2	2573	29	30	9			4		1	4
Spit 2	2574	28	22	3			1		1	4
Spit 2	2575	41	24	4			6		1	7
Spit 2	2576	219	71	54	77	31	1492		1	7
Spit 2	2577	144	112	90			1215		1	1
Spit 3	2578	21	15	4	9	3	1	94	1	1
Spit 3	2579	28	12	8	10	8	1	56	1	1
Spit 3	2580	38	39	6	23	3	11	87	1	1
Spit 3	2581	27	34	8	21	5	10	72	1	1
Spit 3	2582	34	37	13			12	103	1	1
Spit 3	2583	27	28	8	22	8	7	80	1	1
Spit 3	2584	17	21	4	17	4	1	108	1	1
Spit 3	2585	37	14	6	12	4	2	82	1	1
Spit 3	2586	22	16	7			2	69	1	1
Spit 3	2587	101	124	42	59	40	479	57	1	1
Spit 3	2588	93	73	23	28	13	188	86	1	1
Spit 3	2589	110	46	16	39	14	68	47	1	1
Spit 3	2590	55	46	16	38	16	38	48	1	1
Spit 3	2591	65	27	12		10	31	86	1	1
Spit 3	2592	52	41	11	19	9	29	80	1	1
Spit 3	2593	36	40	10	29	10	19	69	1	1
Spit 3	2594	37	33	9	18	4	11	73	1	1
Spit 3	2595	37	43	11	22	9	19	73	1	1
Spit 3	2596	41	31	6	21	6	8	71	1	1
Spit 3	2597	38	13	3			1		1	1
Spit 3	2598	24	18	3	12	3	2		1	1
Spit 3	2599	29	20	7			3		1	1
Spit 3	2600	46	21	28			8		1	1
Spit 3	2601	20	17	3	8	3	4		1	1
Spit 3	2602	33	23	4			4		1	1
Spit 3	2603	70	51	13			58		1	1
Spit 3	2604	54	35	12	32	8	40		1	2
Spit 3	2605	36	26	8	22	6	8	95	1	2
Spit 3	2606	36	32	15	28	11	32	70	1	2
Spit 3	2607	32	30	7	17	3	9	80	1	2
Spit 3	2608	37	26	11		12	9	54	1	2
Spit 3	2612	18	15	6	11	6	1	68	1	2
Spit 3	2613	60	90	19	29	16	118	69	1	2
Spit 3	2614	61	66	11	26	7	56	93	1	2
Spit 3	2615	70	87	31	46	21	187	82	1	2
Spit 3	2616	91	0	13		7	48	65	1	2
Spit 3	2617	42	39	11	19	6	22	78	1	2

Q12	Num	Length	Width	T/ness	P width	P t/ness	Weight	P angle	Mater	Type
Spit 3	2618	42	32	7	18	2	13	71	1	2
Spit 3	2619	37	32	6	17	7	11	136	1	2
Spit 3	2620	36	35	5	18	4	8	60	1	2
Spit 3	2621	46	23	16			13		1	2
Spit 3	2622	35	18	7		7	4		1	2
Spit 3	2623	74	65	17			78		1	2
Spit 3	2624	61	100	18			139		1	4
Spit 3	2625	30	38	4			10		1	4
Spit 3	2626	22	14	7			4		1	4
Spit 3	2627	15	19	8			3		1	4
Spit 3	2628	19	17	9			3		1	4
Spit 3	2629	38	13	4			4		1	4
Spit 3	2630	22	20	3			2		1	4
Spit 3	2631	45	18	12			11		1	4
Spit 3	2632	15	28	14			3		1	4
Spit 3	2633	38	12	7			4		1	4
Spit 3	2634	38	26	6			6		1	4
Spit 3	2635	46	25	7			10		1	4
Spit 3	2636	19	18	4			1		1	4
Spit 3	2637	53	27	6			6		1	4
Spit 3	2638	29	28	3			1		1	4
Spit 3	2639	21	22	4			1		1	4
Spit 3	2640	30	32	6			10		1	4
Spit 3	2641	27	10	18			1		1	4
Spit 3	2642	36	35	4			8		1	4
Spit 3	2643	41	23	8			7		1	4
Spit 3	2644	57	25	7			7		1	4
Spit 3	2645	24	18	6			2		1	4
Spit 3	2646	33	28	8			10		1	4
Spit 3	2647	27	16	4			2		1	4
Spit 3	2648	33	29	4			9		1	4
Spit 3	2649	19	40	9			8		1	4
Spit 3	2650	20	6	7			2		1	4
Spit 3	2651	37	20	12			6		1	4
Spit 3	2652	24	19	4			1		1	4
Spit 3	2653	28	16	7			3		1	4
Spit 3	2654	24	10	4			1		1	4
Spit 3	2655	30	11	2			1		1	4
Spit 3	2656	12	15	3			1		1	4
Spit 3	2657	27	6	3			1		1	4
Spit 3	2658	19	12	3			1		1	4
Spit 3	2659	26	12	3			1		1	4
Spit 3	2660	16	14	4			1		1	4
Spit 3	2661	28	10	4			1		1	4
Spit 3	2662	21	9	1			1		1	4
Spit 3	2663	25	14	3			1		1	4
Spit 3	2664	17	12	2			1		1	4
Spit 3	2665	7	12	6			1		1	4
Spit 3	2666	15	15	3			1		1	4
Spit 3	2667	22	7	3			1		1	4
Spit 3	2668	23	4	2			1		1	4
Spit 3	2669	18	12	1			1		1	4
Spit 3	2670	9	20	6			1		1	4
Spit 3	2671	15	10	2			1		1	4
Spit 3	2672	16	8	4			1		1	4
Spit 3	2673	17	7	4			1		1	4
Spit 3	2674	19	8	4			1		1	4
Spit 3	2675	9	17	1			1		1	4
Spit 3	2676	19	15	3			1		1	4
Spit 3	2677	15	12	2			1		1	4
Spit 3	2678	17	9	4			1		1	4

Q12	Num	Length	Width	T/ness	P width	P t/ness	Weight	P angle	Mate	Type
Spit 3	2679	12	13	2			1		1	4
Spit 3	2680	16	5	2			1		1	4
Spit 3	2681	12	11	2			1		1	4
Spit 3	2682	42	39	4			3		1	4
Spit 3	2683	33	24	11			11		1	4
Spit 3	2684	42	13	7			4		1	4
Spit 3	2685	35	14	7			2		1	4
Spit 3	2686	34	18	3			1		1	4
Spit 3	2687	22	28	13			7		1	4
Spit 3	2688	27	17	2			1		1	4
Spit 3	2689	20	15	6			1		1	4
Spit 3	2690	16	14	2			1		1	4
Spit 3	2691	33	19	6			2		1	4
Spit 3	2692	32	24	5			5		1	4
Spit 3	2693	73	69	19			64		1	4
Spit 3	2694	77	67	14			72		1	4
Spit 3	2695	49	47	15			37		1	4
Spit 3	2696	90	61	14			70		1	4
Spit 3	2697	96	45	14			67		1	4
Spit 3	2698	50	41	12			21		1	4
Spit 3	2699	45	35	7			20		1	4
Spit 3	2700	56	34	7			16		1	4
Spit 3	2701	46	37	5			15		1	4
Spit 3	2702	51	26	8			15		1	4
Spit 3	2703	54	28	10			16		1	4
Spit 3	2704	45	36	14			22		1	4
Spit 3	2705	51	28	9			17		1	4
Spit 3	2706	66	48	14			50		1	4
Spit 3	2707	44	25	14			17		1	4
Spit 3	2708	68	36	14			47		1	4
Spit 3	2709	40	31	11			15		1	4
Spit 3	2710	48	39	14			25		1	4
Spit 3	2711	60	22	12			11		1	4
Spit 3	2712	29	23	4			2		1	4
Spit 3	2713	42	19	5			5		1	4
Spit 3	2714	32	27	6			5		1	4
Spit 3	2715	22	38	4			4		1	4
Spit 3	2716	30	35	5			9		1	4
Spit 3	2717	34	32	2			3		1	4
Spit 3	2718	41	17	7			2		1	4
Spit 3	2719	45	29	4			7		1	4
Spit 3	2720	50	31	8			11		1	4
Spit 3	2721	51	38	5			12		1	4
Spit 3	2722	29	26	4			2		1	4
Spit 3	2723	29	20	10			4		1	4
Spit 3	2724	70	66	27			125		1	4
Spit 3	2725	96	48	27			126		1	4
Spit 3	2726	47	79	10			55		1	4
Spit 3	2727	67	81	23			83		1	4
Spit 3	2728	62	86	24			89		1	4
Spit 3	2729	134	30	20			83		1	4
Spit 3	2730	117	54	19			102		1	4
Spit 3	2731	99	38	22			65		1	4
Spit 3	2732	47	70	16			41		1	4
Spit 3	2733	57	60	19			71		1	4
Spit 3	2734	67	41	13			42		1	4
Spit 3	2735	44	39	6			15		1	4
Spit 3	2736	59	73	19			60		1	4
Spit 3	2737	30	26	7			9		1	4
Spit 3	2738	48	34	4			9		1	4
Spit 3	2739	43	35	9			13		1	4

Q12	Num	Length	Width	T/ness	P width	P t/ness	Weight	P angle	Mater	Type
Spit 3	2740	46	20	3			7		1	4
Spit 3	2741	39	32	11			15		1	4
Spit 3	2742	35	19	3			3		1	4
Spit 3	2743	27	19	7			8		1	4
Spit 3	2744	25	22	4			2		1	4
Spit 3	2745	37	19	6			7		1	4
Spit 3	2746	68	25	15			14		1	4
Spit 3	2747	38	21	2			2		1	4
Spit 3	2748	22	18	4			1		1	4
Spit 3	2749	29	33	8			5		1	4
Spit 3	2750	30	17	3			2		1	4
Spit 3	2751	39	22	4			3		1	4
Spit 3	2752	33	27	8			8		1	4
Spit 3	2753	17	18	9			3		1	4
Spit 3	2754	27	12	4			1		1	1
Spit 4	2755	81	74	19	39	7	111	87	1	1
Spit 4	2756	62	27	8	24	8	14	75	1	1
Spit 4	2757	25	45	8			33	66	1	1
Spit 4	2758	39	28	4	17	3	5	90	1	1
Spit 4	2759	31	35	8	24	8	4	118	1	1
Spit 4	2760	18	28	6	21	7	4	62	1	1
Spit 4	2761	28	26	5	14	5	3	78	1	1
Spit 4	2762	27	18	6	9	5	1		1	1
Spit 4	2763	32	16	6	11	4	1	86	1	1
Spit 4	2764	36	24	5	16	4	3	105	1	1
Spit 4	2765	29	37	11	12	6	4	98	1	1
Spit 4	2766	19	18	3	11	3	1		1	1
Spit 4	2767	20	24	4	13	3	1	104	1	1
Spit 4	2768	27	40	3	19	3	4	72	1	1
Spit 4	2769	38	15	7	6	3	2		1	1
Spit 4	2770	32	26	5	12	3	4		1	1
Spit 4	2771	34	17	6	9	5	1	77	1	1
Spit 4	2772	17	23	3	11	2	2	95	1	1
Spit 4	2773	41	17	6	15	5	3	92	1	1
Spit 4	2774	37	25	5	14	3	1	76	1	1
Spit 4	2775	16	14	3	12	4	1	81	1	1
Spit 4	2776	19	16	4	14	4	1	95	1	1
Spit 4	2777	20	16	4	16	5	1	26	1	1
Spit 4	2778	19	14	2	8	2	1	107	1	1
Spit 4	2779	16	9	1	7	2	1	85	1	1
Spit 4	2780	15	81	22			29		1	1
Spit 4	2781	36	42	12			12		1	1
Spit 4	2782	71	51	5			28		1	1
Spit 4	2783	21	38	3			1		1	1
Spit 4	2784	22	25	3			1		1	1
Spit 4	2785	35	30	5			4		1	2
Spit 4	2786	44	52	12	43	11	37		1	2
Spit 4	2787	70	49	11		11	46	87	1	2
Spit 4	2788	39	41	12	26	11	14	74	1	2
Spit 4	2789	48	22	7		7	12	60	1	2
Spit 4	2790	39	45	14	34	14	33	81	1	2
Spit 4	2791	38	21	12		10	7	64	1	2
Spit 4	2792	50	24	7			9	66	1	2
Spit 4	2793	37	21	12			15	81	1	2
Spit 4	2794	18	38	5	15	3	2	84	1	2
Spit 4	2795	15	23	6	17	4	2		1	2
Spit 4	2796	16	30	4	14	3	2		1	2
Spit 4	2797	18	21	3	12	2	1	83	1	2
Spit 4	2798	38	28	7	17	7	8	69	1	2
Spit 4	2799	34	12	7	6	3	2	82	1	2
Spit 4	2800	29	23	11		6	6	87	1	2

Q12	Num	Length	Width	T/ness	P width	P t/ness	Weight	P angle	Mate	Type
Spit 4	2801	23	24	3	11	3	1	85	1	2
Spit 4	2803	24	12	3	9	2	1	102	1	2
Spit 4	2804	22	8	1	6	1	1	98	1	2
Spit 4	2805	45	19	8			8		1	2
Spit 4	2806	20	38	6			6		1	2
Spit 4	2807	29	31	7			7		1	2
Spit 4	2808	17	32	4	18	2	5		1	2
Spit 4	2809	43	22	11		4	10		1	2
Spit 4	2810	27	22	5			8		1	2
Spit 4	2811	14	49	5			1		1	2
Spit 4	2812	37	20	8			3		1	4
Spit 4	2813	35	12	6			3		1	4
Spit 4	2814	24	9	4			1		1	4
Spit 4	2815	25	12	3			1		1	4
Spit 4	2816	21	15	2			1		1	4
Spit 4	2817	24	20	5			1		1	4
Spit 4	2818	31	22	2			1		1	4
Spit 4	2819	23	15	2			1		1	4
Spit 4	2820	10	24	4			1		1	4
Spit 4	2821	16	11	2			1		1	4
Spit 4	2822	35	10	5			3		1	4
Spit 4	2823	20	30	4			3		1	4
Spit 4	2824	15	8	4			1		1	4
Spit 4	2825	28	24	4			3		1	4
Spit 4	2826	19	20	4			1		1	4
Spit 4	2827	25	23	7			3		1	4
Spit 4	2828	53	10	3			2		1	4
Spit 4	2829	33	14	4			3		1	4
Spit 4	2830	27	21	6			2		1	4
Spit 4	2831	23	22	7			3		1	4
Spit 4	2832	24	19	3			2		1	4
Spit 4	2833	24	12	4			1		1	4
Spit 4	2834	17	15	2			1		1	4
Spit 4	2835	11	11	2			1		1	4
Spit 4	2836	26	12	5			2		1	4
Spit 4	2837	18	22	3			1		1	4
Spit 4	2838	20	8	5			1		1	4
Spit 4	2839	33	10	2			1		1	4
Spit 4	2840	23	29	4			2		1	4
Spit 4	2841	15	14	4			1		1	4
Spit 4	2842	18	15	4			1		1	4
Spit 4	2843	16	14	3			1		1	4
Spit 4	2844	23	18	4			3		1	4
Spit 4	2845	40	19	4			4		1	4
Spit 4	2846	29	27	3			2		1	4
Spit 4	2847	23	19	4			1		1	4
Spit 4	2848	19	17	6			1		1	4
Spit 4	2849	33	26	5			5		1	4
Spit 4	2850	29	30	4			2		1	4
Spit 4	2851	26	20	4			4		1	4
Spit 4	2852	25	17	8			3		1	4
Spit 4	2853	18	10	7			1		1	4
Spit 4	2854	40	26	7			5		1	4
Spit 4	2855	22	21	3			2		1	4
Spit 4	2856	19	17	11			4		1	4
Spit 4	2857	35	25	12			8		1	4
Spit 4	2858	29	24	5			3		1	4
Spit 4	2859	43	19	10			5		1	4
Spit 4	2860	32	17	5			2		1	4
Spit 4	2861	22	20	3			1		1	4
Spit 4	2862	38	26	4			7		1	4

Q12	Num	Length	Width	T/ness	P width	P t/ness	Weight	P angle	Matei	Type
Spit 4	2863	26	19	2			1		1	4
Spit 4	2864	15	20	5			1		1	4
Spit 4	2865	27	10	4			1		1	4
Spit 4	2866	20	14	6			1		1	4
Spit 4	2867	16	14	5			3		1	4
Spit 4	2868	12	10	3			1		1	4
Spit 4	2869	11	8	9			1		1	4
Spit 4	2870	15	6	2			1		1	4
Spit 4	2871	17	14	4			1		1	4
Spit 4	2872	12	13	2			1		1	4
Spit 4	2873	15	7	2			1		1	4
Spit 4	2874	15	7	1			1		1	4
Spit 4	2875	10	13	3			1		1	4
Spit 4	2876	13	11	2			1		1	4
Spit 4	2877	15	11	2			1		1	4
Spit 4	2878	15	6	5			1		1	4
Spit 4	2879	13	13	2			1		1	4
Spit 4	2880	14	9	2			1		1	4
Spit 4	2881	8	13	2			1		1	4
Spit 4	2882	10	14	1			1		1	4
Spit 4	2883	10	12	1			1		1	4
Spit 4	2884	16	6	1			1		1	4
Spit 4	2885	7	4	5			1		1	4
Spit 4	2886	9	10	1			1		1	4
Spit 4	2887	82	49	24			70		1	4
Spit 4	2888	65	89	21			106		1	4
Spit 4	2889	68	32	10			33		1	4
Spit 4	2890	60	30	5			11		1	4
Spit 4	2891	62	32	21			37		1	4
Spit 4	2892	53	40	14			26		1	4
Spit 4	2893	40	43	14			31		1	4
Spit 4	2894	51	39	21			24		1	4
Spit 4	2895	31	40	8			14		1	4
Spit 4	2896	29	30	4			6		1	4
Spit 4	2897	58	25	12			14		1	4
Spit 4	2898	47	38	11			25		1	4
Spit 4	2899	43	40	6			11		1	4
Spit 4	2900	33	33	5			7		1	4
Spit 4	2901	50	27	4			8		1	4
Spit 4	2902	25	23	6			5		1	4
Spit 4	2903	42	26	8			7		1	4
Spit 4	2904	22	21	6			2		1	4
Spit 4	2905	21	18	3			1		1	4
Spit 4	2906	14	4	3			1		1	4
Spit 4	2907	32	14	4			1		1	4
Spit 4	2908	19	22	7			2		1	4
Spit 4	2909	28	18	5			1		1	4
Spit 4	2910	19	21	4			1		1	4
Spit 4	2911	31	11	7			1		1	4
Spit 4	2912	12	22	5			1		1	4
Spit 4	2913	21	17	3			1		1	4
Spit 4	2914	21	16	7			1		1	4
Spit 4	2915	12	26	5			1		1	4
Spit 4	2916	23	18	5			1		1	4
Spit 4	2917	24	16	3			1		1	4
Spit 4	2918	8	12	4			1		1	4
Spit 4	2919	34	19	6			3		1	4
Spit 4	2920	11	18	2			2		1	4
Spit 4	2921	29	16	4			1		1	4
Spit 4	2922	47	52	11			17		1	4
Spit 4	2923	72	24	8			15		1	4

Q12	Num	Length	Width	T/ness	P width	P t/ness	Weight	P angle	Mater	Type
Spit 4	2924	59	35	7			15		1	4
Spit 4	2916	60	19	10			11		1	4
Spit 4	2917	30	22	12			7		1	4
Spit 4	2918	50	33	6			14		1	4
Spit 4	2919	27	21	3			4		1	4
Spit 4	2920	26	24	11			4		1	4
Spit 4	2921	33	32	12			18		1	4
Spit 4	2922	26	33	5			4		1	4
Spit 4	2923	15	21	4			1		1	4
Spit 4	2924	36	15	5			6		1	4
Spit 4	2925	33	32	4			1		1	4
Spit 4	2926	40	16	4			3		1	4
Spit 4	2927	32	32	5			3		1	4
Spit 4	2928	32	18	4			2		1	4
Spit 4	2929	27	16	3			1		1	4
Spit 4	2930	17	12	2			1		1	4
Spit 4	2931	41	16	8			2		1	4
Spit 4	2932	24	26	4			2		1	4
Spit 4	2933	17	16	6			1		1	4
Spit 4	2934	24	16	3			1		1	4
Spit 4	2935	19	26	5			1		1	4
Spit 4	2936	21	19	3			1		1	4
Spit 4	2937	13	30	4			1		1	4
Spit 4	2938	11	19	2			1		1	4
Spit 4	2939	17	22	3			1		1	4
Spit 4	2940	28	17	5			1		1	4
Spit 4	2941	22	14	3			1		1	4
Spit 4	2942	27	19	4			1		1	4
Spit 4	2943	17	27	6			1		1	4
Spit 4	2944	26	9	6			1		1	4
Spit 4	2945	29	24	4			1		1	4
Spit 4	2946	41	14	6			1		1	4
Spit 4	2947	25	17	3			1		1	4
Spit 4	2948	26	27	4			1		1	4
Spit 4	2949	29	26	9			2		1	4
Spit 4	2950	29	26	8			5		1	4
Spit 4	2951	47	22	7			3		1	4
Spit 4	2952	32	12	3			1		1	4
Spit 4	2953	17	20	4			1		1	4
Spit 4	2954	14	26	4			1		1	4
Spit 4	2955	28	16	6			1		1	4
Spit 4	2956	23	16	1			1		1	4
Spit 4	2957	30	13	5			1		1	4
Spit 4	2958	29	13	4			1		1	4
Spit 4	2959	27	11	5			1		1	4
Spit 4	2960	23	21	3			1		1	4
Spit 4	2961	14	36	11			4		1	4
Spit 4	2962	35	21	11			10		1	4
Spit 4	2963	21	18	4			1		1	4
Spit 4	2964	22	16	3			1		1	4
Spit 4	2965	14	20	5			1		1	4
Spit 4	2966	20	24	7			3		1	4
Spit 4	2967	17	13	3			1		1	4
Spit 4	2968	30	9	5			1		1	4
Spit 4	2969	18	17	7			1		1	4
Spit 4	2970	11	22	6			1		1	4
Spit 4	2971	12	32	4			1		1	4
Spit 4	2972	31	14	3			1		1	4
Spit 4	2973	29	15	7			1		1	4
Spit 4	2974	24	10	5			1		1	4
Spit 4	2975	17	23	3			1		1	4

Q12	Num	Length	Width	T/ness	P width	P t/ness	Weight	P angle	Matei	Type
Spit 4	2976	36	17	3			1		1	4
Spit 4	2977	18	22	3			1		1	4
Spit 4	2978	29	28	4			1		1	4
Spit 4	2979	18	21	1			1		1	4
Spit 4	2980	14	17	1			1		1	4
Spit 4	2981	8	9	6			1		1	4
Spit 4	2982	16	17	2			1		1	4
Spit 4	2983	16	10	2			1		1	4
Spit 4	2984	12	16	1			1		1	4
Spit 4	2985	13	12	2			1		1	4
Spit 4	2986	17	15	3			1		1	4
Spit 4	2987	16	15	2			1		1	4
Spit 4	2988	20	15	3			1		1	4
Spit 4	2989	17	18	2			1		1	4
Spit 4	2990	17	11	1			1		1	4
Spit 4	2991	20	12	4			1		1	4
Spit 4	2992	22	14	9			1		1	4
Spit 4	2993	11	21	6			1		1	4
Spit 4	2994	14	13	2			1		1	4
Spit 4	2995	10	14	3			1		1	4
Spit 4	2996	16	10	3			1		1	4
Spit 4	2997	14	11	2			1		1	4
Spit 4	2998	19	12	1			1		1	4
Spit 4	2999	20	14	4			1		1	4
Spit 4	3000	21	11	7			1		1	4
Spit 4	3001	19	9	2			1		1	4
Spit 4	3002	23	6	7			1		1	4
Spit 4	3003	17	18	1			1		1	4
Spit 4	3004	26	7	7			1		1	4
Spit 4	3005	13	10	7			1		1	4
Spit 4	3006	19	9	3			1		1	4
Spit 4	3007	14	10	2			1		1	4
Spit 4	3008	12	11	4			1		1	4
Spit 4	3009	16	13	2			1		1	4
Spit 4	3010	22	8	2			1		1	4
Spit 4	3011	15	21	2			1		1	4
Spit 4	3012	16	11	1			1		1	4
Spit 4	3013	25	14	6			1		1	4
Spit 4	3014	25	14	4			1		1	4
Spit 4	3015	18	17	2			1		1	4
Spit 4	3016	27	9	6			1		1	4
Spit 4	3017	17	29	3			1		1	4
Spit 4	3018	27	10	4			1		1	4
Spit 4	3019	20	12	3			1		1	4
Spit 4	3020	24	14	4			1		1	4
Spit 4	3021	16	7	2			1		1	4
Spit 4	3022	28	15	8			1		1	4
Spit 4	3023	23	10	2			1		1	4
Spit 4	3024	20	14	3			1		1	4
Spit 4	3025	15	13	6			1		1	4
Spit 4	3026	26	10	7			1		1	4
Spit 4	3027	12	24	4			1		1	4
Spit 4	3028	23	14	4			1		1	4
Spit 4	3029	16	12	2			1		1	4
Spit 4	3030	15	18	3			1		1	4
Spit 4	3031	22	20	5			2		1	4
Spit 4	3032	31	11	6			1		1	4
Spit 4	3033	16	25	3			1		1	4
Spit 4	3034	14	20	3			1		1	4
Spit 4	3035	19	18	2			1		1	4
Spit 4	3036	30	22	5			4		1	4

Q12	Num	Length	Width	T/ness	P width	P t/ness	Weight	P angle	Mater	Type
Spit 4	3037	26	12	5			1		1	4
Spit 4	3038	23	12	3			1		1	4
Spit 4	3039	15	20	4			1		1	4
Spit 4	3040	16	18	3			1		1	4
Spit 4	3041	43	18	4			6		1	4
Spit 4	3042	25	14	4			1		1	4
Spit 4	3043	21	17	3			1		1	4
Spit 4	3044	19	11	3			1		1	4
Spit 4	3045	9	12	1			1		1	4
Spit 4	3046	13	16	2			1		1	4
Spit 4	3047	14	16	3			1		1	4
Spit 4	3048	22	14	2			1		1	4
Spit 4	3049	21	14	1			1		1	4
Spit 4	3050	17	8	3			1		1	4
Spit 4	3051	24	8	3			1		1	4
Spit 4	3052	14	17	2			1		1	4
Spit 4	3053	20	10	4			1		1	4
Spit 4	3054	8	18	2			1		1	4
Spit 4	3055	16	13	4			1		1	4
Spit 4	3056	10	15	4			1		1	4
Spit 4	3057	16	14	2			1		1	4
Spit 4	3058	19	13	4			1		1	4
Spit 4	3059	14	11	1			1		1	4
Spit 4	3060	18	10	2			1		1	4
Spit 4	3061	17	21	4			1		1	4
Spit 4	3062	16	14	2			1		1	4
Spit 4	3063	20	16	1			1		1	4
Spit 4	3064	15	10	1			1		1	4
Spit 4	3065	22	11	5			1		1	4
Spit 4	3066	20	8	4			1		1	4
Spit 4	3067	17	15	5			1		1	4
Spit 4	3068	24	10	4			1		1	4
Spit 4	3069	26	24	11			4		1	4
Spit 4	3070	33	32	12			18		1	4
Spit 4	3071	26	33	5			4		1	4
Spit 4	3072	15	21	4			1		1	4
Spit 4	3073	36	15	5			6		1	4
Spit 4	3074	33	32	4			1		1	4
Spit 4	3075	40	16	4			3		1	4
Spit 4	3076	32	32	5			3		1	4
Spit 4	3077	32	18	4			2		1	4
Spit 4	3078	27	16	3			1		1	4
Spit 4	3079	17	12	2			1		1	4
Spit 4	3080	41	16	8			2		1	4
Spit 4	3081	24	26	4			2		1	4
Spit 4	3082	17	16	6			1		1	4
Spit 4	3083	24	16	3			1		1	4
Spit 4	3084	19	26	5			1		1	4
Spit 4	3085	21	19	3			1		1	4
Spit 4	3086	13	30	4			1		1	4
Spit 4	3087	11	19	2			1		1	4
Spit 4	3088	17	22	3			1		1	4
Spit 4	3089	28	17	5			1		1	4
Spit 4	3090	22	14	3			1		1	4
Spit 4	3091	27	19	4			1		1	4
Spit 4	3092	17	27	6			1		1	4
Spit 4	3093	26	9	6			1		1	4
Spit 4	3094	29	24	4			1		1	4
Spit 4	3095	41	14	6			1		1	4
Spit 4	3096	25	17	3			1		1	4
Spit 4	3097	26	27	4			1		1	4

Q12	Num	Length	Width	T/ness	P width	P t/ness	Weight	P angle	Mate	Type
Spit 4	3098	29	26	9			2		1	4
Spit 4	3099	29	26	8			5		1	4
Spit 4	3100	47	22	7			3		1	4
Spit 4	3101	32	12	3			1		1	4
Spit 4	3102	17	20	4			1		1	4
Spit 4	3103	14	26	4			1		1	4
Spit 4	3104	28	16	6			1		1	4
Spit 4	3105	23	16	1			1		1	4
Spit 4	3106	30	13	5			1		1	4
Spit 4	3107	29	13	4			1		1	4
Spit 4	3108	27	11	5			1		1	4
Spit 4	3109	23	21	3			1		1	4
Spit 4	3110	14	36	11			4		1	4
Spit 4	3111	35	21	11			10		1	4
Spit 4	3112	21	18	4			1		1	4
Spit 4	3113	22	16	3			1		1	4
Spit 4	3114	14	20	5			1		1	4
Spit 4	3115	20	24	7			3		1	4
Spit 4	3116	17	13	3			1		1	4
Spit 4	3117	30	9	5			1		1	4
Spit 4	3118	18	17	7			1		1	4
Spit 4	3119	11	22	6			1		1	4
Spit 4	3120	12	32	4			1		1	4
Spit 4	3121	31	14	3			1		1	4
Spit 4	3122	29	15	7			1		1	4
Spit 4	3123	24	10	5			1		1	4
Spit 4	3124	17	23	3			1		1	4
Spit 4	3125	36	17	3			1		1	4
Spit 4	3126	18	22	3			1		1	4
Spit 4	3127	29	28	4			1		1	4
Spit 4	3128	18	21	1			1		1	4
Spit 4	3129	14	17	1			1		1	4
Spit 4	3130	8	9	6			1		1	4
Spit 4	3131	16	17	2			1		1	4
Spit 4	3132	16	10	2			1		1	4
Spit 4	3133	12	16	1			1		1	4
Spit 4	3134	13	12	2			1		1	4
Spit 4	3135	17	15	3			1		1	4
Spit 4	3136	16	15	2			1		1	4
Spit 4	3137	20	15	3			1		1	4
Spit 4	3138	17	18	2			1		1	4
Spit 4	3139	17	11	1			1		1	4
Spit 4	3140	20	12	4			1		1	4
Spit 4	3141	22	14	9			1		1	4
Spit 4	3142	11	21	6			1		1	4
Spit 4	3143	14	13	2			1		1	4
Spit 4	3144	10	14	3			1		1	4
Spit 4	3145	16	10	3			1		1	4
Spit 4	3146	14	11	2			1		1	4
Spit 4	3147	19	12	1			1		1	4
Spit 4	3148	20	14	4			1		1	4
Spit 4	3149	21	11	7			1		1	4
Spit 4	3150	19	9	2			1		1	4
Spit 4	3151	23	6	7			1		1	4
Spit 4	3152	17	18	1			1		1	4
Spit 4	3153	26	7	7			1		1	4
Spit 4	3154	13	10	7			1		1	4
Spit 4	3155	19	9	3			1		1	4
Spit 4	3156	14	10	2			1		1	4
Spit 4	3157	12	11	4			1		1	4
Spit 4	3158	16	13	2			1		1	4

Q12	Num	Length	Width	T/ness	P width	P t/ness	Weight	P angle	Mate	Type
Spit 4	3159	22	8	2			1		1	4
Spit 4	3160	15	21	2			1		1	4
Spit 4	3161	16	11	1			1		1	4
Spit 4	3162	25	14	6			1		1	4
Spit 4	3163	25	14	4			1		1	4
Spit 4	3164	18	17	2			1		1	4
Spit 4	3165	27	9	6			1		1	4
Spit 4	3166	17	29	3			1		1	4
Spit 4	3167	27	10	4			1		1	4
Spit 4	3168	20	12	3			1		1	4
Spit 4	3169	24	14	4			1		1	4
Spit 4	3170	16	7	2			1		1	4
Spit 4	3171	28	15	8			1		1	4
Spit 4	3172	23	10	2			1		1	4
Spit 4	3173	20	14	3			1		1	4
Spit 4	3174	15	13	6			1		1	4
Spit 4	3175	26	10	7			1		1	4
Spit 4	3176	12	24	4			1		1	4
Spit 4	3177	23	14	4			1		1	4
Spit 4	3178	16	12	2			1		1	4
Spit 4	3179	15	18	3			1		1	4
Spit 4	3180	22	20	5			2		1	4
Spit 4	3181	31	11	6			1		1	4
Spit 4	3182	16	25	3			1		1	4
Spit 4	3183	18	18	2			1		1	4
Spit 4	3184	20	9	2			1		1	4
Spit 4	3185	13	19	3			1		1	4
Spit 4	3186	20	7	1			1		1	4
Spit 4	3187	20	10	1			1		1	4
Spit 4	3188	16	10	1			1		1	4
Spit 4	3199	15	11	4			1		1	4
Spit 4	3200	18	10	1			1		1	4
Spit 4	3201	15	9	3			1		1	4
Spit 4	3202	22	11	3			1		1	4
Spit 4	3203	13	14	5			1		1	4
Spit 4	3204	13	20	6			1		1	4
Spit 4	3205	25	7	3			1		1	4
Spit 4	3206	17	15	3			1		1	4
Spit 4	3207	11	14	1			1		1	4
Spit 4	3208	16	10	1			1		1	4
Spit 4	3209	14	7	2			1		1	4
Spit 4	3210	17	14	2			1		1	4
Spit 4	3211	15	10	1			1		1	4
Spit 4	3212	15	17	2			1		1	4
Spit 4	3213	10	11	2			1		1	4
Spit 4	3214	16	15	1			1		1	4
Spit 4	3215	12	13	1			1		1	4
Spit 4	3216	16	10	1			1		1	4
Spit 4	3217	13	9	2			1		1	4
Spit 4	3218	15	22	4			1		1	4
Spit 4	3219	21	9	2			1		1	4
Spit 4	3220	12	11	2			1		1	4
Spit 4	3221	5	10	4			1		1	4
Spit 4	3222	13	10	5			1		1	4
Spit 4	3223	11	14	4			1		1	4
Spit 4	3224	15	12	1			1		1	4
Spit 4	3225	11	7	4			1		1	4
Spit 4	3226	14	10	1			1		1	4
Spit 4	3227	13	12	2			1		1	4
Spit 4	3228	24	7	1			1		1	4
Spit 4	3229	21	14	2			1		1	4

Q12	Num	Length	Width	T/ness	P width	P t/ness	Weight	P angle	Mate	Type
Spit 4	3230	19	10	6			1		1	4
Spit 4	3231	27	8	4			1		1	4
Spit 4	3232	19	7	2			1		1	4
Spit 4	3233	9	17	2			1		1	4
Spit 4	3234	15	6	1			1		1	4
Spit 4	3235	16	17	3			1		1	4
Spit 4	3236	21	15	1			1		1	4
Spit 4	3237	27	10	3			1		1	4
Spit 4	3238	15	10	3			1		1	4
Spit 4	3239	17	10	1			1		1	4
Spit 4	3240	20	20	4			1		1	4
Spit 4	3241	15	11	1			1		1	4
Spit 4	3242	12	10	1			1		1	4
Spit 4	3243	14	15	4			1		1	4
Spit 4	3244	16	15	2			1		1	4
Spit 4	3245	10	16	2			1		1	4
Spit 4	3246	18	14	4			1		1	4
Spit 4	3247	16	13	2			1		1	4
Spit 4	3248	13	17	1			1		1	4
Spit 4	3249	15	9	2			1		1	4
Spit 4	3250	15	13	2			1		1	4
Spit 4	3251	14	10	1			1		1	4
Spit 4	3252	16	18	2			1		1	4
Spit 4	3253	16	13	2			1		1	4
Spit 4	3254	9	15	2			1		1	4
Spit 4	3255	15	12	4			1		1	4
Spit 4	3256	11	17	1			1		1	4
Spit 4	3257	21	11	2			1		1	4
Spit 4	3258	17	8	5			1		1	4
Spit 4	3259	17	14	1			1		1	4
Spit 4	3260	10	14	1			1		1	4
Spit 4	3261	13	7	3			1		1	4
Spit 4	3262	17	8	1			1		1	4
Spit 4	3263	14	13	2			1		1	4
Spit 4	3264	10	14	4			1		1	4
Spit 4	3265	14	15	1			1		1	4
Spit 4	3266	9	15	2			1		1	4
Spit 4	3267	11	14	1			1		1	4
Spit 4	3268	18	13	1			1		1	4
Spit 4	3269	20	10	2			1		1	4
Spit 4	3270	16	21	5			1		1	4
Spit 4	3271	23	11	1			1		1	4
Spit 4	3272	16	15	2			1		1	4
Spit 4	3273	17	14	2			1		1	4
Spit 4	3274	22	10	3			1		1	4
Spit 4	3275	18	9	1			1		1	4
Spit 4	3276	13	12	1			1		1	4
Spit 4	3277	10	14	3			1		1	4
Spit 4	3278	14	9	3			1		1	4
Spit 4	3279	9	14	2			1		1	4
Spit 4	3280	10	14	1			1		1	4
Spit 4	3281	10	9	1			1		1	4
Spit 4	3282	12	18	4			1		1	4
Spit 4	3283	15	11	2			1		1	4
Spit 4	3284	9	12	3			1		1	4
Spit 4	3285	11	9	3			1		1	1
Spit 5	3286	14	20	3			1		1	4
Spit 5	3287	19	18	2			1		1	4
Spit 5	3288	30	22	5			4		1	4
Spit 5	3289	26	12	5			1		1	4
Spit 5	3290	23	12	3			1		1	4

Q12	Num	Length	Width	T/ness	P width	P t/ness	Weight	P angle	Mate	Type
Spit 5	3291	15	20	4			1		1	4
Spit 5	3292	16	18	3			1		1	4
Spit 5	3293	43	18	4			6		1	4
Spit 5	3294	25	14	4			1		1	4
Spit 5	3295	21	17	3			1		1	4
Spit 5	3296	19	11	3			1		1	4
Spit 5	3297	9	12	1			1		1	4
Spit 5	3298	13	16	2			1		1	4
Spit 5	3299	14	16	3			1		1	4
Spit 5	3300	22	14	2			1		1	4
Spit 5	3301	21	14	1			1		1	4
Spit 5	3302	17	8	3			1		1	4
Spit 5	3303	24	8	3			1		1	4
Spit 5	3304	14	17	2			1		1	4
Spit 5	3305	20	10	4			1		1	4
Spit 5	3306	8	18	2			1		1	4
Spit 5	3307	16	13	4			1		1	4
Spit 5	3308	10	15	4			1		1	4
Spit 5	3309	16	14	2			1		1	4
Spit 5	3310	19	13	4			1		1	4
Spit 5	3311	14	11	1			1		1	4
Spit 5	3312	18	10	2			1		1	4
Spit 5	3313	17	21	4			1		1	4
Spit 5	3314	16	14	2			1		1	4
Spit 5	3315	20	16	1			1		1	4
Spit 5	3316	15	10	1			1		1	4
Spit 5	3317	22	11	5			1		1	4
Spit 5	3318	20	8	4			1		1	4
Spit 5	3319	17	15	5			1		1	4
Spit 5	3320	24	10	4			1		1	4
Spit 5	3321	49	79	20	27	16	69	112	1	1
Spit 5	3322	72	51	18	40	17	56	56	1	1
Spit 5	3323	34	31	7	12	2	10	99	1	1
Spit 5	3324	55	26	6	13	1	8		1	1
Spit 5	3325	33	41	4		2	8		1	1
Spit 5	3326	51	25	6			11		1	1
Spit 5	3327	29	32	9	24	5	10		1	2
Spit 5	3328	47	27	11	23	11	216	116	1	2
Spit 5	3329	57	15	8		4	8		1	2
Spit 5	3330	4	17	6	7	1	1		1	4
Spit 5	3331	63	150	8			334		1	4
Spit 5	3332	68	51	12			51		1	4
Spit 5	3333	51	46	6			13		1	4
Spit 5	3334	79	29	8			19		1	4
Spit 5	3335	37	24	8			7		1	4
Spit 5	3336	35	28	13			14		1	4
Spit 5	3337	35	24	4			6		1	4
Spit 5	3338	57	14	6			6		1	4
Spit 5	3339	43	14	4			5		1	4
Spit 5	3340	29	23	3			2		1	4
Spit 5	3341	28	22	3			1		1	4
Spit 5	3342	14	26	8			3		1	4
Spit 5	3343	19	32	7			5		1	4
Spit 5	3344	18	33	6			4		1	4
Spit 5	3345	16	14	4			1		1	4
Spit 5	3346	21	22	3			2		1	4
Spit 5	3347	26	11	2			1		1	4
Spit 5	3348	29	21	4			2		1	4
Spit 5	3349	18	30	6			3		1	4
Spit 5	3350	26	8	4			1		1	4
Spit 5	3351	16	10	4			1		1	4

Q12	Num	Length	Width	T/ness	P width	P t/ness	Weight	P angle	Mater	Type
Spit 5	3352	13	11	5			1		1	4
Spit 5	3353	16	14	2			1		1	4
Spit 5	3354	18	15	4			1		1	4
Spit 5	3355	22	10	2			1		1	4
Spit 5	3356	16	9	4			1		1	4
Spit 5	3357	14	8	1			1		1	4
Spit 5	3358	10	9	4			2		1	1
Spit 5	3359	10	14	4			1		1	4
Spit 5	3360	11	16	2			1		1	4
Spit 5	3361	18	9	6			1		1	4
Spit 6	3362	10	15	3			1		1	4
Spit 6	3363	19	9	3			1		1	4
Spit 6	3364	19	10	2			1		1	4
Spit 6	3365	10	18	2			1		1	4
Spit 6	3366	15	10	5			1		1	4
Spit 6	3367	15	13	1			1		1	4
Spit 6	3368	16	6	2			1		1	4
Spit 6	3369	8	17	4			1		1	4
Spit 6	3370	10	19	1			1		1	4
Spit 6	3371	17	18	2			1		1	4
Spit 6	3372	18	13	4			1		1	4
Spit 6	3373	40	38	6			7		1	1
spit 6	3374	27	12	5			2		1	4
Spit 6	3375	94	58	25			123		1	4
Spit 6	3376	31	36	5			8		1	4
Spit 6	3377	34	26	6			4		1	4
Spit 6	3378	32	24	8			3		1	4
Spit 6	3379	21	20	3			1		1	4
Spit 6	3380	16	14	3			1		1	4
Spit 6	3381	21	12	2			1		1	4
Spit 6	3382	22	12	2			1		1	4
Spit 6	3383	11	9	1			1		1	1
Spit 7	3384	19	10	3			1		1	4
Spit 7	3385	16	9	2			1		1	4
Spit 7	3386	3	10	2			1		1	4
Spit 7	3387	16	14	3			1		1	4
Spit 7	3388	15	14	3			1		1	4
Spit 7	3389	17	13	3			1		1	4
Spit 7	3390	35	21	10	14	10	6	75	1	1
Spit 7	3391	27	11	4	4	2	1		1	4
Spit 7	3392	26	11	4			1		1	4
Spit 7	3393	24	11	3			1		1	4
Spit 7	3394	20	9	1			1		1	4
Spit 7	3395	15	6	1			1		1	

Appendix B Measurement of axes by region

Length	Width	Thickness	Source	Petrological Group	Weight gms
166	131	29	Mt Isa	green basalt	1020
111	88	28	Mt Isa	green basalt	410
204	173	37	Mt Isa	green basalt	2459
101	97	32	Mt Isa	green basalt	580
129	39	37	Mt Isa	green basalt	413
134	57	28	Mt Isa	green basalt	433
132	90	41	Mt Isa	green basalt	734
91	108	37	Mt Isa	green basalt	432
97	79	39	Mt Isa	green basalt	380
74	66	29	Mt Isa	green basalt	257
39	83	43	Mt Isa	green basalt	109
121	87	20	Mt Isa	green basalt	no record
101	82	51	Mt Isa	green basalt	568
100	90	33	Mt Isa	green basalt	427
92	79	30	Mt Isa	green basalt	321
166	143	36	Mt Isa	green basalt	1297
114	112	28	Mt Isa	green basalt	531
131	88	41	Mt Isa	dolerite	579
155	92	27	Mt Isa	green basalt	564
120	106	37	Mt Isa	dolerite	636
117	107	22	Mt Isa	green basalt	533
189	150	53	Glenormiston	green basalt	2300
109	111	36	Glenormiston	green basalt	535
169	108	41	Glenormiston	green basalt	1120
133	114	52	Glenormiston	green basalt	1035
109	98	48	Glenormiston	green basalt	776
109	102	34	Glenormiston	green basalt	523
111	83	39	Glenormiston	green basalt	515
148	122	29	Glenormiston	green basalt	860
109	102	34	Glenormiston	green basalt	602
160	140	31	Glenormiston	green basalt	1110
130	105	52	Glenormiston	green basalt	870
120	83	49	Glenormiston	green basalt	610
139	97	42	Glenormiston	green basalt	788
189	158	32	Glenormiston	green basalt	1543
207	160	54	Glenormiston	green basalt	2485
140	112	40	Glenormiston	green basalt	954
134	123	42	Glenormiston	green basalt	874
134	120	40	Glenormiston	green basalt	916
94	87	26	Glenormiston	green basalt	339
153	103	38	Glenormiston	green basalt	967
101	89	33	Glenormiston	green basalt	411
160	139	31	Glenormiston	green basalt	1436
124	115	42	Glenormiston	green basalt	922
115	80	29	Glenormiston	green basalt	514
157	102	44	Glenormiston	green basalt	1232
136	117	20	Glenormiston	green basalt	626
146	123	27	Glenormiston	green basalt	872

90	86	34	Glenormiston	green basalt	394
145	111	29	Glenormiston	green basalt	861
140	121	32	Glenormiston	green basalt	977
143	115	37	Glenormiston	green basalt	1184
140	120	26	Glenormiston	green basalt	837
127	112	40	Glenormiston	green basalt	1031
107	101	21	Glenormiston	green basalt	693
175	130	29	Glenormiston	green basalt	1176
96	88	33	Glenormiston	green basalt	461
119	103	30	Glenormiston	green basalt	632
100	91	36	Boulia	green basalt	513
104	127	35	Boulia	green basalt	895
111	84	34	Boulia	green basalt	517
139	96	37	Boulia	green basalt	843
103	86	28	Boulia	green basalt	489
103	99	29	Boulia	green basalt	635
97	95	37	Boulia	green basalt	557
124	91	40	Boulia	green basalt	766
127	112	29	Boulia	green basalt	928
112	111	37	Boulia	green basalt	801
95	81	31	Boulia	green basalt	441
103	109	40	Boulia	green basalt	802
104	86	39	Boulia	green basalt	475
88	86	39	Boulia	green basalt	481
83	70	22	Boulia	green basalt	236
65	66	22	Boulia	green basalt	188
85	101	81	Boulia	green basalt	464
92	74	22	Boulia	green basalt	264
90	86	34	Boulia	green basalt	432
130	103	35	Boulia	green basalt	869
82	77	34	Boulia	green basalt	348
140	121	32	Boulia	green basalt	876
131	127	33	Boulia	green basalt	849
103	93	40	Boulia	green basalt	673
92	86	36	Boulia	gren basalt	517
129	94	28	Boulia	green basalt	602
108	81	35	Boulia	green basalt	514
115	95	20	Boulia	green basalt	423
122	111	40	Boulia	green basalt	836
89	83	35	Boulia	green basalt	440
82	90	31	Boulia	green basalt	358
86	74	26	Boulia	green basalt	295
100	84	26	Boulia	green basalt	413
94	88	40	Boulia	green basalt	469
84	94	28	Boulia	green basalt	432
141	127	37	Boulia	green basalt	1155
114	106	31	Boulia	green basalt	628
114	80	45	Boulia	basalt	676
138	110	37	Boulia	diorite	939

104	94	30	Boulia	green basalt	507
133	96	42	Boulia	green basalt	922
108	111	34	Boulia	green basalt	682
98	84	27	Boulia	green basalt	364
55	55	16	Boulia	green basalt	104
125	84	26	Boulia	green basalt	482
82	75	29	Boulia	green basalt	308
104	96	39	Boulia	green basalt	586
91	62	27	Boulia	green basalt	259
102	87	28	Boulia	green basalt	446
103	89	32	Boulia	green basalt	452
136	118	28	Boulia	green basalt	909
125	112	126	Boulia	green basalt	804
124	99	36	Boulia	green basalt	760
105	101	35	Boulia	basalt black/grey fine	558
111	111	106	Boulia	green basalt	654
103	99	34	Boulia	green basalt	670
76	74	40	Boulia	green basalt	316
100	96	46	Boulia	green basalt	661
92	86	36	Boulia	green basalt	547
104	103	38	Boulia	green basalt	633
155	116	53	Boulia	green basalt	1425
133	106	42	Boulia	green basalt	1067
188	122	45	Boulia	green basalt	1748
116	95	29	Boulia	green basalt	587
99	97	32	Boulia	green basalt	456
104	86	40	Boulia	green basalt	628
113	105	40	Boulia	green basalt	723
141	108	38	Boulia	green basalt	1040
71	69	30	Boulia	green basalt	256
117	120	31	Boulia	basalt fine black grey	776
130	80	45	Boulia	basalt weathered	798
104	97	35	Boulia	green basalt	506
85	89	35	Boulia	green basalt	413
111	103	39	Boulia	green basalt	648
103	77	30	Boulia	gren basalt	430
113	100	32	Boulia	green basalt	632
98	90	24	Boulia	green basalt	406
112	97	34	Boulia	green basalt	630
102	94	35	Boulia	green basalt	652
105	86	33	Boulia	green basalt	554
107	105	38	Boulia	green basalt	831
120	97	27	Boulia	green basalt	591
114	85	39	Boulia	green basalt	611
117	100	45	Boulia	green basalt	772
92	90	30	Boulia	green basalt	409
95	79	41	Boulia	green basalt	523
129	84	19	Boulia	dolerite	367
100	58	31	Boulia	green basalt	210

166	87	61	White Cliffs	dolerite	1454
172	101	43	White Cliffs	dolerite	1234
112	96	30	White Cliffs	green basalt	622
78	69	20	Broken Hill	green basalt	213
84	60	32	Broken Hill	green basalt	225
85	71	25	Broken Hill	green basalt	331
65	50	37	Broken Hill	green basalt	259
127	108	28	Broken Hill	green basalt	723
102	60	23	Broken Hill	green basalt	284
95	50	44	Wilcannia	green basalt	374
72	58	28	Enngonia	basalt weathered	191
58	37	57	Enngonia	basalt	237
72	45	29	Enngoia	sed rock indet	160
168	99	52	Enngoia	light yel lge grains qu	1258
75	71	38	Enngonia	green basalt	282
73	67	28	Enngonia	green basalt	259
68	55	37	Enngonia	green basalt	255
83	59	36	Enngonia	green basalt	316
118	85	30	Louth	green basalt	476
109	79	54	Louth	dolerite	708
129	97	60	Louth	dolerite? quartz grain	1063
81	67	30	Louth	green basalt	270
100	92	39	Louth	green basalt	644
54	55	23	Louth	green basalt	128
77	60	34	Louth	green basalt	313
110	89	49	Louth	dolerite large grained	752
55	43	25	Louth	green basalt	126
77	73	23	Louth	green basalt	286
85	39	35	Louth	green basalt	207
150	66	56	Louth	dolerite	1059
117	70	34	Louth	green basalt	505
111	63	32	Louth	green basalt	437
77	63	28	Louth	green basalt	289
105	72	28	Louth	quartzite	317
108	88	60	Louth	green basalt	908
62	57	16	Louth	indet	106
83	63	36	Louth	no	316
147	78	60	Louth	dolerite	920
110	84	39	Louth	green basalt	607
93	75	36	Louth	green basalt	438
123	73	38	Louth	green basalt	489
95	82	51	Louth	dolerite	493
149	88	43	Louth	dolerite	1181
208	109	51	Bourke	green basalt	1942
105	63	29	Bourke	green basalt	318
88	43	26	Bourke	green basalt	174
92	72	38	Bourke	dolerite fine grained li	382
103	72	15	Bourke	green basalt	
91	55	32	Bourke	green basalt	242

71	54	30	Bourke	green basalt	194
78	66	28	Bourke	green basalt	242
92	63	40	Bourke	yellow- lge grains silc	407
102	79	34	Bourke	yellow-lge grains silc	506
95	36	28	Bourke	green basalt	171
80	43	30	Bourke	green basalt	249
88	69	39	Bourke	green basalt	433
72	91	16	Bourke	indet	154
77	69	25	Bourke	green basalt	234
103	90	55	Bourke	dolerite	741
114	58	34	Cobar	green basalt	465
123	84	28	Cobar	green basalt	407
141	68	28	Cobar	green basalt	417
139	61	47	Cobar	green basalt	430
132	73	36	Cobar	green basalt	481
129	75	35	Cobar	green basalt	463
128	84	29	Cobar	green basalt	542
107	67	35	Cobar	green basalt	532
151	73	47	Cobar	green basalt	561
133	68	41	Cobar	green basalt	673
102	63	40	Cobar	indet- (dolerite?)	361
82	58	16	Cobar	green basalt	130
112	62	33	Cobar	green basalt	455
76	57	33	Cobar	green basalt	259
82	53	35	Cobar	green basalt	291
64	67	38	Cobar	Diorite-grey	318
76	49	20	Cobar	green basalt	157
82	38	33	Cobar	green basalt	212
66	38	22	Cobar	indet	109
85	47	28	Cobar	green basalt	210
64	62	21	Cobar	indet	165
61	56	25	Cobar	green basalt	162
60	47	20	Cobar	green basalt	112
129	93	57	Cobar	dolerite	942
67	37	18	Cobar	green basalt	106
89	72	43	Menindee	green basalt	456
79	60	42	Menindee	green basalt	329
74	68	27	Menindee	green basalt	224
84	62	43	Menindee	green basalt	391
91	67	37	Menindee	green basalt	432
102	54	34	Menindee	green basalt	412
144	95	42	Menindee	dolerite	972
159	83	52	Menindee	dolerite	995
143	97	41	Menindee	dolerite	937
87	65	33	Manara	green basalt	308
106	64	27	Manara	green basalt	331
86	72	38	Manara	green basalt	396
121	84	36	Manara	dolerite	629
79	64	24	Manara	green basalt	235

92	55	45	Manara	green basalt	347
88	61	34	Manara	green basalt	316
74	59	35	Manara	green basalt	310
145	80	34	Manara	green basalt	634
102	94	29	Manara	green basalt	502
148	55	44	Manara	green basalt	687
143	112	63	Manara	dolerite	2373
179	100	57	Manara	dolerite	1606
104	90	56	Manara	dolerite	782
78	73	27	Manara	dolerite	253
120	85	42	Manara	dolerite	675

Axes	Num	Length	Width	Weight
Reduction floor				
R2	1	110	98	520
R2	2	117	88	580
R2	3	150	146	1525
R2	4	116	88	561
R2	5	108	114	710
R2	6	95	97	490
R2	7	81	86	396

R2	8	80	92	383
R2	9	137	115	1024
R2	10	115		
R2	11	110	115	744
R2	12	102	98	
R2	13	110	98	628
R2	14	90	90	536
R2	15	99	94	598
R2	16	95	98	525
R2	17	145	134	1382
R2	18	121	125	1124
R2	19	116	140	987
R2	20	91	100	455
R2	21	93	104	547
R2	22	141	139	1740
R2	23	94	79	534
R2	24	136	150	1094
R2	25	139	180	2308
R2	26	113	110	739
R2	27	111	104	667
R2	28	103	114	741
R2	29	128	107	796
R2	30	107	118	719
R2	31	125	102	828
R2	32	124	120	1023
R2	33	114	121	902
R2	34	93	100	660
R2	35	112	99	730
R2	36	102	83	563
R2	37	110	125	694
R2	38	113	89	510
R2	39	132	132	1061
R2	40	127	116	929
R2	41	110	91	546
Axes	Num	Length	Width	Weight
R2	42	110	119	999
R2	43	96	92	591
R2	44	90	105	519
R2	45	99	111	687
R2	46	123	188	
R2	47	109	95	
R2	48	144	109	1105
R2	49	111	100	518
R2	50	101	86	485

R2	51	107	123	799
R2	52	133	143	1166
R2	53	130	100	854
R2	54	92	105	227
R2	55	96	104	441
R2	56	115	120	907
R2	57	80	67	330
R2	58	90	90	562
R2	59	142	186	1738
R2	60	130	115	970
R2	61	240	225	4911
R2	62	70	70	182
R2	63	116	112	892
R2	64	125	102	1059
R2	65	130	140	1151
R2	66	105	80	478
R2	67	108	96	852
R2	68	94	110	554
R2	69	125	119	916
R2	70	100	110	673
R2	71	130	133	1165
R2	72	99	106	522
R2	73	84	76	333
R2	74	124	125	912
R2	75	104	109	443
R2	76	103	104	552
R2	77	98	91	410
R2	78	100	94	640
R2	79	112	111	610
R2	80	121	112	738
R2	81	120	110	777
R2	82	111	97	696
R2	83	133	122	
R2	84	98	114	586

Axes	Num	Length	Width	Weight
R2	85	116	114	694
R2	86	118	104	514
R2	87	141	132	1390
R2	88	141	130	1081
R2	89	122	146	1475
R2	90	116	116	985
Quarries				
Q2	91	109	109	703
Q2	92	147	154	1788
Q2	93	149	146	1741

Q2	94	120	126	1073
Q2	95	152	139	1517
Q2	96	119	102	724
Q2	97	131	105	1172
Q2	98	165	134	1210
Q2	99	148	185	2201
Q2	100	128	134	1317
Q2	101	144	134	1547
Q2	102	75	88	273
Q2	103	130	134	791
Q2	104	124	128	898
Q2	105	185	140	1809
Q2	106	114	118	665
Q2	107	153	138	1837
Q2	108	111	108	726
Q2	109	131	121	1054
Q2	110	105	112	698
Q2	111	112	118	650
Q2	112	134	130	1221
Q2	113	123	125	1090
Q2	114	195	147	1689
Q2	115	106	131	713
Q2	116	155	200	1856
Q2	117	104	111	717
Q2	118	133	118	980
Q2	119	144	134	1491
Q2	120	154	180	2064
Q2	121	110	111	811
Q2	122	102	104	610
Q2	123	135	137	1289
Q2	124	151	117	1078
Q2	125	113	118	730

Axes	Num	Length	Width	Weight
Q2	126	103	108	763
Q2	127	147	154	1664
Q2	128	146	173	2060
Q2	129	203	165	2064
Q2	130	143	130	1198
Q2	131	152	130	1607
Q2	132	154	134	1230
Q2	133	136	122	1272
Q2	134	177	185	2913
Q2	135	120	140	1121
Q2	136	155	157	2592

Q3	137	164	110	1016
Q3	138	130	133	1225
Q3	139	115	170	1906
Q3	140	134	153	1636
Q3	141	190	160	1654
Q3	142	134	182	812
Q3	143	202	185	3134
Q3	144	147	145	1526
Q3	145	108	104	718
Q3	146	132	189	1614
Q3	147	259	199	5560
Q3	148	163	165	1927
Q3	149	106	160	1362
Q3	150	121	138	1182
Q3	151	170	166	2277
Q3	152	173	160	1779
Q3	153	185	180	2927
Q3	154	175	137	1430
Q3	155	137	154	470
Q3	156	165	155	1548
Q3	157	140	134	1353
Q9	158	125	116	998
Q9	159	142	99	936
Q9	160	73	71	197
Q9	161	152	145	1451
Q9	162	101	116	817
Q9	163	127	115	770
Q9	164	145	134	1342
Q9	165	153	147	1818
Q9	166	145	151	1714
Q9	167	132	123	1230
Axes	Num	Length	Width	Weight
Q9	168	147	104	1000
Q9	169	151	174	2648
Q10	170	108	147	605
Q10	171	160	117	1269
Q10	172	180	145	3294
Q10	173	210	198	3580
Q10	174	215	174	2935
Q10	175	134	102	727
Q11	176	136	134	1103
Q11	177	115	101	550
Q11	178	136	116	961
Q11	179	135	116	891
Q11	180	107	104	698

Q11	181	148	124	1197
Q11	182	116	145	958
Q11	183	133	127	1042
Q11	184	153	141	1520
Q11	185	153	148	1536
Q11	186	160	123	1405
Q11	187	146	131	1278
Q11	188	114	99	598
Q11	189	144	148	1639
Q11	190	120	106	628
Q11	191	133	133	1044
Q11	192	165	155	1885
Q11	193	200	165	2248
Q11	194	151	140	1539
Q11	195	133	148	1214
Q11	196	146	137	1125
Q11	197	133	87	614
Q11	198	195	163	2290
Q11	199	180	146	2028
Q11	200	146	140	1493
Q11	201	128	147	1115
Q12	202	115	117	877
Q12	203	134	116	1306
Q12	204	140	144	1167
Q12	205	163	160	2399
Q12	206	147	118	1325
Q12	207	137	136	1027
Q12	208	150	155	1785
Q12	209	171	157	2400
Q12	210	145	155	1427
Q12	211	124	120	823
Q12	212	152	144	1541
Q12	213	137	144	1353
Axes	Num	Length	Width	Weight
Q12	214	117	151	1187
Q12	215	145	144	1734
Q12	216	118	130	791
Q12	217	144	165	1695
Q12	218	174	153	1806
Q12	219	149	154	1697
Q12	220	127	118	1140
Q12	221	131	151	1494
Q12	222	128	131	847
Q12	223	141	135	1194
Q12	224	175	144	1690
Q12	225	138	140	1483
Q12	226	125	120	801

Q12	227	137	128	933
Q12	228	126	129	1006
Q12	229	152	123	1204
Q12	230	160	133	1389
Q12	231	140	128	1137