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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 focusing 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.
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.
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.
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.
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).
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 were 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.

![Diagram](diagram.png)

**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, McBrayde 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 Leichhardt-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 52
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 embeddedness 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 ($\pm 3.87m^2 = \pm 15m$). 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 tramping 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.

<table>
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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.

<table>
<thead>
<tr>
<th>Type</th>
<th>Raw Material</th>
<th>Description</th>
</tr>
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<tr>
<td>1</td>
<td>Basalt</td>
<td>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.</td>
</tr>
<tr>
<td>2</td>
<td>Quartzite</td>
<td>Quartzite was used extensively in tool manufacture at Moondarra. Quartzites are metamorphosed quartz sandstones and are median- to coarse-grained.</td>
</tr>
<tr>
<td>3</td>
<td>Quartz</td>
<td>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.</td>
</tr>
<tr>
<td>4</td>
<td>Chert</td>
<td>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).</td>
</tr>
</tbody>
</table>

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.

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Measurement convention used</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flake Length</td>
<td>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.</td>
</tr>
<tr>
<td>Flake Width</td>
<td>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).</td>
</tr>
<tr>
<td>Flake Thickness</td>
<td>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.</td>
</tr>
<tr>
<td>Platform Width</td>
<td>The width of the platform was measured with callipers on the platform surface between the margins to the nearest millimetre.</td>
</tr>
<tr>
<td>Platform Thickness</td>
<td>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.</td>
</tr>
<tr>
<td>Weight</td>
<td>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).</td>
</tr>
<tr>
<td>Platform Angle</td>
<td>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.</td>
</tr>
</tbody>
</table>

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.

![Diagram of technological attributes to define debitage categories](image)

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 \( \div \) Mean \( \times 100 \) 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).
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.
<table>
<thead>
<tr>
<th>Location</th>
<th>Area in square metres</th>
<th>Stone type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q1</td>
<td>600</td>
<td>Quartz</td>
</tr>
<tr>
<td>Q2</td>
<td>3579.3</td>
<td>Basalt</td>
</tr>
<tr>
<td>Q3</td>
<td>6359.9</td>
<td>Basalt</td>
</tr>
<tr>
<td>Q4</td>
<td>5046.9</td>
<td>Basalt</td>
</tr>
<tr>
<td>Q5</td>
<td>3353.1</td>
<td>Basalt</td>
</tr>
<tr>
<td>Q6</td>
<td>667.5</td>
<td>Basalt</td>
</tr>
<tr>
<td>Q7</td>
<td>208.5</td>
<td>Basalt</td>
</tr>
<tr>
<td>Q8</td>
<td>1130.9</td>
<td>Basalt</td>
</tr>
<tr>
<td>Q9</td>
<td>185.1</td>
<td>Basalt</td>
</tr>
<tr>
<td>Q10</td>
<td>2894.4</td>
<td>Basalt</td>
</tr>
<tr>
<td>Q11</td>
<td>5422.3</td>
<td>Basalt</td>
</tr>
<tr>
<td>Q12</td>
<td>18899.9</td>
<td>Basalt</td>
</tr>
<tr>
<td>Q13</td>
<td>5429.9</td>
<td>Basalt</td>
</tr>
<tr>
<td>Q14</td>
<td>11025.6</td>
<td>Quartz</td>
</tr>
<tr>
<td>Q15</td>
<td>496.6</td>
<td>Basalt</td>
</tr>
<tr>
<td>Q16</td>
<td>4971.2</td>
<td>Basalt</td>
</tr>
<tr>
<td>Q17</td>
<td>1023.1</td>
<td>Basalt</td>
</tr>
<tr>
<td>Q18</td>
<td>7945.1</td>
<td>Basalt</td>
</tr>
<tr>
<td>Q19</td>
<td>7796.5</td>
<td>Basalt</td>
</tr>
<tr>
<td>Q20</td>
<td>1277.9</td>
<td>Basalt</td>
</tr>
<tr>
<td>Q21</td>
<td>3047.7</td>
<td>Basalt</td>
</tr>
<tr>
<td>Q22</td>
<td>401.2</td>
<td>Basalt</td>
</tr>
<tr>
<td>Q23</td>
<td>Not recorded</td>
<td>Quartzite</td>
</tr>
<tr>
<td>Q24</td>
<td>Not recorded</td>
<td>Quartzite, creek bed</td>
</tr>
<tr>
<td>Q25</td>
<td>975.1</td>
<td>basalt</td>
</tr>
<tr>
<td>Q26</td>
<td>5518.2</td>
<td>basalt</td>
</tr>
<tr>
<td><strong>Total Area, Quarries</strong></td>
<td><strong>98,255.9m²</strong></td>
<td></td>
</tr>
<tr>
<td>R1</td>
<td>8858.2m²</td>
<td></td>
</tr>
<tr>
<td>R2</td>
<td>51051.8m²</td>
<td></td>
</tr>
<tr>
<td>R3</td>
<td>4937.1m²</td>
<td></td>
</tr>
<tr>
<td>R4</td>
<td>1880.5m²</td>
<td></td>
</tr>
<tr>
<td>R5</td>
<td>677.5m²</td>
<td></td>
</tr>
<tr>
<td>R6</td>
<td>9301.6m²</td>
<td></td>
</tr>
<tr>
<td><strong>Total Area, Reduction Floors</strong></td>
<td><strong>76,706.7m²</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Total Area of Moondarra</strong></td>
<td><strong>174,962.6m²</strong></td>
<td></td>
</tr>
</tbody>
</table>

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 scree 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 flakedebitage 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 6,359.9 m² 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 5046.9 m² 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 3,353 m². 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.

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 m² 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 98,255.9m², 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 76,706.7m². The total area of the Moondarra’s reduction floors and quarries is 174,962.6 m² 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.
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.](image)

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 photographs show grass growing in the centre where mining presumably took place.

<table>
<thead>
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<th>Feature</th>
<th>Dimensions</th>
<th>Calculation of Volume</th>
<th>Volume</th>
</tr>
</thead>
<tbody>
<tr>
<td>North wall</td>
<td>L 4.8m x W1.71 x H0.35m</td>
<td>(Length x Breadth x Height) x 11÷14</td>
<td>2.26m³</td>
</tr>
<tr>
<td>South wall</td>
<td>L 4.8m x W2.45m x H0.75</td>
<td>(Length x Breadth x Height) x 11÷14</td>
<td>6.93m³</td>
</tr>
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<td>Eastern wall</td>
<td>Outer Semi-circle Dia. 5.3m</td>
<td>(Diameter x Pi ÷ 2) x (Height x 11÷14)</td>
<td>3.60m³</td>
</tr>
<tr>
<td></td>
<td>Inner Semi-circle Dia. 1.3m</td>
<td>(Diameter x Pi ÷ 2) x (Height x 11÷14)</td>
<td>- 0.88m³</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Outer volume – Inner volume</td>
<td>= 2.72m³</td>
</tr>
<tr>
<td>Western wall</td>
<td>Outer Semi-circle Dia. 4.9m</td>
<td>(Diameter x Pi ÷ 2) x (Height x 11÷14)</td>
<td>2.69m³</td>
</tr>
<tr>
<td></td>
<td>Inner Semi-circle Dia. 1.0m</td>
<td>(Diameter x Pi ÷ 2) x (Height x 11÷14)</td>
<td>- 0.43m³</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Outer Volume – Inner Volume</td>
<td>= 2.26m³</td>
</tr>
<tr>
<td>Volume of walls</td>
<td></td>
<td>Nth wall + South wall + East wall + West wall</td>
<td>14.17m³</td>
</tr>
<tr>
<td>Area of the excavation</td>
<td>L3.3m W 1.2m</td>
<td>L x B</td>
<td>4.08²</td>
</tr>
<tr>
<td>Estimated depth of the excavation</td>
<td></td>
<td>Depth = Volume of walls ÷ Area of excavation (14.17m³ ÷ 4.08m²)</td>
<td>3.47m</td>
</tr>
</tbody>
</table>

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.
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.

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

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. (Aiston 1928:123)

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 (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 ringeracks 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 10² 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.
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.
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.

<table>
<thead>
<tr>
<th>Length</th>
<th>Width</th>
<th>T/ness</th>
<th>P Length</th>
<th>P Width</th>
<th>Weight</th>
<th>P Angle</th>
</tr>
</thead>
<tbody>
<tr>
<td>mm</td>
<td>mm</td>
<td>mm</td>
<td>mm</td>
<td>mm</td>
<td>gm</td>
<td>deg.</td>
</tr>
<tr>
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<td>37</td>
<td>11</td>
<td>21</td>
<td>8</td>
<td>47</td>
</tr>
<tr>
<td>Standard Error</td>
<td>2.438</td>
<td>2.25</td>
<td>1.00</td>
<td>1.42</td>
<td>0.71</td>
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<td>51</td>
<td>4</td>
<td>12</td>
<td>3</td>
<td>1</td>
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<tr>
<td>Standard Dev.</td>
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<td>24</td>
<td>11</td>
<td>12</td>
<td>6</td>
<td>131</td>
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<tr>
<td>Sample Var.</td>
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<td>564.53</td>
<td>111.65</td>
<td>155.25</td>
<td>40.37</td>
<td>17120.49</td>
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<td>Kurtosis</td>
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<td>1.40</td>
<td>4.34</td>
<td>1.58</td>
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<td>89</td>
<td>58</td>
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<tr>
<td>Minimum</td>
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<td>1</td>
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<td>64</td>
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<td>4117</td>
<td>1179</td>
<td>1625</td>
<td>619</td>
<td>5237</td>
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<tr>
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<td>111</td>
<td>111</td>
<td>76</td>
<td>78</td>
<td>111</td>
</tr>
</tbody>
</table>

Table 6.3. Dimensions of complete basalt trimming flakes recovered from R3 and R4
Table 6.4. Dimensions of complete basalt trimming flakes recovered from Q12.

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

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).

<table>
<thead>
<tr>
<th>Reduction sequence</th>
<th>Location</th>
<th>Number of axes</th>
<th>Number with cortex</th>
<th>Percentage of cortex on each axe</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>Quarries</td>
<td>n141</td>
<td>n8 = 5.7 percent of the assemblage</td>
<td>4 at 100% 1 at 75% 3 at 25%</td>
</tr>
<tr>
<td>4</td>
<td>Reduction Floor</td>
<td>n91</td>
<td>n6 = 6.6 percent of the assemblage</td>
<td>1 at 75% 5 at 25%</td>
</tr>
</tbody>
</table>

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).

<table>
<thead>
<tr>
<th>General Reduction Sequence</th>
<th>Stages of Production</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Flake Blank</td>
<td>1 Unretouched Flake</td>
<td></td>
</tr>
<tr>
<td>2 Edged blank</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 Thinned blank</td>
<td>2* Retouched flake at the quarry</td>
<td>Hiscock (forthcoming) and Innes (1991) do include edge trimming in their stages of production.</td>
</tr>
<tr>
<td>4 Final trimming</td>
<td>3 Retouched flake at the reduction floor</td>
<td></td>
</tr>
<tr>
<td>5 Edge ground axe</td>
<td>4 Retouched flake that has been edge ground</td>
<td></td>
</tr>
</tbody>
</table>

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.

<table>
<thead>
<tr>
<th>Reduction floors</th>
<th>Length mm</th>
<th>Width mm</th>
<th>Thickness mm</th>
<th>Weight gm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stage 3 axes</td>
<td>Mean</td>
<td>114</td>
<td>112</td>
<td>42</td>
</tr>
<tr>
<td></td>
<td>Median</td>
<td>111</td>
<td>109</td>
<td>41</td>
</tr>
<tr>
<td></td>
<td>Count</td>
<td>90</td>
<td>89</td>
<td>90</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Quarries</th>
<th>Length mm</th>
<th>Width mm</th>
<th>Thickness mm</th>
<th>Weight gm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stage 2 axes</td>
<td>Mean</td>
<td>142</td>
<td>137</td>
<td>52</td>
</tr>
<tr>
<td></td>
<td>Median</td>
<td>140</td>
<td>135</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td>Count</td>
<td>147</td>
<td>134</td>
<td>42</td>
</tr>
</tbody>
</table>

Table 6.7. Comparative analysis between axe blanks from reduction floors and quarries.
Table 6.8. Dimensions and extent of shaping on retouched flakes from different parts of the quarry (from Hiscock forthcoming).

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

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

<table>
<thead>
<tr>
<th>Reduction stage</th>
<th>Sample</th>
<th>Feather</th>
<th>Hinge</th>
<th>Step</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Unretouched flakes on ridges (n=102)</td>
<td>82</td>
<td>15</td>
<td>2</td>
</tr>
<tr>
<td>2</td>
<td>Retouched flakes on ridges (n=119)</td>
<td>65</td>
<td>35</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>Retouched flakes on reduction floors (n=27)</td>
<td>48</td>
<td>52</td>
<td>0</td>
</tr>
</tbody>
</table>

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.
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 Grindstones

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.
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.