Granite Grooves

A Study on Granitic Grinding Grooves in North East Victoria

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Abstract

Grinding grooves are grooves on rock outcrops which result from the sharpening of stone tools or grinding of ochre, seeds or other resources. Previous research has shown that many of these grinding grooves correlate to the sharpening of ground-edge axes. Ground-edge axes are a stone artefact type that has been identified throughout the world and have been dated to a maximum of between 44,000 and 49,000 years of age in northern Australia. Ground-edge axes were commonly made from an extremely hard volcanic rock which was ground, along an edge, to create a smooth, sharp axe head which could be hafted to a wooden handle.

Grinding grooves are usually located on a rock outcrop near water, which provided essential lubrication for the grinding process and the grinding grooves that result from the sharpening of ground-edge axes are usually narrow, relatively short and deeper in the middle section than at either end.

This thesis explores the potential of grinding groove sites to provide information about trade and exchange patterns, social interaction and language development, and identifies local variations in stone tool technology across north eastern Victoria. Grinding grooves present tangible, unmoveable evidence that certain types of tools were manufactured in an area. From an analysis of the dimensions of a groove we can make conclusions regarding the size and shape of the blank which initially created the groove. Grinding grooves of particular dimensions can therefore act as a proxy for actual ground-edge axes and can inform theories of trade and exchange throughout Victoria.

The time required to form grinding grooves, indicates a period of use and most likely habitation of particular area. Frequently grinding grooves are found in clusters, this may provide information on social practices around tool manufacture and sharpening. We can postulate that grinding was done in company, that skills were passed on, stories were shared and language refined during these activities. The variety of groove shapes and sizes at a location may provide information about other activities nearby such as food preparation or ceremonial activities.

The size and shape of a grinding groove will also be affected by the nature of the geology on which it is made and the nature of the blank being used. This thesis investigates the variations inherent as a result of geology and the implications of these variations for site selection.

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Declaration

I certify that this thesis does not incorporate without acknowledgment any material previously submitted for a degree or diploma in any university; and that to the best of my knowledge and belief it does not contain any material previously published or written by another person except where due reference is made in the text.

Name: Rose Overberg

Signature:

Date: 4 November 2019

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I would like to acknowledge that this research has taken part on the country of the Taungurung and, Gunai Kurnai people and pay my respects to their Elders, past and present.

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1. Introduction

1.1 Background

Ground-edge axes are a stone artefact type that has been identified throughout the world. At a site in the northern Kimberley archaeologists have recently identified a fragment of a ground-edge axe in stratified deposits which have been dated to between 44,000 and 49,000 years before present (BP) (Hiscock *et al.* 2016). At the Nawarla Gabarnmang in Jawoyn country in southwestern Arnhem Land, a fragment of ground-edge axe has been identified in securely dated strata. This strata has been dated to greater than 30,000 BP (Geneste *et al.* 2012). Other early occurrences of ground-edge axes have been identified in Japan and dated to the Japanese Paleolithic (around 35,000 years BP) (Imamura 1996).

Ground-edge axes were commonly made from an extremely hard volcanic rock (such as a basalt or greenstone) which, after the selection or knapping of a suitable blank, were further ground, along an edge, to create a smooth, sharp axe head which could be attached to a wooden haft (Burke and Smith 2004).

Ground-edge axes are also referred to as edge-ground axes and sometimes as ground-stone axes or hatchets. The term ground-edge axe is used for consistency throughout this thesis, as this is the common Victorian terminology for this artefact type (Aboriginal Victoria 2008). The literature tends to use terms such as hatchet and axe interchangeably, with little inference as to the subtleties of meaning of each word. According to Dickson (1976:35), the differences are considerable; a hatchet implies one-handed use with a different action to the two-handed use of a hafted axe.

Grinding grooves were formed as a result of the sharpening of these ground-edge axes. Grinding grooves are the highly abraded surfaces resultant from the manufacture and ongoing sharpening of ground-edge axes and other stone tools. The grooves are usually located on a rock outcrop near water, which provided essential lubrication for the grinding process. Grinding grooves that result from the sharpening of ground-edge axes are usually narrow, relatively short and deeper in the middle section than at either end (Burke and Smith 2004).

Grinding grooves sites are a critically important site type for many reasons. These sites provide evidence of the use of certain tools in Victoria, as the morphology of each groove correlates to a certain size and shape, which we presume to be a ground edge axe due to ethnography and experimental archaeological results. As such, grinding groove sites may be used as a proxy for the distribution of ground-edge axes in Victoria and can provide information on ground-stone axe trade networks throughout Victoria. Greenstone (mafic volcanic rock) was a commonly used raw material for ground-edge axes in Victoria (McBryde 1978; 1984a). Mapping the location of recorded greenstone axes versus the location of axe grinding grooves can provide validation of theories of exchange networks.

The time required to form grinding grooves in itself indicates a period of use and most likely habitation of particular area. Experimental archaeology has demonstrated that each groove may be indicative of several hours of work (Dickson 1972; Dickson 1976). In this regard grinding grooves may also be indicative of time spent in company of others. Frequently grinding grooves are found in clusters and this may be able to inform about social practices around tool manufacture and sharpening.

Engineering of the local environment frequently evident at grinding groove sites indicates the systematic and planned nature of ground-stone axe preparation. Frequently we see evidence for channelling in stone or creation of small water wells adjacent to the grinding grooves (Mathews 1896). Ready access to water was essential in the grinding process and engineering of this access to water demonstrates that these practices were unlikely to be opportunistic and that careful planning and site selection was essential. This is indicative of a cultural landscape and a holistic approach to the environment.

This thesis will focus on the granite grinding grooves sites of north eastern Victoria. Grinding grooves have long been of interest to anthropologists and natural historians (Howitt 1996; Mathews 1896; Smyth 1878). Detailed studies and analysis have previously been undertaken on sandstone grinding grooves in Gippsland (Cusack *et al.* 1999; Haskovec 1981). However, a detailed synthesis and subsequent analysis of the form, function and distribution of grinding grooves in granite in north eastern Victoria has not yet been undertaken. The north eastern Victorian sites include Hughes Creek (near Tarcombe), Lima East (two adjacent sites), Reedy Creek (near Eldorado) and Pine Gully (near Wangaratta). Taungurung Land and Waters Corporation advises that there are other recently identified grinding groove sites in north east Victoria (Almeida 2019), however these sites have not been included in this study.

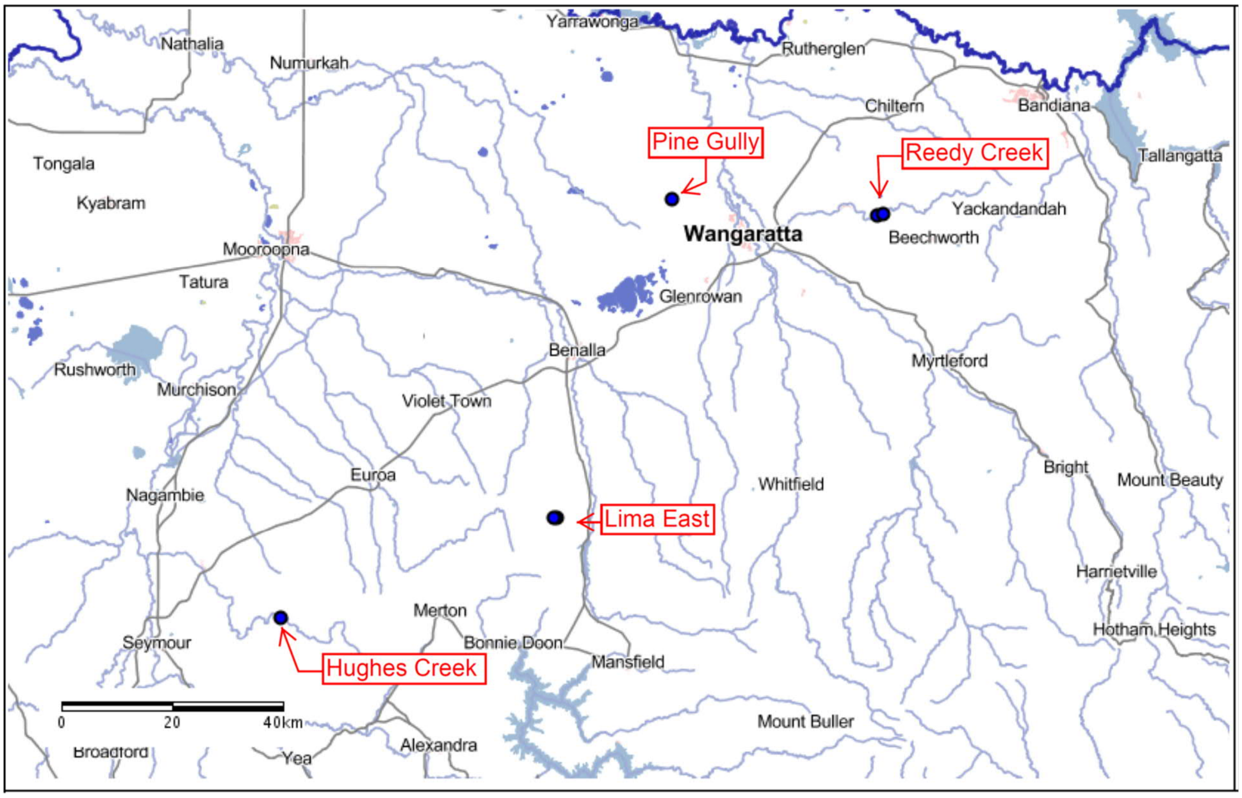

Figure 1.1 : Locations of grinding groove sites in north east Victoria studied as part of this research

1.2 Aims and research questions

This thesis primarily seeks to understand the importance of grinding grooves as a site type, and how form, distribution and function of these sites can shed light on the nature of ground-edge axe use and exchange, the use of resources and technological change in Victoria.

This research examines ethnographic reports and empirical data for several grinding groove reference sites in north eastern in Victoria. These reference sites have been selected primarily on the morphology of the grooves – these are theorised as ground-edge axe sharpening grooves - and secondly on the geology of the grinding groove substrate – all these sites are in granite. Interestingly, granite grinding grooves are only recorded in mountainous areas of north eastern Victoria (possibly a consequence of the dominant geology in the region). The collated reference site data has been analysed, statistically, comparatively and spatially, to address the following primary and secondary questions.

The primary research question considered is:

- What can the attributes of grinding groove sites (geology, form, distribution, and function) tell us about ground-edge axe exchange, use of resources and technological change in Victoria?

In the process of answering this question, the following secondary questions will also be considered:

- What can ethnographic information tell us about the location, frequency of use and nature of ground-edge axes manufactured in Victoria?
- How do the characteristics of the selected reference grinding groove sites compare to one another, particularly in relation to morphology, distribution and function?
- What does the morphology of the grinding grooves indicate about resource use and stone tool technologies? Are the grinding grooves purely the result of stone tool manufacture or is there evidence of seed grinding and resource use? Are there other archaeological sites types within close proximity which may inform this question?
- How does different geology respond to the process of grinding, as seen at these sites? Should we expect different use, wear and morphology for different geological types? How can this information be used to improve analysis and understanding of use patterns on different geological substrates?
- What kind of predictive model can be developed for grinding groove sites and what recommendations can be made for future management and conservation?

1.3 Consultation with Traditional Owners

A letter was sent to the Traditional Owners of the areas investigated in this research. This letter advised the Traditional Owners of the details of the research and requested permission to access the Victorian Aboriginal Heritage Register (VAHR).

The Taungurung Land and Waters Corporation and the Gunai Kurnai Land and Waters Corporation both provided permission to the VAHR (on 19 February 2019 and 14 August 2018, respectively). Letters received from these organisations are provided in Appendix A.

The results of this research will be communicated back to these organisations. Future studies, or site visits to any of the sites identified in this thesis should be undertaken in collaboration with representatives from these organisations.

1.4 Permission to access the VAHR

Permission was provided by the Traditional Owners for access to the VAHR to inform this research. Access was subsequently provided by Aboriginal Victoria on 17 June 2019.

1.5 Significance

The research presented in this thesis is significant as this is the first time a systematic review of grinding grooves, with a focus on their occurrence on granite, has been undertaken for north eastern Victoria. Scientifically, these grinding groove sites present a unique opportunity for further research into technologies, resource use, social interaction and exchange networks.

This research also adds to the existing knowledge base on ground-edge axes, which have been extensively studied throughout Australia. Their quarrying, manufacture and distribution has been used to infer trade and exchange patterns and networks.

1.6 Structure of this thesis

Chapter 2 presents a review of previous research and literature relevant to the study of grinding grooves and ground-edge axes. This chapter outlines the current understanding of the formation of ground-edge axes and grinding grooves, their typology and main characteristics and presents theories expounded by previous researchers on implications for economy (trade) and social value of these items.

Chapter 3 presents the methodology involved in this research. This includes resources accessed, processes followed and analyses undertaken to deliver the results.

Chapter 4 will provide detailed results of the ethnographic research and questions around what early (non-Aboriginal) authors reported and concluded about these artefact types and whether any of these theories still hold today will be considered. Chapter 4 will also present the result of the data synthesis and statistical analysis.

Chapter 5 will draw together the outcomes of the literature review, and the results from the detailed research and analysis to present a discussion how the nature of the geological substrate, the form and distribution of grinding grooves (as a proxy for the ground-edge axes themselves) and the function of grinding grooves can inform our understandings of exchange networks, resource use and technological change in Victoria.

Chapter 6 will tease out the conclusions arising from this research and provide a clear, concise summary of the current state of understanding as a result of this thesis. Chapter 6 will also provide guidance for future study in this research area.

2. Literature review

This literature review provides a brief overview of the archaeology in north eastern Victoria, where it is relevant to grinding groove sites and ground axe distribution; previous research relevant to ground-edge axe manufacture, grinding groove formation and use; and regional and local ethnography with particular attention to Victorian examples. Aspects of this research are discussed in more detail in the analysis, discussion and conclusion chapters of this thesis.

The existing literature on ground-edge axes, their formation and value in trading and exchange networks is considerable (McBryde 1978; McBryde 1984b; McBryde and Watchman 1976; McBryde and Watchman 1979; McConnell 1987). Conversely, detailed studies of grinding grooves, particularly those in peer-reviewed journals, are limited. Available studies are dated, although still relevant in many aspects ((Dickson 1972; Dickson 1976; Dickson 1980)) or they are unpublished reports such as Theses or archaeological consulting reports These unpublished reports contain excellent details about particular places and sites, but do not necessarily contain the same degree of analysis or rigour demonstrated in a peer-reviewed journal article.

2.1 Overview of archaeology in north east Victoria

In Victoria, clans were the basic units of pre-European Aboriginal society and comprised patrilineal descent groups with territories defined by ritual and economic responsibilities. Clusters of neighbouring clans, which shared a common dialect and political and economic interests, distinguished themselves from other clusters by the use of a language name (Barwick 1984). The Hughes Creek and Lime East groove sites are located within the traditional lands of the Taungurung (*Daung wurrung)* language group who were situated along the Broken, Delatite, Goulburn, Coliban and Campaspe watersheds.

Resources of the rivers, creeks and associated floodplains in Taungurung territory would have been plentiful offering such plants as the Kurrajong (*Pimelia* sp.), which provided fibres that were spun to make nets for harvesting Bogong moths (Massola 1962). Roots and bulbs as well as seeds and fruits were also available both on the floodplain and on the high plains. One staple plant food that was available was the daisy yam or Murnong (*Microseris scapigera*), which provided a reliable source of starch (Massola 1962). Other vegetable foods noted in the diet of neighbouring tribes were wild raspberries, cherries, currants, kangaroo apple, pigface and mushrooms (Land Conservation Council 1991: 19). Game was also plentiful and known animal foods include kangaroos, echidna, koala, possums, emus, fish and wombats.

A search of the VAHR for the north eastern Victorian study region indicated that:

- Artefact scatters are the most likely type of site to be found in the study region.
- Scarred trees are the next most likely place type, where suitable mature Box or Eucalypt trees remain
- Aboriginal sites will be most commonly be found on rises within close proximity to waterways such as creeks, swamps and rivers. Sites are most likely to occur within 200 m of waterways in the study region. Flat terraces above rivers and creeks are likely to have sensitivity for the occurrence of Aboriginal sites.

A collection of stone tools managed by the Euroa Historical Society (close to the Hughes Creek and Lima East groove sites) ('The Farmers Arm Collection' VAHR 8024-0040), provides some examples of locally made ground-edge axes and other large tools (Cusack 2003). Notably in this collection are four examples of ground edge axes, which demonstrate the characteristic smooth surface and fine edge of these tools, achieved through the grinding process.

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Figure 2.1 : Examples of locally made ground-edge axes (four examples in upper left of image) from the collection at Euroa Historical Society (VAHR 8024-0040) (Cusack 2003)

2.2 Ground-edge axes

Ground-edge axes are widely distributed throughout Australia, with the apparent exception of southwestern Australia and Tasmania. Hiscock *et al.* (2016) document a northern Kimberley site which provides evidence of ground-edge axe production in northern Australia between 44,000 and 49,000 years ago. This is the earliest evidence of a ground-edge axe yet reported in the world, and has implications for the first human occupation of Australia. Hiscock (2008) also reported on the discovery of ground-edge axes recovered from the Pleistocene levels of Malangangerr in Arnhem Land. The deposits associated with these tools have been dated to 25,000-30,000 years ago (Schrire 1982). These ground-edge axes were made by grinding both sides of the stone with an abrasive until a smooth bevel developed.

Ground-edge axes had a unique position within the tool kit of Australian Aboriginals. They lasted a long time, were easily transportable and highly valued and were often exchanged over long distances (Brumm 2010).

Lourandos (1983) and McBryde (1984a) document the distribution of ground-edge axes across south eastern Australia, which they claim supports the likelihood of gathering of different groups, and exchange of resources and tools and toolkits technologies between these groups. Ground-edge axes, often made from particular sources of high-quality, potentially high-value volcanic materials, played an important role in establishing and cementing relationships between various groups (McBryde 1984, Grave et al 2012)

In Victoria, research and analysis of patterns of distribution of ground-stone axes relative to known quarry sites has been a focus of several researchers (McBryde 1978; McBryde 1984b; McBryde and Watchman 1976; McBryde and Watchman 1979; McConnell 1987). The Mount William greenstone quarry near Lancefield in central Victoria has been extensively studied and researched (McBryde 1978; McBryde and Watchman 1979). This site produced greenstone; an altered volcanic rock of Cambrian age mostly consisting of amphibole hornfels. This was widely traded throughout many parts of Victoria (McBryde 1984a). Mount William lies within one of six Cambrian greenstone belts in Victoria and is one of at least ten ground-edge axe quarries within Victoria (National Heritage List 2007). The other quarries are: Mount Camel, Howqua River, Cosgrove, Jallukar, Berrambool and Baronga on the Hopkins River; and Ceres and Dog Rocks near Geelong (McBryde and Watchman 1976).

A key finding of McBryde's axe distribution studies is that greenstone axes are present despite other geologically suitable rocks occurring in most of the locations. McBryde (1978:357) notes that 'there is no technological necessity in the importation of greenstone'. In other words, people who imported greenstone axes could have easily manufactured their own axes if they wanted to. McBryde argued that greenstone from certain quarries had certain social and symbolic value that made it desirable for more than simple utilitarian reasons.

McBryde (1984b) makes an important argument in her discussion on traditional exchange systems, regarding what can and cannot be inferred from the available data. The social and economic aspects of these exchange networks cannot be easily separated, nor can the exchange of goods be merely interpreted as a mechanism for getting materials that were needed. The depths and complexities of the social and economic interactions that would have occurred at each meeting are myriad (McBryde 1984b). As McBryde states 'levels of meaning and imperative beyond the distribution of rare resources and expectations of economic returns are involved' (McBryde 1984b:268).

Historical accounts and ethnographic descriptions indicate that throughout Australia, tools and raw materials were procured in a manner of ways. Reciprocal gift exchange, bartering for raw materials or travel to the source of the raw materials were all common practice. Often gift exchange and bartering would take place at large inter-tribal gatherings. Such gatherings met the needs of society and ritual while also fulfilling the need to source new raw stone materials (Grave *et al.* 2012).

The lack of evidence of greenstone ground-edge axes imported to Gippsland, with whom the Kulin speakers of central and western Victoria historically had an enmity, further supports this contention (McBryde 1978). In other words, 'social barrier, traditional group alignments and hostilities may be invoked to explain the areas of non-penetration' of greenstone axes (McBryde and Harrison 1981:191).

In the archaeological record ground-edge axes have become one of the best artefact classes for provenance work. They are highly durable objects in the archaeological record, and their source can often be determined through geochemical analysis. Combined with information about the nature and distribution of materials, these stone tools provide an invaluable source of information about the movement of raw materials and tools across the country (Grave *et al.* 2012).

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Figure 2.2 : Example of greenstone ground-edge axe found at a farm near Violet Town (Strathbogie Ranges Nature Review 2013)

2.3 Grinding grooves and geology

Grinding grooves are formed by the process of stone tool sharpening or manufacture. The characteristics of the geological substrate and the material being ground into it influence the shape, size and depth of the grooves (Dickson 1981). For example, a harder-wearing ground-edge axe material such as greenstone, may require greater grinding, resulting in deeper grooves. Similarly, a larger stone tool will necessitate the formation of a wider groove for its treatment.

Geology of the grinding groove substrate (the rock outcrop on which grooves are usually made) will also influence the morphology of the grooves, the time required to grind an appropriate edge and therefore the desirability of the location for the task. The majority of the recorded grinding grooves in Victoria, New South Wales and Queensland occur in sandstone (Cusack *et al.* 1999; Haskovec 1981; Hiscock and Mitchell 1993; McBryde 1974). Sandstone is particularly conducive as a grinding medium because of its uniform fine-grained nature and sharp quartz grains bound in a clay and iron rich matrix (Dickson 1980). Gorecki *et al.* (1992) reported from a study at Esmeralda Station in northwest Queensland, that 'all the 1040 hatchet grinding grooves… were on fine-grained sandstone'. In southern New South Wales and southern Victoria, grinding grooves usually found on sandstone outcrops immediately adjacent to a water source; such as rock pools on rock platforms, exposed bedrock in creek beds, and under drip-lines in rock-shelters. For example at the Stratford, Munro and Boisdale (East Gippsland) sites, grinding grooves have only ever been identified on sandstone outcrops (Cusack *et al.* 1999; Haskovec 1981).

However, in mountainous areas of north east Victoria, exposed granite outcrop is more common than sandstone and all the identified grinding grooves are on granite, with a range of groove morphologies evident. Grinding grooves in granite may be a particularly Victorian feature, as there is little information about grinding grooves occurring in this type of geology elsewhere in Australia, with the exception of grinding patches recorded on granite in Western Australia by Veth and O’Connor (1996). Grinding patches differ considerably in formation and are indicative of grinding seeds and grains as opposed to the tool manufacture processes evident in the grinding grooves which are the subject of this research.

Experimental archaeology undertaken by Dickson (Dickson 1972; 1976; 1980; 1981) was undertaken in sandstone; however, some of his conclusions can still be applied to granite as medium for grinding grooves. Dickson concluded that a good medium for grinding would contain fine grains and be firmly bonded (and not significantly weathered). As detailed in Hiscock (2008), stone tools varied regionally and manufacture and construction of tools varied in response to different environments. The tool-kits that resulted were consequently matched to the resources that people needed to procure and reflected the materials that were available. Therefore, although granite is not the most ideal whetstone, in north eastern Victoria that was what was available.

2.4 Grinding groove morphology and implications for tool type

Grinding groove morphology can indicate tools with different uses, and inferences can be made about the nature of the tools produced at a site, and subsequently the types of resources used, threats encountered, or tool-kits needed by the local population. For example, long elliptical-shaped grooves are interpreted as being formed during the making or re-sharpening of ground-edge axes. Whereas, long thin grooves are usually associated with sharpening wooden spear points or bone points. Broader, shallower grinding areas may have formed during seed or food processing or grinding of ochre. Of importance to this study, ground-edge axe grinding grooves are:

> … located on horizontal or near horizontal rock surfaces ... the grooves are typically elongated, deepest in the middle of the long axis (length) and rising to the surface at either end of the long axis. The long axis of a groove is invariably straight and is longer than the width. The depth to which the groove has been abraded is smaller than either the length or width (Hiscock and Mitchell 1993:6).

The formation of these ground-edge axes, from an unshaped, quarried piece of rock or a large pebble, to a blank (vaguely in the shape of an axe head), to a highly ground or polished ground-edge axe with potential for hafting is a considerable process. Quarry sites were highly prized, blanks were traded extensively and ideal grinding sites were reused (McBryde 1984b).

The morphology of the grinding groove can suggest a range of social, physical and economic characteristics. Dickson's experimental research showed that (on sandstone) the size of the resultant grinding grooves is dependent on factors such as the position of the person grinding, the angle at which the stone is held and the action used in grinding. Dickson (1980) noted that grooves form in a grinding motion with a series of forward strokes under pressure and return strokes without pressure. Dickson notes that the size of the groove is the result of the size of the blank, rather than the size of the resultant tool Dickson (1980:158).

The abundance of grooves at many sites is also explained by Dickson, who found that while the grinding of one ground-stone axe results in a groove about 1 cm deep at the centre, subsequent axe grinding in the same groove does not deepen it at the same rate. He states that 'using an old groove makes it easier to get a desirable profile on the hatchet, but the greater area of contact for the limited muscle power available makes the work harder and a little slower' (Dickson 1972:208). Dickson, drawing on his experiments over 15 years (Dickson 1981), found that certain dimensions of grooves reflected ground-stone axe grinding whereas others resulted from activities such as seed grinding and the processing of ochre for pigment production. He found ground-edge axe grinding grooves to be 'typically 25 to 50 cm long … commonly 5 to 8 cm (wide) … and the depth is about 2 to 4 cm at mid length' (Dickson 1981:43). He indicated that grooves 'less than 25 cm long, 2.5 cm to 3 cm wide with deep V shaped sections … were unsuitable for grinding ground-stone axes and that they were possibly used for grinding spears' (Hiscock and Mitchell 1993:31) while grooves 'broad and shallow with no definite shape … were the result of natural phenomena' (Hiscock and Mitchell 1993:31).

Haskovec (1981) in his honours research in Gippsland, identified a variety of different sandstone grinding groove forms. Firstly, common grinding grooves (up to 25 mm deep) which were used to make ground-edge hatchets. Secondly, rarer, broader and shallower grooves (1-15 mm deep) more likely used for polishing nearly completed tools. Thirdly, unusually large grooves, probably used for grinding a large tool and finally butterfly-shaped grooves, likely the results of re-use of a groove for grinding a larger tool than the initial tool that shaped the groove.

The shape and design of the ground-edge axe is consistent, and critical to its durability and functionality. Dickson (1976) notes that most ground-edge axes have an edge which is curved in plan, but straight in profile. The curvature in plan is the natural result of the grinding process, whilst conversely, the straightness in profile is a skill that takes some time to master, but is essential in creating a strong, durable tool. A ground-edge axe with a curved edge in profile is more likely to fracture in use (Figure 2.3).

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Figure 2.3 : Plan and profile drawings of ground-edge axes, showing variation between straight edge in profile (Fig.1) and curved edge in profile (Fig.2.) (Dickson 1976:40)

3. Methods

This chapter presents the methods utilised to find, collate, analyse and interpret the data as part of this thesis preparation.

3.1 Research methods

3.1.1 Ethnographic and archival

Ethnographic and archival research was undertaken at libraries including the State Library of Victoria, the Aboriginal Victoria Library and the Flinders University Library. Online research was undertaken using Trove, the National Library of Australia website.

The research focused on early (pre 1900) accounts of encounters with Aboriginal people in the areas of Victoria and New South Wales.

3.1.2 Database searches

A search of the VAHR was undertaken to identify the nature, location and number of grinding groove sites in Victoria. The results of this dataset were further filtered to determine those registered sites where the grinding groove substrate was granite. These sites are referred to as reference sites for the purposes of this analysis.

3.2 Analytical methods

3.2.1 Site attributes

A database of attributes for the grinding groove reference sites was developed, this was collated through reviewing the VAHR site cards, published reports on the sites and analysis of photos and context plans for each site. Archaeological field data was collated, where available, for the reference sites. The following attributes were included

- Geological substrate (granite or sandstone),
- the length of maximum axis in centimetres,
- the width of maximum axis in centimetres,
- the depth of grinding groove depression below original rock surface in centimetres,
- the distance of each groove from the primary water source in metres,

- orientation of each groove,
- orientation of water flow in area relative to groove orientation,
- density of grooves – including density of grooves per m^2 for entire registered site and also total number of grooves within a 1 m radius of each groove.

Limitations in this site attribute recording were identified for several sites where insufficient information was available. These sites, and implications for the results, have been noted in Chapter 4: Results.

3.2.2 Statistical analysis

Simple statistical analysis methods were adopted. The aim of the analyses was to seek patterns in the data and whether there were relationships or dependencies between the data sets. Statistical analysis of the collated data was undertaken as follows:

- Graphical comparison of morphological attributes, particularly the dimensions (length, width, depth) of the grinding grooves and comparison to results of experimental archaeology reported by Dickson (Dickson 1972; 1976; 1980; 1981) and sandstone grinding grooves reported by Haskovec (1981) and Cusack *et al.* (1999)
- Graphical comparison of the morphology of the granitic grinding grooves in this study to the sandstone grooves from Haskovec (1981).

3.2.3 Geological comparative analysis

Comparisons between the behaviour of a granite substrate versus a sandstone substrate during the grinding process were developed based on a study of the abrasion resistance of each rock type.

Comparative analysis of the location of the granite grinding groove sites versus sandstone groove sites in relation to proximity to water was undertaken to inform a discussion on the methods used in grinding granite versus those used in sandstone and the necessity for water in the grinding process for each rock type.

3.2.4 Mapping

Simple mapping was undertaken to present the geographic distribution of grinding groove sites in north eastern Victoria. The aim of the analysis was to show the location of the identified sites in relation to each other.

Grinding groove sites are useful as a proxy for the distribution of ground-edge axes in Victoria and can provide information on the potential trade networks of ground-stone axes throughout Victoria. Greenstone (mafic volcanic rock) was a commonly used raw material for ground-edge axes in Victoria (McBryde 1978; 1984a). Mapping the location of recorded greenstone axes versus the location of axe grinding grooves can provide validation of theories of exchange networks. The thesis refers to the mapping undertaken by Isabel McBryde of greenstone axe distribution throughout Victoria.

4. Results

4.1 Ethnography

Ethnographic accounts and research have the potential to provide useful information about the use of grinding grooves to sharpen stone tools such as ground-edge axes, but also about raw material collection, quarrying processes and exchange networks that enable the use of these tools.

4.1.1 Quarrying, selection, manufacture and use of ground-edge axes

Ethnographic accounts provide useful information on the types of materials used for ground-edge axes. Robert Brough Smyth provides details on the construction and form of ground-edge axes and hatchets and their common hafting with wood or sinew. These first-hand accounts provide an evocative picture of the practicality and usefulness of these tools:

> The hatchets are of various forms, and differ in size and weight; but those of the Victorian natives are nearly all of the same general character. They are provided with wooden handles, as a rule; and the handles are, in Victoria, all of the same shape, and they are fastened to the stone uniformly with cord and gum (Smyth 1878:358).

Smyth (1878) describes the rock types used to make ground-edge axes a being multiple and varied. ‘The rocks used for making tomahawks are granite, porphyry, diorite, basalt, lava, metamorphosed sandstone, hard sandstone, dense quartzite resembling hornstone, and granular quartzite’ (Smyth 1878:358).

Historical records can provide a contemporary (or near contemporary) account of the manufacture and formation of ground-edge axes and the subsequent formation of grinding grooves. For example, in northern NSW on the Clarence River, settler George Gray described the process of creating ground-edge axes, whereby ‘greywacke pebbles were ground to shape in grinding grooves on boulders, situated in the bed of the river itself, with the aid of running water and sand’ (Gray 1915:186-187).

Similarly, Howitt (1996) provides an account of the ground-edge axe manufacture in Gippsland:

> Stone tomahawks and axes are made either from waterworn pebbles or pieces split from larger blocks of stone. The former was the practice in Gippsland, where suitable material is very plentiful in the mountain streams…A Kurnai man, having found a waterworn stone suitable for his purpose, first of all chipped or pounded the part intended or the cutting edge with a hard rounded pebble, then having brought it somewhat into shape, he rubbed it down on a suitable rock in the bed of a stream until he had produced a good edge. This process was much more expeditious than might be expected (Howitt 1996:312).

Dickson's experimental archaeology confirms the Howitt's comments regarding the 'expeditious' nature of use of suitbaly shaped pebbles for ground-edge axe manufacture. Dickson notes that the use of pebbles is 'neither a long nor exhausting process' (Dickson 1972:208), and typicaly takes between one and one and a half hours. The potential for continued use, re-sharpening and portability of ground-edge axes can be likened to Hiscock's *extension strategy*, whereby the shape, size and design of a stone tool is engineered to enable ongoing maintenance and therfore continued functionality, as the tool is reduced during normal use (Hiscock 2006; Hiscock and Maloney 2017).

4.1.2 Ground-edge axes: a critical part of the tool kit

As originally claimed by some early ethnographers (Smyth 1878) the ground-edge axe may have been 'the ultimate all-purpose heavy duty tool' (McBryde 1984a:267). Its flexibility of use, transportability, strength and toughness would have imbued it with considerable value in traditional Aboriginal society. Smyth (1878) documents the importance of axes (hafted as hachets) in the tool-kits of Aboriginal Victorians:

> A man never leaves his encampment without his hatchet. With its help he ascends trees almost as rapidly as the native bear can climb. He cuts a notch for his toes, and placing the hatchet between his teeth, so as to set free his arms, ascends one step, cuts another notch, and so on until the height he desires to reach is attained. The rapidity with which he climbs and his dexterity would surprise a stranger. With the stone hatchet he cuts open limbs of trees to get opossums out of the hollows; splits open trunks to take out honey or grubs or the eggs of insects; cuts off sheets of bark for his miam or for canoes; cuts down trees, and shapes the wood into shields or clubs or spears; cuts to

> pieces the larger animals of the chase, if necessary; and strikes off flakes of stone for inserting in the heads of spears and for skinning beasts and cleaning the skins. With an old tomahawk he will shape from a rough block of stone a new tomahawk (Smyth 1878:379).

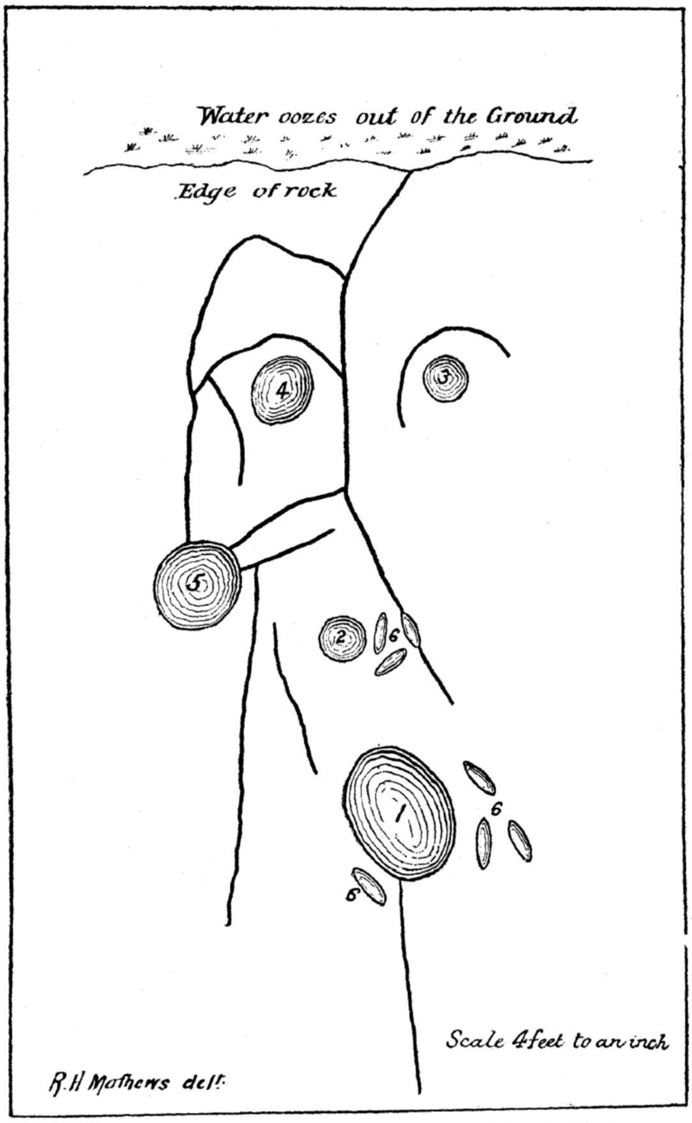
The development and use of ground-edge axes was a ‘technological achievement of ecological, environmental and adaptive innovation and efficiency’ (Geneste *et al.* 2012:9), which resulted in the utilisation of a range of resources including the working of timber and bark, removal of possums and other small tree-dwelling animals from tree hollows, and the cutting and shaping of canoes and other weapons and tools from trees. Geneste, et al (2012) argue that in addition to the utilitarian applications of ground-edge axes, the social and symbolic associations and trade and economic elements, increase the cultural significance of these tools to more than they initially appear.

4.1.3 Engineering the local environment

There is evidence that the environment was sometimes engineered to meet the need for sharpening of stone tools. R.H. Mathews (1896) documents a grinding groove site in the County of Cumberland (metropolitan Sydney and surrounds south to Wollongong and north to the Hawkesbury River). The site also includes circular depressions, postulated by Mathews as ovens for boiling water, however also possibly ready water storage areas for grinding activities. Mathews’ grinding grooves are in Hawkesbury Sandstone and consist of seven ‘elongated oval hollows’ (Mathews 1896:258) which are fed by water which moves through shallow ground channels in the sandstone outcrop (dark lines shown in Figure 4.1)). Mathews notes that ‘

> a very small stream of water, oozing out of the earth on the highest side, where the ground is on a level with the surface of the rock, trickles over the latter; and to prevent this from running into the holes, grooves have been cut in the surface of the rock about an inch deep, and an inch and a half wide, for the purpose of conducting the water along them…The cutting of these grooves in the hard rock with the rude tools used by the natives would be a work of considerable labour. The marks of these tools are evident in all the grooves (Mathews 1896:256).

The manipulation and engineering of the sandstone outcrop to suit the needs of the stone tool worker, as evident from this channel design, illustrates the importance of grinding grooves and the absolute necessity of being able to conveniently sharpen tools as needed.



STONE COOKING-HOLES AND GROOVES FOR STONE-GRINDING.

Figure 4.1 : Illustration of ground sandstone features, including holes, grooves and channels (Mathews 1896:255)

4.1.4 Social implications of grinding groove sites

The sharpening of ground-edge axes, similar to knapping activities, was part of normal life. Linkages to other community activities can be seen in the ethnographic record. R.H Mathews at the Cumberland County site, documents that associated with, and in close proximity to, the grinding grooves are at least 35 engravings of men, women and animals

(Mathews, 1896). Mathews concluded that this area represents a regular camp site as evident by the variety of activities evidently undertaken at the site. This example details a connection between grinding grooves and everyday function and social interactions such as story-telling and food preparation activities.

Authors have argued that current human communities provide evidence of the linkages between language use and the sharing of lithic technology (Bril *et al.* 2005; Stout 2002). The social character of the process of stone tool manufacture, for example knapping, has been identified in these studies. Some ethnographic studies have examined the social, and particularly language, implications of lithic technology, emphasising the social character of knapping in current human communities. In these groups, verbal interaction is a key component of the knapping learning process, especially for transmitting complex technological concepts (Bril *et al.* 2005; Stout 2002)

A recent study conducted experimental tests to evaluate the role of language in the teaching of lithic technology. Lombao *et al.* (2017) designed and developed an experimental program where they tested the acquisition of knapping skills in thirty non-experts in the early stages of learning. Three different methods of teaching were tested: imitation-emulation, gestural communication, and verbal communication. All the learners carried out the task with blanks that were equal in shape and size, and were asked to try to recreate what the teacher was doing. The results indicate that the learners improved their knapping skills in teaching conditions - both gestural and verbal communication-, and specially through the latter. This study supports the hypothesis of co-evolution between lithic technology and social learning.

4.2 Ground-edge axe distribution in Victoria

Research by Isabel McBryde (McBryde 1978; McBryde 1979; McBryde 1984a; McBryde and Harrison 1981; McBryde and Watchman 1976)) has documented Aboriginal ground stone axe exchange systems across south eastern Australia by comparing the distribution of over 3,000 axes of known raw materials across the landscape with the location of known quarries and outcrops of the same raw materials. The distribution of axes from known quarry sources of Mount William and Mount Camel are presented in Figure 4.2 and Figure 4.3 (McBryde 1978). The distribution of ground-edge axes associated with Mount William quarry is extensive. Axes sourced from Mount William have been recorded 700 km to the north near Broken Hill, NSW and 550km to the west near Adelaide.

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Figure 4.2 : Distribution of Mount William ground-edge axes (McBryde 1978:370)

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Figure 4.3 : Distribution of Mount Camel ground-edge axes (McBryde 1978:371)

4.3 Grinding groove sites in north east Victoria

This thesis focuses on the characteristics, patterns and conclusions that can be made from a study of granite grinding grooves in north eastern Victoria. Elsewhere in Victoria, particularly in Gippsland, other authors have undertaken studies with a particular focus on sandstone grinding grooves (Cusack *et al.* 1999; Haskovec 1981). Major conclusions from these studies and how they compare to those in this thesis are presented in Chapter 5.

Error! Reference source not found. presents a summary of grinding groove sites in north east Victoria. Details of each of these sites are provided in Tables 4.2 to 4.6.

Table 4.1 : Grinding groove sites in north east Victoria

Site Name	Components	Geology
Lima East Grinding Grooves 1	30 grooves	Granite
Lima East Grinding Grooves 2	5 grooves	Granite
Hughes Creek Grinding Grooves, Tarcombe	43 grooves	Granite
Reedy Creek Grinding Grooves, Eldorado	29 grooves	Granite
Pine Gully grooves	12 grooves	Granite

Table 4.2 : Lima East Grinding Grooves 1

Lima East Grinding Grooves 1, VAHR #8024-0050	
Location	Sugarloaf Creek, Lima East
Environment	Mountainous forested area. Grooves on outcrop in Sugarloaf Creek. Located 800 m from Lima East Grinding Grooves 2 site.
Count of grooves	20 grinding grooves
Geology	Granite outcrop
Dimension of site	6.5 m long by 3.4 m wide.
Orientation of grooves	North west/south east
Orientation of water flow	North west/south east
Reference:	Edwards (2010a)
Plan Drawing:	Image removed due to copyright restriction.
Photograph:	Image removed due to copyright restriction.

Table 4.3 : Lima East Grinding Grooves 2

Lima East Grinding Grooves 2, VAHR #8024-0051	
Location	Sugarloaf Creek, Lima East
Environment	Mountainous forested area. Grooves on outcrop in Sugarloaf Creek. The granite outcrop is bounded by a large granite boulder on each side Located 800 m from Lima East Grinding Grooves 1 site.
Count of grooves	5 grinding grooves
Geology	Granite outcrop
Dimension of site	3 m long by 7.6 m wide.
Orientation of grooves	North west/south east
Orientation of water flow	North west/south east
Reference:	Edwards (2010b)
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Table 4.4 : Hughes Creek Grinding Grooves

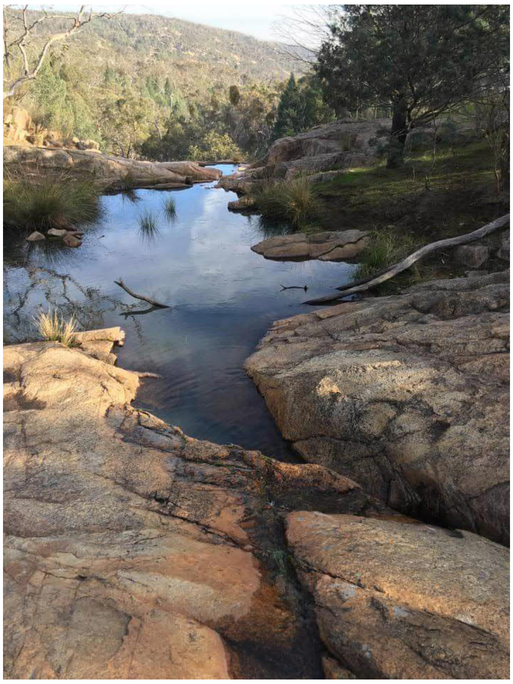
Hughes Creek Grinding Grooves, VAHR #7924-0443	
Location	On Hughes Creek, near Tarcombe
Environment:	Mountainous forested area. Grooves on outcrop in Hughes Creek.
Count of grooves	53 grinding grooves, clustered in 9 sets
Geology	Late Devonian Strathbogie Granite, which can vary from fine to coarse grained in the region (Edwards 1998).
Dimension of site	3 m long by 7.6 m wide.
Orientation of grooves	South west/north east
Orientation of water flow	South west/north east
Reference:	Prosser (2012)
Plan Drawing:	Image removed due to copyright restriction.

Hughes Creek Grinding Grooves, VAHR #7924-0443	
Photographs:	Image removed due to copyright restriction. (Strathbogie Ranges Nature Review 2013)

Table 4.5 : Reedy Creek Grinding Grooves

Reedy Creek Grinding Grooves , VAHR #8225-0131	
Location	Reedy Creek, Eldorado
Environment	Mountainous forested area. Grooves on outcrop in Reedy Creek.
Count of grooves	29 grinding grooves
Geology	Granite outcrop
Dimension of site	3 m long by 3 m wide
Orientation of grooves	North/south
Orientation of water flow	North/south
Reference:	Greenwood and White (2002)
Plan Drawing:	Image removed due to copyright restriction.
Photograph:	Not available

Table 4.6 : Pine Gully Grinding Grooves

Pine Gully Grinding Grooves	
Location	Pine Gully Creek, Mount Bruno
Environment	Mountainous forested area. Grooves on outcrop in Pine Gully Creek. The outcrop is immediately adjacent to several waterholes and a seasonal waterfall.
Count of grooves	12 grinding grooves
Geology	Granite outcrop
Dimension of site	5 m long by 5 m wide
Orientation of grooves	North east / south west
Orientation of water flow	North east / south west
Reference:	A preliminary recording of this site was submitted to Aboriginal Victoria, for further internal investigation
Plan Drawing:	Not available
Photograph:	

4.4 Statistical results

4.4.1 Morphological results

Morphological analysis has considered the length, depth and width of each of the grinding grooves from three of the reference sites, Lima East grinding grooves 1, Lima East grinding grooves 2 and Hughes Creek grinding grooves.

Length and depth of grinding grooves are not considered to be characteristic of the type of tool produced. Dickson (1980) considered that the length of a groove was representative of the size and position of the operator, using a comfortable extension of the arms and a two-handed grip of the stone tool.

Depth of the grinding grooves is also dependent on the quality of the substrate (McConnell 1981). Other variables affecting depth are the operator's intended degree of sharpening, and any secondary use of the grooves. Grooves used for final polishing may also not be as deep as earlier ones created in the initial rough grinding of a blank.

Width, therefore is the main indicator for the actual size of the initial blank from which a stone tool is made. Secondary use of a groove, presenting as a stepped groove, as observed by Haskovec (1981) in sandstone was not identified at any of the granite sites in north eastern Victoria.

4.4.1.1 Width versus length

Analysis of width versus length of grinding grooves has been undertaken and is presented in Figure 4.4. This chart includes data from the two Lima East grinding groove sites (located 800 m apart) and the Hughes Creek grinding groove site. Average values from the sandstone grinding groove sites in Gippsland from Haskovec (1981) are also presented. For comparison the range of the experimental data developed by Dickson (1980) for sandstone groove morphology is presented.

This analysis suggests that the grinding grooves at the Lima East sites and the Hughes Creek site have different morphologies. Distinct clusters for each of the two areas are evident in Figure 4.4. The Lima East grooves are consistently longer and wider than the Hughes Creek grooves. Two of the grooves from Lima East 1 (grooves 28 and 29) are considerably wider (30 and 39 cm respectively) than the remaining grooves from that site. These grooves are unlikely to be related to ground-edge axe sharpening, and may possibly be indicative of resource use, such as seed or ochre grinding. Given the distance between Lima East and Hughes Creek – 60 km – over mountainous country, and the unknown dates for the creation of the grooves it is likely that different groups of people were responsible for the formation of the grooves. As noted by Dickson (1980) the morphology of the groove is dependent on a range of factors (including angle and position of worker), and therefore local variation is to be expected.

It is interesting to note the differences in the data from sandstone grinding grooves in Gippsland compared to Dickson's experimental data for sandstone. The mean measurements from the Gippsland data show a shorter and wider set of grooves than the average developed by Dickson (1980).

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Figure 4.4 : Width of groove versus length of groove for granite sites (Lima East 1 and 2 and Hughes Creek) compared to the mean measurements from 15 sandstone grinding groove sites referenced in Haskovec (1981)

4.4.1.2 Depth versus length

An analysis of groove depth versus groove length for granites sites in north east Victoria, compared to sandstone sites in Gippsland is presented in Figure 4.5. Statistical analysis was undertaken using the Pearson correlation coefficient which produces ‘r’, a dimensionless index that ranges from -1.0 to 1.0 (where 1 is total positive linear correlation, 0 is no linear correlation, and −1 is total negative linear correlation) and measures the linear relationship between two data sets. The results of this analysis for the granite sites returned a correlation coefficient of 0.76, and for the sandstone sites a correlation coefficient of 0.58, both of which indicate a high level of linear relationship between groove depth and groove length. This result proves the correlation between the two factors and affirms Dickson’s (1980) theory that depth and length of a grinding groove are linearly related and primarily dependent on the physique, position and intentions of the operator.

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Figure 4.5 : Depth of groove versus length of groove for granite sites (Lima East 1 and 2 and Hughes Creek) compared to sandstone sites referenced in Haskovec (1981)

4.5 Geological comparisons

4.5.1 Geology of the grinding groove sites

The geology of the four case study grinding groove sites each consists of granite. However, the nature, distribution and geological properties of each of the sites are dependent on the chemical composition and structure of the localised granite batholith within which they are located.

The Strathbogie Granite, upon which the Lima East and Hughes Creek grinding grooves sites are located, is a coarse-grained porphyritic granite. The term 'porphyritic' defines a rock texture with large crystal inclusions – in the case of the Strathbogie granite these consists of large (approx. 50 mm diameter) potassium (K-) feldspar crystals (Welch, et al. 2011). This will most likely have the effect of a very hard granite, with potential for a wide variation in texture across different locations, dependent on the amount of porphyry.

Contrary to this, the Killawarra and Woolshed Valley Granites (locations of Pine Gully and Reedy Creek grinding groove sites) are medium grained, and the Woolshed Valley Granite includes muscovite as a major component (Welch, et al. 2011). Muscovite is a thin, layered mineral, generally soft and more easily breakable. This texture would most likely have the effect of a softer, finer-grained matrix within a grinding groove context.

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Figure 4.6 : Location of Hughes Creek and Lima East grinding groove sites within the Strathbogie Granite G217). Excerpt from Map 25, Nagambie/Euroa (Welch et al. 2011)

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Figure 4.7 : Location of Pine Gully and Reedy Creek grinding groove sites within the Killawarra Granite (G206) and the Woolshed Valley Granite (G193). Excerpt from Map 19, Wangaratta/Albury (Welch et al. 2011)

4.5.2 Granite versus sandstone

Each of the grinding groove reference sites in north eastern Victoria assessed in this research, is recorded on granite, which is consistent with the outcropping geology in the region (Figure 4.6 and Figure 4.7). Likewise, elsewhere in Victoria, where sandstone is the dominant outcropping geology, grinding grooves are predominantly recorded on sandstone (Haskovec 1981).

It is interesting to examine the differences in the nature of granite and sandstone and how these differences may affect the degree of abrasion of the rock outcrop and the speed and ease of the grinding process. The degree of abrasion on a geological surface will vary dependent on the mineral composition and type of geology. Abrasion is the mechanical scraping of a rock surface by friction between particles. In this situation the friction is artificially created by contact between rocks (the ground stone blank and the substrate). The intensity of abrasion depends on the hardness, the concentration (pressure), the velocity and mass of the moving particles.

Abrasive resistance is a geological property dependent on the hardness of the composite minerals and the strength of the chemical or physical bonds between the mineral grains in the rock. Comparison between a typical granite and a typical sandstone indicates that both geologies will contain a significant proportion of quartz, which is considered a hard and durable mineral, however, granite is considered to be more abrasion resistant than sandstone. This difference is because the mineral grains in granite are tightly packed, with the grains chemically attached to each other, whereas in sandstone the grains are usually cemented together with a softer and less durable clay mineral. When sandstone is subject to abrasion the quartz grains will detach from the sandstone, while similar abrasion of granite will result in the wearing away of the surface grains. An appropriate reference is the ‘Resistance to Abrasion Index’ for common rock types (Table 4.7)(ASTM International 2015). This index is calculated by subjecting the stone to an abrasive medium and measuring the volume of stone lost during the test. The index unit is hardness (Ha). The lower the index number, the lower the resistance to abrasion. Table 4.7 demonstrates that granite has a higher abrasion resistance than sandstone (granite is more than twice as resistant to abrasion than sandstone), and as a result granite will abrade more slowly, and subsequently require more pressure (or a greater duration of abrasion) from the worker to achieve the same result.

Table 4.7 : Abrasion Resistance Index for typical Australian rock types (ASTM International 2015)

Stone type	Typical Abrasion Resistance Index (Ha)
Granite	50-150
Marble	15-50
Sandstone	4-24
Slate	4-20
Limestone	<1-20

4.5.3 Geography and proximity to water

Across Victoria grinding grooves are found in a variety of different environments. There is an obvious bias towards mountainous areas where there is outcropping rock which can act as a substrate, and as such grooves are less likely on the riverine plain or other areas where thick accumulation of sedimentary layers results in the covering of outcropping rocks. In these areas grinding grooves will be more likely to be found along the banks of rivers or creeks where water erosion has resulted in the removal of covering sediments.

Comparative analysis of the location of the granite grinding groove sites and proximity to water was undertaken to inform a discussion on the methods used in grinding granite versus those used in grinding sandstone and whether water was necessary in the grinding process for each rock type.

In this study, each of the granite grinding groove reference sites was located in close proximity to flowing water. Each of the reference sites was located on outcropping granite in the middle or sides of a flowing creek and the orientation of the grooves was the same as the orientation of water flow at each site.

4.6 Associated site types

In north eastern Victoria, at the granite groove reference sites assessed in this research, there are no other nearby recorded Aboriginal sites. In the wider region the most common Aboriginal site types are stone artefact scatters and scarred trees. The paucity of sites recorded nearby is possibly the result of a lack of field survey in the surrounding regions, as these grinding groove sites were all recorded by government agencies during specific targeted recording projects.

5. Discussion

This chapter discusses and contextualises the results that were presented in Chapter 4. It evaluates the results with consideration to the literature review and discusses the major themes developed throughout the research. The final section identifies the limitations of this study and provides recommendations for future studies.

5.1 Geological variation and implications for grinding groove morphology

Grinding grooves are formed by the process of stone tool sharpening or manufacture. The characteristics of the geological substrate (the rock outcrop on which grooves are created) and the material being ground into it influence the shape and size of the grooves.

Geology of the grinding groove substrate will also influence the morphology of the grooves, the time required to grind an appropriate edge, and therefore the desirability of the location for the task. As a substrate for grinding grooves, granite provides a good initial coarse-grind to help transform the blank into a roughly ground tool. Granite, by nature, contains largish angular minerals, predominantly hard quartz grains which are tightly cemented together in a matrix. As a whetstone it would be essential to add water in the grinding process on a granite medium, as the nature and coarse size of the grains would not facilitate dry-grinding. However, in contrast if polishing or adding a final sharp edge to a stone tool, sandstone would be a preferred medium. The finer and rounded quartz grains within sandstone, which are bounded together in a softer clay matrix would provide a polishing effect on a stone tool. A fine-grained sandstone would permit a dry-polish (no water added)

However, it would be highly unusual for there to have been ready access to suitable outcrops of varying geology to meet the needs of different stages of the ground-edge axe manufacture process. Therefore, it is more likely that compromise was required. The primary factor influencing the choice of grinding groove substrate in a region appears to have been the dominant outcropping geology. Whilst ground-edge axe blanks were transportable, the grinding surface was not.

The morphology (shape and size) of the grinding grooves has been compared to other sites in Victoria with differing geology (sandstone sites from Gippsland) and compared to results from experimental archaeology. This analysis indicates that the granite grooves present a wider spectrum of measurements than the experimental archaeology would support. Whether this is a consequence of the variations in methodology of the experimental archaeology, given that it was conducted on sandstone, or whether it is the result of local variations in operator, geology and resource needs, we cannot be certain. The results do, however, indicate that there is a wide variation in morphology of granite grinding grooves, and that conclusions relating to sandstone grooves cannot necessarily be ascribed to granite grooves.

The granite grinding grooves, particularly the Lima East sites, show a wide range in length and width attributes. It is likely that the widest and longest outliers in these datasets are the result of different practices to ground-edge axe manufacture. These grooves may be the result of grinding of seeds or ochre, or the sharpening of flatter wooden implements or tools.

There is a noticeable correlation between length and depth of grinding grooves at each site, across both granite and sandstone, as evidenced by the Pearson correlation coefficients. Dickson (1980) identified that these attributes are both primarily affected by the physique and position of the operator, and as such a correlation between the two attributes is not unexpected.

Grinding groove morphology can indicate tools with different uses, and inferences can be made about the nature of the tools produced at the site, and subsequently the types of resources used, threats encountered or tool-kits needed by the local population. The variations evident across the reference sites in this study indicate that local factors are likely to have influenced the selection of site, the intensity of use and the nature of resources and tools used or manufactured at each site.

5.2 Engineering the environment

Ethnographic accounts document the essential toolkit of the Australian Aboriginals. A ground-edge axe was critical to this toolkit for its durability and flexibility of use.

The manufacture of ground-edge axes requires a good, strong raw material for a blank and a grinding substrate of appropriate abrasive resistance to facilitate the grinding of an edge on a tool. Selection and adaptation of an appropriate site for the production of a ground-edge axe was very important. The literature review and this research have identified that the key criteria for site selection, namely, suitable geology and water within close reach, could both be adapted when required. If the ideal substrate of sandstone was not available, such as in north eastern Victoria, then a suitable granite outcrop was used and compromise achieved. If water was not within reach, then small water holes or channels could be made to store water and channel it for the grinding process. Each of the granite grinding groove reference sites discussed in this research included grooves located within close reach (less than 2 metres) of water. Seasonal variation would have had some influence as water levels fluctuated, however all of the groove sites are located close to permanent water sources.

This research has identified that local variation is a factor at the reference sites for this research. Dickson's experimental archaeology in the 1970s and 1980s confirmed that variation is inherent in the formation of the grooves (Dickson 1972, 1980, 1981). The shapes and sizes of the granite grooves vary considerably across north east Victoria.

5.3 Social interaction and language development

The time required to form grinding grooves in itself indicates a period of use and most likely habitation of particular area. Experimental archaeology has demonstrated that each groove may be indicative of several hours of work (Dickson 1972; Dickson 1976). In this regard grinding grooves may also be indicative of time spent in company of others. Frequently grinding grooves are found in clusters and this may be able to inform about social practices around tool manufacture and sharpening.

The differences in morphology for length and depth analysed in this research indicates a wide range in each of these factors at granite sites. This variation may indicate a range of uses of these grooves, and that possibly the grinding of ground-stone axes was not the only use for these sites. There is the potential that foods including grains and seeds and/or ochre were also ground at these sites. Further research on use-wear, and residue would be required to inform this hypothesis.

The clustering of grinding grooves at a location may provide evidence for social activities. We can postulate that grinding was done in company, that skills were passed on, stories were shared and language refined during these activities. The variety of groove shapes and sizes at a location may provide information about other activities nearby such as food preparation of ceremonial activities. There is a fair bit of conjuncture in these hypotheses, however recent research has shown a link between language use and the sharing of lithic technology, where verbal interaction is a key component of learning how to knapp stone, especially when transmitting complex technological concepts (Bril *et al.* 2005; Lombao *et al.* 2017; Stout 2002).

5.4 Grinding grooves - a proxy for ground-stone axes?

Ground-edge axes are widely distributed throughout Australia and had a unique position within the tool kit of Australian Aboriginals. Historical accounts and ethnographic descriptions indicate that throughout Australia, tools and raw materials were procured in a manner of ways. Reciprocal gift exchange, travel to the source of the raw materials or bartering for raw materials were all common practice. The importance of ground-edge axes as a trade commodity have been studied in detail by researchers.

Grinding groove sites are useful as a proxy for the distribution of ground-edge axes in Victoria and can provide information on the potential trade networks of ground-stone axes throughout Victoria. Greenstone (mafic volcanic rock) was a commonly used raw material for ground-edge axes in Victoria ((McBryde 1978; 1984). McBryde's mapping of the location of greenstone axes has indicated that greenstone from certain quarries was preferred, even when other suitable local material would have been available. Greenstone axes from the Mount William quarry have been found throughout much of Victoria, emphasising their importance in trade and exchange practices. In the archaeological record, ground-edge axes have become the preferred artefact class for provenance research.

It may be appropriate to use grinding groove distribution (and morphological analyses) as a proxy for the distribution and trade of stone tools, in particular ground-stone axes. However, it is not simple to access or analyse the available data. The records available on the VAHR are not searchable by stone artefact type (i.e. ground-stone axes) so a researcher would need to comb through thousands of records to identify the locations of all recorded ground-stone axes in Victoria. In addition, the recorded details for each of the grinding groove sites in Victoria varies in quality, detail and suitability. Some grinding grooves are recorded in great detail, with dimensions, orientation and qualities of each groove recorded, other sites merely provide a count of the number of grooves and a rough mud map sketch of the location. These inconsistencies make analysis and comparison difficult.

5.5 Predictive modelling for grinding grooves

Grinding groove sites in Victoria are likely to be present where there is outcropping granite or sandstone and accessible water. Archaeologists in cultural heritage assessments may not factor the likelihood of grinding grooves into their predictive modelling at the research phase of a project. This is partly the result of the scarcity of recorded grinding groove sites in Victoria which results in none being recorded within a certain search radius of a project area for a particular study. This is also partly because of the little research that has been undertaken on these site types, and their consequent low profile in academic research.

Predictive models for these site types need to be updated to reflect this increased understanding of the nature and occurrence of grinding groove sites. In areas of granite outcrop, grinding grooves may be present near water sources. In these locations grooves are likely to consist in a group, with generally the same orientation and within less than 2 metres distance from the water. Grooves will often be located on boulders or granite outcrops in the centre or edge of a waterway.

5.6 Future research directions

There has been little to no published research on grinding grooves in a granitic medium in Victoria. Considering the large areas of Victoria where granite is the dominant outcropping geology, there appears to be a big gap in the current understanding of grinding grooves, their formation in different geologies apart from sandstone, their frequency of use and their eventual weathering and deterioration. This has implications for management and protection of these sites.

Similarly, there is no published research into the implications of the use of the granitic grinding grooves of north eastern Victoria and what this can tell us about resource use and occupation patterns in the region. There are many unanswered questions about the Victorian granitic grinding groove sites. Were people just ‘travelling through’? or did they stay and camp or use the sites on a regular basis? What tools were being made or improved on these grooves? Did the granite substrate limit the tool production, tool size or tool morphology?

This research has utilised legacy data sets from the VAHR and from unpublished theses, and consultant archaeological reports. The limitations of these legacy data sets have been identified - indeed, the variation in quality of documentation of grinding grooves is significant. This sheds light on the challenges of undertaking research based on legacy data sets. However, these data sets also provide considerable scope and potential for research, in setting baselines and agendas from which to branch out to further study and in identifying the value of new research and data collection to inform existing hypotheses.

This review has demonstrated that there are considerable gaps in information available about grinding groove sites in Victoria and confirms that further research is warranted.

5.7 Limitations

This thesis was purely desktop research-based, and as a result the opportunity to ground-truth and check the measurements of previous researchers or record sites in greater detail was not possible. This factor has limited the breadth and depth of the data available for analysis.

6. Conclusion

The discussion presented in Chapter 5 is summarised here together with the questions that were posed at the beginning of this thesis. The subsidiary questions are presented initially, and summarised to answer the primary question

What can ethnographic information tell us about the location, frequency of use and nature of tools manufactured in Victoria?

Ethnographic accounts provide useful accounts of the selection, sourcing and exchange of raw materials, and document the use of certain geologies for grinding and refining the ground-edge axes. There are no ethnographic accounts specific to the north eastern Victorian region studied in this thesis.

How do the characteristics of the selected reference grinding groove sites compare to one another, particularly in relation to morphology, distribution and function?

What does the morphology of the grinding grooves indicate about resource use and stone tool technologies? Are the grinding grooves purely the result of stone tool manufacture or is there evidence of seed grinding and resource use? Are there other archaeological sites types within close proximity which may inform this question?

The morphology of the grinding grooves at these north eastern Victoria references sites indicates a wide range of stone tool sizes and morphologies. The two Lima East grinding groove sites demonstrate larger and wider grooves than the Hughes Creek grinding groove site. Grooves at both of these sites show considerable variation to Dickson's experimental archaeology (Dickson 1980) and the sandstone reference sites from Gippsland cited by Haskovec (1981). This variation indicates that these sites were used for a variety of tools and resources and that local variations in operator size and posture, resource need and geology (of axe blank and substrate) will influence the size, shape and distribution of grooves. There are no recorded Aboriginal sites nearby which may have informed this discussion.

All of the north eastern Victorian grinding groove sites are located in or immediately adjacent to a permanent, flowing water source. All of the sites are located on granite, as the dominant outcropping geology in the mountainous areas of north east Victoria.

How does different geology respond to the process of grinding, as seen at these sites? Should we expect different use, wear and morphology for different geological types? How can this information be used to improve analysis and understanding of use patterns on different geological substrates?

The majority of ground-axe grinding grooves recorded throughout Victoria are recorded on sandstone. Sandstone is a preferred substrate for grinding, providing an even-textured, gently eroding outcrop which gradually loses grains throughout the grinding process. As a result, sandstone grinding grooves have the potential to become deeper more quickly and shown less evidence of abrasion than grooves in granite. When granite is used as the grinding groove substrate the grooves are likely to be more shallow, show a greater degree of abrasion of existing mineral grains (as they are less likely to come out of the matrix) and require greater effort to create grooves.

Sandstone substrates would also allow for the potential for dry-grinding, creating a polish, of a stone tool, as the fine sandstone grains create a lubricating substance. Whereas a granite substrate will always require the addition of water as a means of lubrication during the grinding. Therefore, we could expect to observe granite grooves being consistently located near water, whereas sandstone grooves may be located away from water in some situations.

What kind of predictive model can be developed for grinding groove sites and what recommendations can be made for future management and conservation?

Predictive models for these sites types need to be updated to reflect an increased understanding of the nature and occurrence of grinding groove sites. In areas of granite outcrop, grinding grooves may be present near water sources. In these locations grooves are likely to be in a group, with generally the same orientation and within less than 2 metres distance from the water. Grooves will often be located on a relatively flat boulder or granite outcrop in the centre or edge of a waterway.

Grinding groove sites are susceptible to damage from land use management activities, such as grading or landscaping of rivers or creeks. To effectively manage these sites, they need to be identified and then the landowner or manager needs to be counselled as to their cultural significance and the importance of protection and management of these sites.

What can the attributes of grinding groove sites (geology, form, distribution, and function) tell us about ground-edge axe exchange, use of resources and technological change in Victoria?

Grinding grooves sites are a critically important site type for many reasons. Grinding grooves are the highly abraded surfaces resultant from the manufacture and ongoing sharpening of ground-edge axes and other stone tools. These sites provide evidence of the use of certain tools in Victoria, as the morphology of each groove correlates to a certain size and shape, which we presume to be a ground edge axe due to ethnography and experimental archaeology. As such grinding groove sites may be used as a proxy for the distribution of ground-edge axes in Victoria and can provide information on ground-stone axe trade networks throughout Victoria. Greenstone (mafic volcanic rock) was a commonly used raw material for ground-edge axes in Victoria (McBryde 1978; 1984a).

The time required to form grinding grooves in itself indicates a period of use and most likely habitation of particular area. Experimental archaeology has demonstrated that each groove may be indicative of several hours of work (Dickson 1972; Dickson 1976). In this regard grinding grooves may also be indicative of time spent in company of others. Frequently grinding grooves are found in clusters and this may be able to inform about social practices around tool manufacture and sharpening.

Engineering of the local environment frequently evident at grinding groove sites indicates the systematic and planned nature of ground-stone axe preparation. Frequently we see evidence for channelling in stone or creation of small water wells adjacent to the grinding grooves (Mathews 1896). Ready access to water was essential in the grinding process and engineering of this access to water demonstrates that these practices were unlikely to be opportunistic and that careful planning and site selection was essential. This is indicative of a cultural landscape and a holistic approach to the environment.

7. References

Aboriginal Victoria 2008 *Aboriginal Ground-Edge Axes*. Victoria, Australia: State Government of Victoria:1-2.

Almeida, F. 2019 *Support for Thesis on grinding grooves and access to VAHR*.

ASTM International 2015 *ASTM C1353 / C1353M-15a Standard Test Method for Abrasion Resistance of Dimension Stone* West Conshohocken, PA: ASTM International.

Barwick, D. 1984 Mapping the past: an atlas of Victorian clans 1835-1904. *Aboriginal History* 8(1-2):100-131.

Bril, B., V. Roux and G. Dietrich 2005 Stone knapping: Khambhat (India), a unique opportunity? In V. Roux and B. Bril (eds), *Stone knapping: the necessary conditions for a uniquely hominin behaviour*, pp.53-71. Cambridge: McDonald Institute for Archaeological Research.

Brumm, A. 2010 The falling Sky: Symbolic and cosmological association of the Mt William greenstone hatchet quarry, central Victoria, Australia. *Cambridge Archaeological Journal* 20(2):179—196.

Burke, H. and C. Smith 2004 *The Archaeologist's Field Handbook*. Crows Nest: Allen & Unwin.

Cusack, J. 2003 *Farmers Arms Collection, VAHR Site Card #8024-0040*: Victorian Aboriginal Heritage Register.

Cusack, J., C. Webb and B. Marshall 1999 *Gippsland Axe Grinding Grooves Management Project*.

Dickson, F.P. 1972 Ground Edge Axes. *Mankind* 8:206-211.

Dickson, F.P. 1976 Australian Ground Stone Hatchets: Their Design and Dynamics. *Australian Archaeology* 5:33 - 48.

Dickson, F.P. 1980 Of Grinding Grooves. *Archaeology and Physical Anthropology in Oceania* 15:157-167.

Dickson, F.P. 1981 *Australian Stone Hatchets: A Study in Design and Dynamics*. Sydney: Academic Press.

Edwards, A. 2010a *Lima East Grinding Grooves 1, AV Site Card #8024-0050*: Victorian Aboriginal Heritage Register.

Edwards, A. 2010b *Lima East Grinding Grooves 2, AV Site Card #8024-0051*: Victorian Aboriginal Heritage Register.

Edwards, J. 1998 *Longwood and part of Yea. 1:50 000 geological map*: Geological Survey of Victoria.

Geneste, J.-M., B. David, H. Plisson, J.-J. Delannoy and F. Petchey 2012 The origins of ground-edge axes: New findings from Nawarla Gabarnmang, Arnhem Land (Australia) and global implications for the evolution of fully modern humans. *Cambridge Archaeological Journal,* 22(1):1-17.

Gorecki, P., M. Grant and M. Salmon 1992 The 1992 archaeological surveys on Esmeralda Station, Gulf of Carpentaria: preliminary results. *Queensland Archaeological Research* 9:54-58.

Grave, P., V. Attenbrow, L. Sutherland, R. Pogson and N. Forster 2012 Non-destructive pXRF of mafic stone tools. *Journal of Archaeological Science* 39:1674-1686.

Gray, G. 1915 *The Journal of George Gray 1846-1941.* Grafton: Clarence River Historical Society.

Greenwood, S. and J. White 2002 *Reedy Creek Grinding Grooves 1 (AV#8225-0131)*: Victorian Aboriginal Heritage Register.

Haskovec, I.P. 1981 *The Grinding Grooves of Gippsland*, Division of Prehistory,, Latrobe University,, Unpublished Report.

Hiscock, P. 2006 Blunt and to the Point: Changing Tehnological Strategies in Australia. In I. Lilley (ed), *Archaeology of Oceania: Australia and the Pacific Islands*, pp.69-95. Carlton: Blackwell Publishing.

Hiscock, P. 2008 *Archaeology of Ancient Australia.* London: Routledge.

Hiscock, P. and T. Maloney 2017 Australian lithic technology. In T.T. Hodos (ed), *Routledge Handbook of Archaeology and Globalization*, pp.301–318. Abingdon: Routledge.

Hiscock, P. and S. Mitchell 1993 *Stone Artefact Quarries and Reduction Sites in Australia: Towards a type profile*. Canberra: Australian Governement Publishing Service.

Hiscock, P., S. O'Connor, J. Balme and T. Maloney 2016 World's earliest ground-edge axe production coincides with human colonisation of Australia. *Australian Archaeology* 82(1):2-11.

Howitt, A.W. 1996 *The Native Tribes of South-east Australia*. Canberra: Aboriginal Studies Press.

Imamura, K. 1996 *Prehistoric Japan, New perspectives on insular East Asia*. Honolulu: University of Hawaii Press.

Land Conservation Council 1991 *Review of Melbourne Area District 2, Descriptive Report*. Melbourne: Land Conservation Council.

Lombao, D., M. Guardiola and M. Mosquera 2017 Teaching to make stone tools: new experimental evidence supporting a technological hypothesis for the origins of language. *Scientific Reports* 7(1):14394.

Lourandos, H. 1983 Intensification: A late Pleistocene-Holocene archaeological sequence from southwestern Victoria. *Archaeology in Oceania* 18(2):81 - 94.

Massola, A. 1962 The Aborigines of the Victorian high plains. *Proceedings of the Royal Society of Victoria* 75(2):319-325.

Mathews, R.H. 1896 Stone Cooking-Holes and Grooves for Stone-Grinding Used by the Australian Aborigines. *The Journal of the Anthropological Institute of Great Britain and Ireland* 25:255-259.

McBryde, I. 1974 *Aboriginal prehistory in New England : an archaeological survey of northeastern New South Wales*. Sydney: Sydney University Press.

McBryde, I. 1978 Wil-im-ee Moor-ring: Or, Where do Axes Come From? *Mankind* 11:354-382.

McBryde, I. 1979 Petrology and Prehistory: lithic evidence for exploitation of stone resources and exchanges systems in Australia. In T. H. McK. Clough and W.A. Cummings (eds), *Stone Age Studies*, pp.113-126. . London: CBA.

McBryde, I. 1984a Exchange in south-eastern Australia: an ethnohistorical perspective. *Aboriginal History* 8(2):132-153.

McBryde, I. 1984b Kulin greenstone quarries: the social contexts of production and distribution for the Mt William site. *World Archaeology* 16(2):267 - 285.

McBryde, I. and G. Harrison 1981 Valued goods or valuable stone? Consideration of some aspects of the distribution of greenstone artefacts in south-eastern Australia. In F. Leach and J. Davidson (eds), *Archaeological Studies of Pacific Stone Resources.*, pp. 183-208. BAR International Series.

McBryde, I. and A. Watchman 1976 The distribution of greenstone axes in southeastern Australia: A preliminary report. *Mankind* 10(3):163-174.

McBryde, I. and A. Watchman 1979 *Petrology and prehistory: lithic evidence for exploitation of stone resources and exchange systems in Australia*.

McConnell, A. 1981 The petrological analysis, with respect to abrasive quality, of some South East Gippsland sandstones used for grinding Aboriginal ground-edge axes. In I.P. Hascovec (ed), *Axes on the Ground*. Division of Prehistory Latrobe University,.

McConnell, A. 1987 *Report on the Howqua River Greenstone Area Survey and Recording of Howqua Quarry 1 and 2.*

National Heritage List 2007 *Mount William Stone Hatchet Quarry*. Retrieved 11 November from http://www.environment.gov.au/heritage/places/national/mount-william.

Prosser, L. 2012 *Hughes Creek Grinding Groove Aboriginal Place Site card #7924-0443*.

Schrire, C. 1982 *The Alligator Rivers: Prehistory and ecology in western Arnhem Land*. Canberra: Australian National University.

Smyth, R.B. 1878 *The Aborigines of Victoria*. Melbourne.

Stout, D. 2002 Skill and cognition in stone tool production. *Current Anthropology* 43:693-720.

Strathbogie Ranges Nature Review 2013 *Tarcombe Axe Grinding Grooves*. Retrieved from https://strathbogierangesnaturereview.wordpress.com/2013/02/12/tarcombe-axe-grinding-grooves/.

Veth, P. and S. O'Connor 1996 A preliminary analysis of basal grindstones from the Carnarvon Range, Little Sandy Desert. *Australian Archaeology* 43:20-22.

Welch, S.I., D.V. Higgins and G.A. Callaway 2011 *Surface Geology of Victoria 1:250 000*: Geological Survey of Victoria.

Appendix A. Letters from Traditional Owner organisations

TAUNGURUNG LAND & WATERS COUNCIL
FIRST PEOPLE OF THE RIVERS AND MOUNTAINS

Rose Overberg

Masters in Archaeology and Heritage Management

Flinders University

Broadford, 19 February 2019,

Re: Support for Thesis on grinding grooves and access to VAHR - Achris

Dear Rose,

This is to inform you that Taungurung Land and Waters Council strongly supports your research proposal for the study of grinding grooves in Northeast Victoria, including those from Taungurung Country. We therefore would like to let you know that you have permission to access Achris for the purpose of your Desktop research within the Taungurung RAP area.

We can further inform you that within the last one and a half years we have had reports of further grinding grooves locations for which we are currently taking the necessary recording procedures for registration. We will equally be happy to share with you the results of the current assessment, in the case you are interested.

Please make sure to keep us updated of your progress and results, and good luck in your research.

Ngun godjin

(kind regards)

Francisco Almeida, PhD

Cultural Heritage Programs Manager

37 High St Broadford, VIC 3658 PO BOX 505 Broadford, VIC 3658 Phone (03) 5784 1433 enquiries@taungurung.com.au

Gunaikurnai Land and Waters Aboriginal Corporation

Gunaikurnai Land and Waters Aboriginal Corporation
RNTBC (ICN 4768) | ABN 43 709 397 769

27 Scriveners Road, Kalimna West VIC 3909 | T 03 5152 5100 | F 03 5152 1666 | E reception@glawac.com.au
www.gunaikurnai.org

14 August 2018

Rose Overberg
Over0043@flinders.edu.au

Dear Ms Overberg

RE. PERMISSION TO ACCESS THE VICTORIAN ABORIGINAL HERITAGE REGISTER TO CARRY OUT RESEARCH ON ABORIGINAL GRINDING GROOVES IN GUNAIKURNAI RAP AREA, EAST GIPPSLAND

Thank you for your request to seek support from the Gunaikurnai Land and Waters Aboriginal Corporation ('GLaWAC') to access the Victorian Aboriginal Heritage Register ('VAHR') for the purposes of research into grinding grooves in the GLaWAC RAP area. This will be an interesting topic and we look forward to obtaining a copy of your thesis on completion of your research. GLaWAC therefore supports your application for access to this information on the VAHR.

Yours faithfully,

Roger Fenwick
Chief Executive Officer
Gunaikurnai Land and Waters Aboriginal Corporation

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