Excavations, Surveys and Heritage Management in Victoria

Volume 9

2020

Excavations, Surveys and Heritage Management in Victoria
Volume 9, 2020

Edited by

Elizabeth Foley

David Frankel

Susan Lawrence

Caroline Spry

with the assistance of

Ilya Berelov

Shaun Canning

Front cover:
Dead standing black box Culturally Modified Tree along Kromelak *(Outlet Creek) (Photo: Darren Griffin)*

Excavations, Surveys and Heritage Management in Victoria Volume 9, 2020

Melbourne

ISSN 2208-827X

Contents

Abstracts

Editorial note

The papers included in this ninth issue of *Excavations, Surveys and Heritage Management in Victoria* were presented at the annual Victorian Archaeology Colloquium held at La Trobe University on 1 February 2020. Once again we had over 150 participants whose attendance testifies to the importance of this fixture within the local archaeological calendar. It continues to be an important opportunity for consultants, academics, managers and Aboriginal community groups to share their common interests in the archaeology and heritage of the State of Victoria.

The papers published here deal with a variety of topics that span Victoria's Aboriginal and European past. While some papers report on the results of specific research projects others focus on aspects of method, approach, education and the social context of our work. and approach.

In addition to the more developed papers, we have continued our practice of publishing the abstracts of other papers given at the Colloquium, illustrated by a selection of the slides taken from the PowerPoint presentations prepared by participants. These demonstrate the range of work being carried out in Victoria, and we hope that many of these will also form the basis of more complete studies in the future. All papers were refereed by the editorial team. This year Elizabeth Foley managed this process and the sub-editing of this volume under the guidance of Caroline Spry. Layout was again undertaken by David Frankel.

Previous volumes of *Excavations, Surveys and Heritage Management in Victoria* are freely available through La Trobe University's institutional repository, Research Online < www.arrow.latrobe.edu.au:8080/vital/access/manager/Repository/latrobe:41999 >. We hope that this will encourage the dissemination of ideas and information in the broader community, both in Australia and internationally.

We grateful to the Colloquium's major sponsors ACHM, Ochre Imprints, Ecology and Heritage Partners and Heritage Insight; sponsors Biosis, ArchLink, Christine Williamson Heritage Consultants and Extent; and to la Trobe University for continuing support. We would like to thank them, and all others involved for their generous contributions towards hosting both the event and this publication. Yafit Dahary of 12 Ovens was, as always, responsible for the catering.

Preparation of this volume was, like so much else in 2020, undertaken during the severe restrictions imposed because of the COVID-19 pandemic. We hope that 2021 will be a better year for all and that even if we are unable to hold our Colloquium at the usual time we will be able to do so later in the year.

The editors and authors acknowledge the Traditional Owners of the lands and heritage discussed at the Colloquium and in this volume, and pay their respects to their Elders, past and present.

Investigating anthropogenic and natural disturbance in Aboriginal archaeological contexts: a case study of sand sheets in southeast Melbourne

Karen Kapteinis[1,2] and Caroline Spry[1, 3]

Abstract

Understanding processes of site formation and disturbance is vital for establishing the archaeological context of Aboriginal places. Post-depositional processes that can impact the integrity of archaeological sites include both anthropogenic and natural factors. The study of particle size distribution of clay, silt and sand, and of the behavioural relationships between stone artefacts throughout a soil profile, provide a means for investigating the stratigraphic integrity of artefact-bearing soils. Particle-size and refit analyses were applied to two soil profiles in sand sheets during a recent salvage excavation program undertaken at an Aboriginal place in Clyde East, southeast Melbourne, to shed light on taphonomic processes that have affected tangible Aboriginal cultural heritage at this location. The first profile reflects natural pedogenic and aeolian processes, whereas the second displays evidence for recent (post-contact) anthropogenic activities. The results of these analyses, together with the observed stratigraphic profiles identified during excavation, provide valuable stratigraphic context for interpreting the nature of Aboriginal occupation in the study area. The results demonstrate the efficacy of this approach for distinguishing between anthropogenic and natural processes of sediment accumulation and reworking which, in turn, provides a more meaningful context for generating behavioural information from the activity traces that Aboriginal people left behind. In doing so, this broadens our knowledge of the interplay between archaeology and geomorphology in sand-sheet contexts of the greater southeastern Melbourne region.

Introduction

Sand dunes, sand sheets and lunettes in Australia have been the focus of many archaeological studies investigating Aboriginal occupation (e.g. Bowler et al. 1970; Coutts 1972; Fitzsimmons et al. 2014; Jankowski et al. 2020; Richards et al. 2007; Thorne and Macumber 1972; Williams et al. 2014). These landforms have been recognised as having a higher potential to contain Aboriginal archaeological sites compared to other landforms due to their elevated, well-drained nature (e.g. Ross 1981; Smith 1991). However, sand dunes and lunettes are dynamic landforms, subject to factors such as wind direction, an available sediment source, and vegetation coverage (Lancaster 2011). These processes act on both the soil profile of the landforms and the regolith below it; as a result, any cultural material deposited on the surface of these landforms will become subject to a particular set of dynamic natural disturbance processes, which are inherent to aeolian environments (Johnson et al. 2008; Schiffer and Rathje 1973).

Because of the particular set of geomorphological processes that affect these aeolian landforms, and by extension the artefacts within them, problems in discerning the stratigraphic context of Aboriginal cultural heritage can occur (Hiscock 1990; Johnson et al. 2008; Peacock and Fant 2002; Stern et al. 2013). It is generally accepted that once an artefact is dropped, it is subject to translocation processes, and to claim an artefact was found in situ requires extensive supporting evidence (e.g. Balek 2002; Fanning and Holdaway 2001; Hewitt and Allen 2010; Hiscock 1990; Stein 1983; Stern et al. 2013). Despite this assumption that no artefact is in situ, it is rare for consultant archaeological investigations in Victoria to assess in detail exactly how post-depositional disturbance has affected an archaeological deposit.

In the Melbourne region, previous archaeological assessments in sandy contexts that include a geomorphological component (Allen et al. 2008; Czastka and Canning 2015; Ellender and Leubbers 2009; Hewitt and de Lange 2007; Light 2010) have focused largely on stratigraphic profiles and geological chronologies, which can prevent a more detailed understanding of site-specific geomorphological processes. Detailed investigations of artefacts struck from the same core or tool are likewise rare. Despite one notable example at Bend Road (Allen et al. 2008; Hewitt and Allen 2010; Hewitt and de Lange 2007), which also involved stone artefact refitting, most investigations make use of geomorphological assessments based on 'naked eye'

[1] Ochre Imprints Pty Ltd, , 33 Johnston Street, Abbotsford, Vic. 3067

[2] Department of Environment, Ecology and Evolution, La Trobe University, Bundoora Vic. 3086

[3] Department of Archaeology and History, La Trobe University, Bundoora Vic. 3086

assessments such as using stratigraphic and regional environmental information to draw conclusions about the taphonomic and geomorphological history of the archaeological context. Such assessments are valuable for interpreting archaeological sites; they provide an additional layer of complexity to what would otherwise be a one-dimensional assessment of stone artefact presence/absence, raw material sourcing and utilisation, and stone artefact use and discard. However, by investigating the role of natural and anthropogenic processes in the formation and modification of a sand sheet, the causes of artefact spatial distribution as well as whether the assemblages reflect Aboriginal occupation or post-depositional events can be better understood.

This paper provides a method for compiling an environmental, post-depositional and archaeological history at a finer resolution; applying particle-size and refitting analyses to two sand-dominated soil profiles in Clyde East, located in the urban growth area to the southeast of Melbourne. Further, a more detailed understanding of what post-depositional processes have affected the stratigraphic profile brings the archaeological signature into focus. This paper presents a particle-size analysis of the different stratigraphic profiles encountered during a recent salvage excavation program; assesses the level of disturbance present within the soil horizons within two excavation pits; investigates the behavioural relationship between artefacts identified in each pit; and adds to our understanding of the interrelationship of the geomorphology and archaeology of the larger southeastern Melbourne region.

Project background

An archaeological salvage program was undertaken to comply with the requirements of previously prepared Cultural Heritage Management Plan (CHMP) 11740 (Dowdell et al. 2018). Commissioned by Balcon Group Pty Ltd, the CHMP was prepared in advance of ground-disturbing activity associated with a proposed residential subdivision (c.131 ha), located across four properties and an adjoining road reserve in Clyde East, 60 km to the southeast of Melbourne CBD (**Figure 1**).

The CHMP assessment identified one Aboriginal place within the activity area: a low-density and widely distributed occurrence of surface and subsurface stone artefacts (LDAD VAHR 7921-1715, n=27). A range of conditions and contingencies formed part of the CHMP, including the requirement for a geomorphologist to undertake a particle-size analysis of the different stratigraphic profiles within salvage excavation pits to assess the level of disturbance of soil horizons.

CHMP 11740 required the excavation of four 3 x 3 m salvage excavation pits (SEPs) on four of the five rises identified during the field survey, all of which contained subsurface stone artefacts (Dowdell et al. 2018:viii–x).

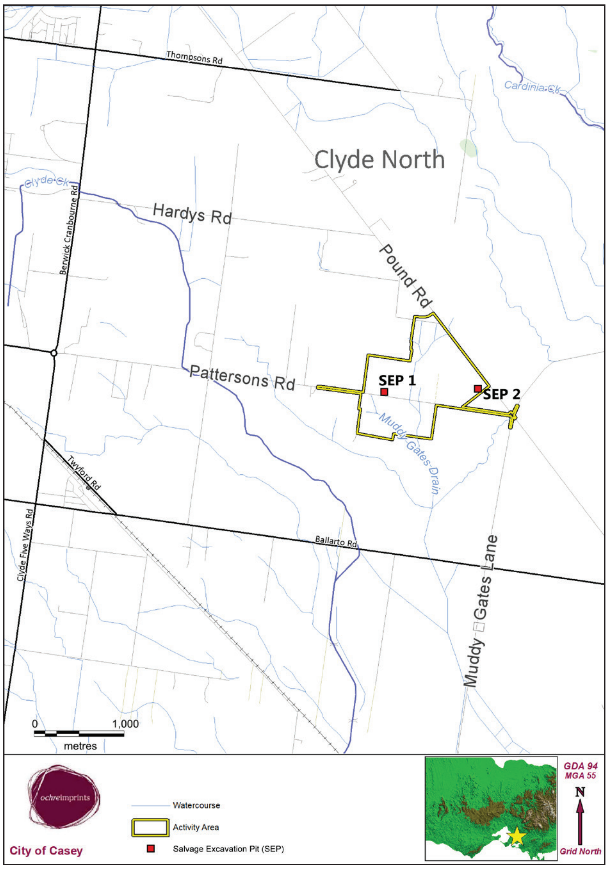

Figure 1. Location of study area and SEPs

The four SEPs were excavated manually in 1 x 1 m grids, with excavation proceeding in spits of 50 mm until an underlying basal layer predating human occupation was reached. All excavated sediments were sieved through 5 mm mesh. All stone artefacts were collected for analysis.

A total of 36 flaked stone artefacts were recovered during the salvage excavation program. These were registered as: a low-density occurrence of 10 subsurface artefacts (LDAD VAHR 7921-1767) and a higher density artefact scatter comprising 26 subsurface artefacts (VAHR 7921-1766). This study focuses on the results of the excavations of Salvage Excavation Pit 1 (SEP 1) and Salvage Excavation Pit 2 (SEP 2). These two SEPs were selected for detailed study as they provided two distinctly different profiles with the potential to provide a deeper understanding of the taphonomic processes acting within the study area. The two SEPs were located approximately 900 m apart on low rises (**Figure 1**).

Regional setting

Physical Environment

Geomorphologically, the study area is located within the Central Sunklands geomorphological subdivision, which comprises a range of landscapes from flat to undulating, on unconsolidated sediments formed over the last 4 million years (VRO 2019). The study area is characterised by a very gently undulating plain on the western edges of the Koo Wee Rup Plain (Spencer-Jones et al. 1975:45). The topography changes little, varying from 20 m above sea level in the north-west to 15 m above sea level in the southeast. The undulating land slopes very gradually to the southeast toward the central parts of the Koo Wee Rup Swamp.

The formation of the landscape in the region was largely driven by climatic changes over the Late Pleistocene and Holocene (120–0.1 ka). The landscape seen at present has formed on a surface of Red Bluff Sandstone, which was deposited in marginal marine conditions during the Neogene (5.8–4.6 Ma) (VandenBerg 2017:12, 17–19). This geological unit dominates the study area, and is comprised of poorly consolidated ferruginous sands, clay and quartz pebble beds (Bell et al. 1967; VandenBerg 2017:9–12). Given its age, this unit has undergone in situ weathering, resulting in the formation of a sand-rich clay regolith (Spencer-Jones et al. 1975:55–60). Developed on this regolith, the soil profile is characterised by acidic mottled yellow duplex soils with a silty A1 horizon overlying a bleached A2 horizon of sandy silt and silty sand. The B horizon comprises mottled yellow and grey, and yellowish-brown clays (Northcote et al. 1975:135–136).

Climatic cycles in the Late Pleistocene and Holocene were dominated by glacial and interglacial periods. Aridification increased from 50 ka onward, culminating in the Last Glacial Maximum (LGM), which lasted until ~18 ka (White and Mitchell 2003:570). During this period, vegetation cover decreased in response to colder and drier conditions, the effects of which destabilised unconsolidated sediments of the upper part of the Red Bluff Sandstone and other older material in the Port Philip Bay and Western Port Basins (Jenkin 1981:39–40). It is suggested that this destabilised material, in particular the sand component, was reworked and mobilised in large volumes to form the siliceous dunes and sand sheets of the Mornington Peninsula (Jenkin 1981:39–40; Keble 1968:50).

Parts of the study area are covered by a mapped deposit of Pleistocene-Holocene age alluvium (Welch et al. 2011). Variably comprised of gravel, sand, silt and clay, this unit typically derives from the local geology, having been transported by water from the surrounding land (Welch et al. 2011). Given these sediments typically originate from the erosion of the surrounding geological units, the soil profiles that developed closely resemble those of the Red Bluff Sandstone, although due to their younger age, they are less developed. However, due to the topographic highs presented across this area, it is likely that this unit may have a veneer of transported sand sheet overlying the deposit. Such soil profiles will typically be comprised of acidic yellow duplex soils with a dark greyish brown sandy silt A1 horizon grading to a slightly bleached A2 horizon, which in turn overlies a strong yellowish-brown B horizon (Northcote et al. 1975:137–138). Where a sand sheet overlies the Red Bluff Sandstone, the soil profile is expected to comprise sandy podosols, which are characterised by a dark grey brown silty sand/sandy silt A1 horizon overlying a bleached sand A2 horizon. Depending on local conditions, a Bhs horizon can form at the interface of the A2 and B horizons, comprising an organic and sesquioxide-rich indurated sand layer or mineral pan, colloquially known as 'coffee rock'. Depending on the depth of the sand sheet, additional sand layers may occur below the Bhs layer, or a clay B horizon may be present (Murphy et al. 2000:135).

Following the end of the LGM around 18–16 ka, an amelioration of environmental conditions occurred (Clark et al. 2009:710). In response to warming temperatures and increases in precipitation, vegetation cover increased, resulting in the stabilisation of sand dunes in the region (Kershaw 1995:655–656). Precipitation and temperatures continued to increase and warm into the Holocene, culminating in the Holocene Climatic Optimum of 9–6 ka (Dodson and Mooney 2002:456; Kershaw 1995:655–656, 667–669; White and Mitchell 2003:570). The wetter conditions promoted the increase of regional water tables, and thus the growth of the local and regional swamps in the low points of the landscape, the largest of which being Koo Wee Rup Swamp to the east and Carrum Swamp to the west.

Gradual aridification occurred at approximately 4 ka onward as the Holocene Climatic Optimum ended in southeastern Australia (Kershaw 1995:669). The decreasing precipitation and lowering of regional water tables resulted in the destabilisation of the landscape in the form of higher erosion rates and the re-mobilisation of dunefields (Dodson and Mooney 2002:457; Kershaw 1995:669). These trends continued into the post-contact period when European agricultural methods were introduced to the Australian landscape (Dodson and Mooney 2002:458). Land clearance, ploughing and urbanisation dramatically altered geomorphic landscapes, which saw order of magnitude changes to erosion and sedimentation rates (Dodson and Mooney 2002:458). In the local region surrounding the study area, widespread stream-channel modification occurred as local farmers tried to control flooding and improve land by draining the low points of the landscape. These land reclamation works began in the 1870s with reclamation of Koo Wee Rup Swamp to the east, and continued locally, as seen by the straight alignment of the man-made Muddy Gates Drain, which bisects the southwestern part of the study area (**Figure 1**).

Previous particle size analysis by Orr (2006) supports the environmental reconstructions undertaken at a broader level. The information provided in the Bend Road investigations showed that sand deposits had been subject to repeated reworking during the Late Pleistocene (Allen et al. 2008; Hewitt and Allen 2010; Hewitt and de Lange 2007), with a period of general landscape stability shown by the slow accumulation of sand and finer particles interrupted by substantial redeposition and reworking of sand during the drier periods at the LGM (Orr 2006).

Archaeology and ethnohistory

Aboriginal people have occupied the region for at least 35,000 years (Allen et al. 2008; Hewitt and Allen 2010; Hewitt and de Lange 2007). Previous archaeological studies suggest that most Aboriginal places that have been documented in the area comprise stone artefacts in surface and subsurface contexts, with occupation typically occurring on either elevated landforms such as sandy rises or within close proximity to perennial watercourses such as Cardinia Creek to the east. Where archaeological deposits have been dated, these generally show cultural material lain down throughout the Holocene, with a mid-Holocene peak (Czastka and Canning 2015; Filihia et al. 2016:11; Murphy and Rymer 2011).

In more recent times, the first Europeans to explore inland and traverse Carrum Swamp were a small group led by William Hovell in 1827, who was met by members of the *Bun wurrung* near Eumemmering Creek. Hovell noted that some of the men and boys present had a front tooth missing, indicating that tooth evulsion was practiced, however, it appears that this practise did not continue long after European contact. An early European settler in the area, Gordon McCrae, recorded that it was common for *Bun wurrung* people in the region to wear 'opossum skin rugs', which were worn with the skin on the inner surface, scored in various patterns and rubbed with red ochre. McCrae also noted that *Bun wurrung* people generally wore forehead bands of netted fibre, often coloured with red ochre, in which they stuck ornamental feathers (Gunson 1968:3–4).

Intertribal relationships with neighbouring groups varied, with the *Bun wurrung* enjoying good relations with the *Woi wurrung*, with whom they shared a similar vocabulary and culture (Broome 2005:xxi; Clark 1990:363). William Thomas, Assistant Protector, witnessed large traditional gatherings between the *Bun wurrung* and the *Woi wurrung* groups where intertribal matters were settled peaceably. Thomas also observed clans living a hunter-gather lifestyle, moving within their lands to make use of seasonal plant and animal resources, trading opportunities and to meet ritual and kinship obligations (Gaughwin and Sullivan 1984; Thomas in Gaughwin 1983:74). Early accounts indicate that the areas along Kananook, Mordialloc and Dandenong Creeks were popular camping places due to the supply of fresh water (Hibbins 1984:12; McGuire 1991:1).

Methods

Particle-size analysis

The particle-size analysis method is used to understand the relative distribution of varying sizes of particles in a sample and is commonly utilised for soil textural analysis (Eshel et al. 2004; Gee and Or 2002). Particle-size analysis, on its own, characterises the size of individual particles in a single particulate sample (Bernhardt 2012). There are multiple methods of particle-size analysis, including pipette methods, nested sieves of differing mesh diameters, hydrometers, and laser diffraction (Eshel et al. 2004). Each method has inherent strengths and weaknesses; this study used laser diffraction, primarily for ease of access and familiarity of the method by the authors. Laser diffraction is commonly used for its ability to provide fast results while only requiring small sample sizes, although there are some disadvantages with costs of the instrumentation (Eshel et al. 2004). Further to this, some misrepresentation of clay and silt fractions can occur in the event the sample is improperly pre-treated to account for aggregation of silt and clays (Eshel et al. 2004; Gee and Or 2002). Despite this, the reliability of accurately determining the various size fractions is increasing (Fisher et al. 2017). As a result, the ability of the instrument to quickly analyse a soil sample and populate a frequency distribution curve that is easily comparable to other samples is of benefit when assessing different soil profiles. When measured in bulk, numerous particle-size distributions can be characterised for a sample and presented as frequency-distribution curves and compared to other comparable samples, with the peak of the curve showing the modal size (Boggs 1987). In plotting the data in this way, the distribution of size particles throughout the sample and the stratigraphic profile can reflect the processes which acted on that material in the past (Lewis 1984:68).

Environmental processes are a significant controlling factor of particle-size distributions. By assessing the particle size distribution of a soil profile, an environmental history can be determined (Folk and Ward 1957; Lewis 1984; Plomaritis et al. 2013). Sedimentary processes such as sorting, deflating/winnowing, and deposition which act on individual particles will, in general, be determined by the size of that particle. Smaller and thus lighter particles have a greater chance of being transported further and more quickly than a larger, heavier particle (Folk 1968; McLaren and Bowles 1985). On this basis, it is known that sediment packages undergoing transport would be better sorted and finer grained than the sediment package left behind, which would be coarser grained and well sorted, with the latter becoming increasingly so with time (Folk 1968; Lewis 1984; McLaren and Bowles 1985). Therefore, by understanding the particle-size distribution of a stratigraphic profile, a conclusion can be made on what processes have acted on that deposit in the past (Folk 1968; Folk and Ward 1957). By extension, in knowing the conditions which would likely have formed a particular profile, it can be possible to identify if and how a profile has been disturbed.

In interpreting the environmental conditions from a particle distribution curve, the skewness and kurtosis (location of the peak along the graph, and how concentrated it is) of that particular sample is key; but note that a series of samples and their particle-size distribution curves for at least one stratigraphic profile is required to make any meaningful conclusions (Folk 1968). Typically, sand dunes which have had particles deposited by saltation (bounding and landing of particles across the surface) and creep (rolling and sliding of particles along the surface) display a bimodal distribution of two peaks along the curve which is negatively skewed (higher proportion of sand particles) (**Figure 2**) (Boggs 1987; Folk 1968; Friedman 1961; Lewis 1984). However, if the dune has been deflated and the finer particles removed leaving a well-sorted lag deposit, the frequency curve will show a unimodal, negatively skewed and often leptokurtic (high concentration of data across a small range) distribution (**Figure 2**) (Barndorff-Nielsen and Christianson 1988; Folk 1968; Friedman 1961; Lewis 1984). Any deviations from these typical frequency curve shapes can therefore indicate the presence of other depositional mechanisms occurring on the deposit.

In this study, soil samples were collected in the field at 100 mm intervals from the soil profile at SEP 1 and SEP 2. In the lab, the soil samples were passed through a 2 mm gauge sieve in order to remove particles larger than coarse sand. The samples were pre-treated by combining 50 g of soil with 50 ml of distilled water and 10 ml of 10% sodium hexametaphosphate (dispersant) and stirred to create a slurry of soil and liquid. The samples were analysed using a Malvern Mastersizer 2000 with pump and stirrer settings on 100%. A sample of the slurry mixture was added to the stirrer well of the instrument and mixed for approximately 30 seconds before being passed into the laser refractive unit for particle-size analysis.

The results of the analysis of each sample were processed into differential volume for each size fraction, which is defined using the Blott and Pye (2012) grain-

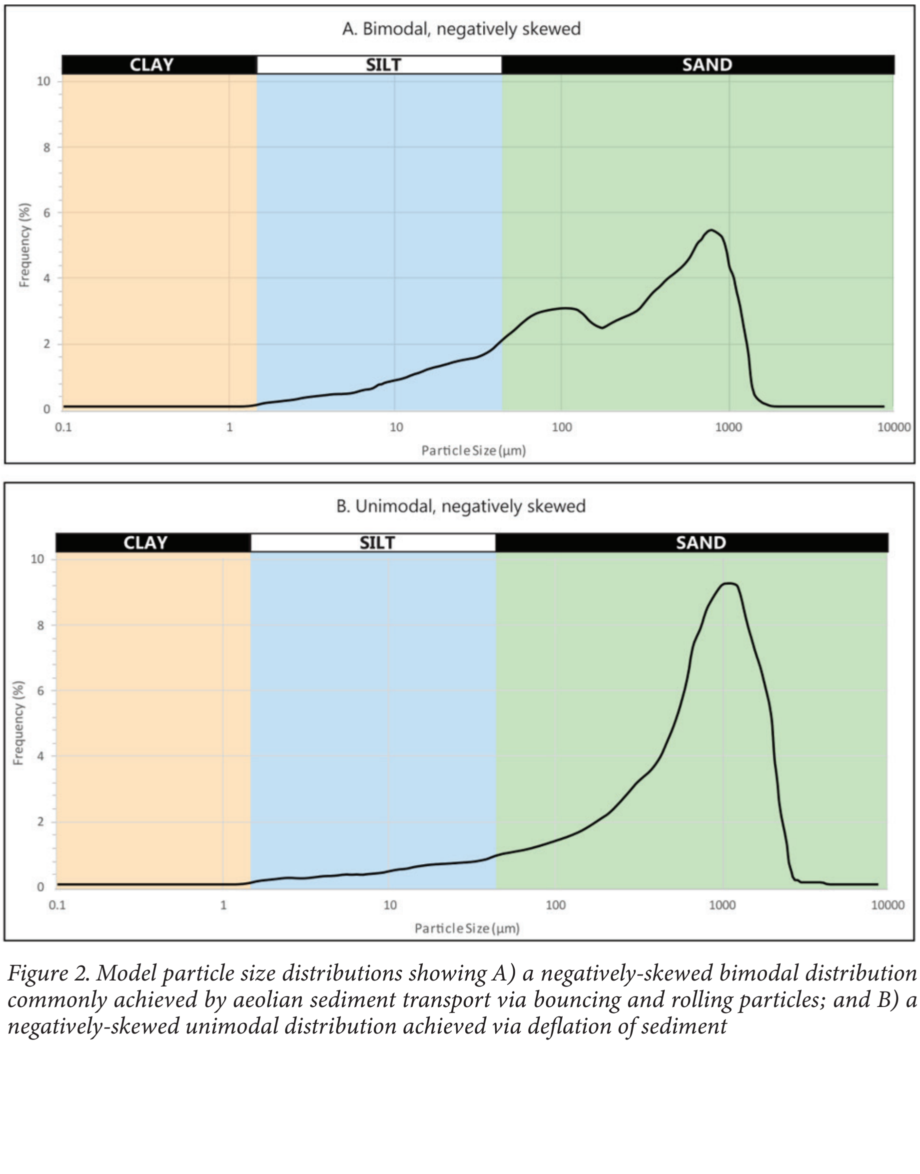

Figure 2. Model particle size distributions showing A) a negatively-skewed bimodal distribution commonly achieved by aeolian sediment transport via bouncing and rolling particles; and B) a negatively-skewed unimodal distribution achieved via deflation of sediment

size classification (clay: 0.01–2 μm; silt: 2–63 μm; sand 63 μm–2 mm) and then graphed logarithmically using Microsoft Excel according to particle-size. Results were grouped on two graphs according to which SEP the samples were derived from to show trends in the particle-size analysis.

Refit analysis and identification of knapping groups

Similar to particle-size analysis, investigation into the presence of artefacts with similar macroscopic and microscopic characteristics ('knapping groups') such as colour and texture, and artefacts that physically refit together ('refits'), in stone artefact assemblages can provide insights into site formation and disturbance (Cahen and Moeyersons 1977; Cahen et al. 1979; Foley et al. 2017; Petraglia 1992; Van Noten et al. 1980; Villa 1982). This analytical technique generates information about the physical and behavioural relationship between individual stone artefacts that were struck from the same piece of rock. In particular, it considers whether stone artefacts making up an assemblage have resulted from one or more stone-working and/or discard 'events'. The presence of knapping groups and refits indicates a common origin for a group of artefacts from the same core or tool. This analytical technique is commonly termed Minimum Analytical Nodule Analysis (Larson and Ingbar 1992; Larson and Kornfeld 1997), or the analysis of raw material units (Conard and Adler 1997; Roebrooks 1988; Roebroeks et al. 1997)—although earlier applications exist (Frison 1974; Kelly 1985).

An assemblage comprising artefacts from a single knapping group, and refits, suggests the working of at least one piece of rock at the same location, most likely during the same stone-knapping 'event'. Conversely, the absence of knapping groups in an assemblage suggests that no two artefacts derive from the same core or tool, and that the assemblage resulted from multiple episodes of stone working and/or discard. However, a scarcity of knapping groups and refits can also be the product of other intersecting processes over long periods of time, including Aboriginal people removing or scavenging stone artefacts from different locations in the landscape, post-depositional processes removing artefacts and reworking assemblages, and post-contact site disturbance. When combined with particle-size analysis, knapping-group and refit analysis is a powerful tool for investigating the nature and likely intactness of a stone artefact assemblage.

Here the investigation of knapping groups and refits followed the techniques outlined in Foley et al. (2017). The first step involves grouping artefacts with similar macroscopic features, including colour, texture, inclusions and cortex. Each knapping group is then assessed for the presence of refits. The process of identifying refits involves the systematic inspection of each artefact of similar colour and texture with all the other artefacts belonging to the same group. An attempt is made to refit each surface of every artefact with each surface of every other artefact from the same group. Where refits are identified, these are joined together using Blu Tack and photographed.

Results

The particle-size distributions, and stone artefact assemblages, for SEP 1 and SEP 2 show different patterns. These patterns are described below.

SEP 2

Particle-size analysis

The particle-size distribution of SEP 2 shows little variation throughout the soil profile, with minor differences likely representing changes in natural formation processes over time. Sand is the dominant size fraction in the soil profile of SEP 1 from 0 to 1600 mm (**Figure 3**; **Table 1**). The distribution of the sand fraction appears to follow two modes; trimodal distribution in the upper 100–900 mm, and unimodal distribution at 0–100m and from 900–1600 mm (**Figure 3**). The trimodal distribution observed between 100–900 mm comprises relatively equal peaks within the fine sand range (~63–140 μm), at the boundary between fine sand and medium sand (~180–320 μm), and in the coarse-sand range (500 μm–2 mm) with all samples negatively skewed. The percentage of sand in this part of the soil profile ranges from 77 to 84% and increases with depth. The distribution of the lower 900 mm and the top 100 mm follows a unimodal, negatively skewed distribution in comparison, with some difference in where each of the peaks fall. The upper 100 mm of the soil profile is dominated by fine sand (67% sand, 33% silt), while the lower 900 mm all have single peaks in the coarse-sand fraction. The percentage of 900–1600 mm sand ranges from 81 to 93%, with an increase down profile. Throughout the profile, the silt component steadily decreases, ranging in percentage from 32% (0–100 mm) down to 4% (1400–1500 mm). At a depth of 1600 mm, sand is removed from the profile and clay increases to 82%, and silt increases to 18%.

Comparison of stratigraphic evidence vs particle-size analysis data

SEP 2 does not contain obvious evidence for disturbance from anthropogenic processes such as earthmoving. Instead, the soil profile is more characteristic of natural processes, both pedogenic and aeolian in nature. The particle-size analysis illustrates two broadly different stratigraphic units; the upper part of the profile between 0–900 mm is much less well-sorted when compared to the lower 900–1600 mm, which is dominated by medium- and coarse-grained sand (**Figure 3)**. This difference indicates two potential periods of sedimentary deposition.

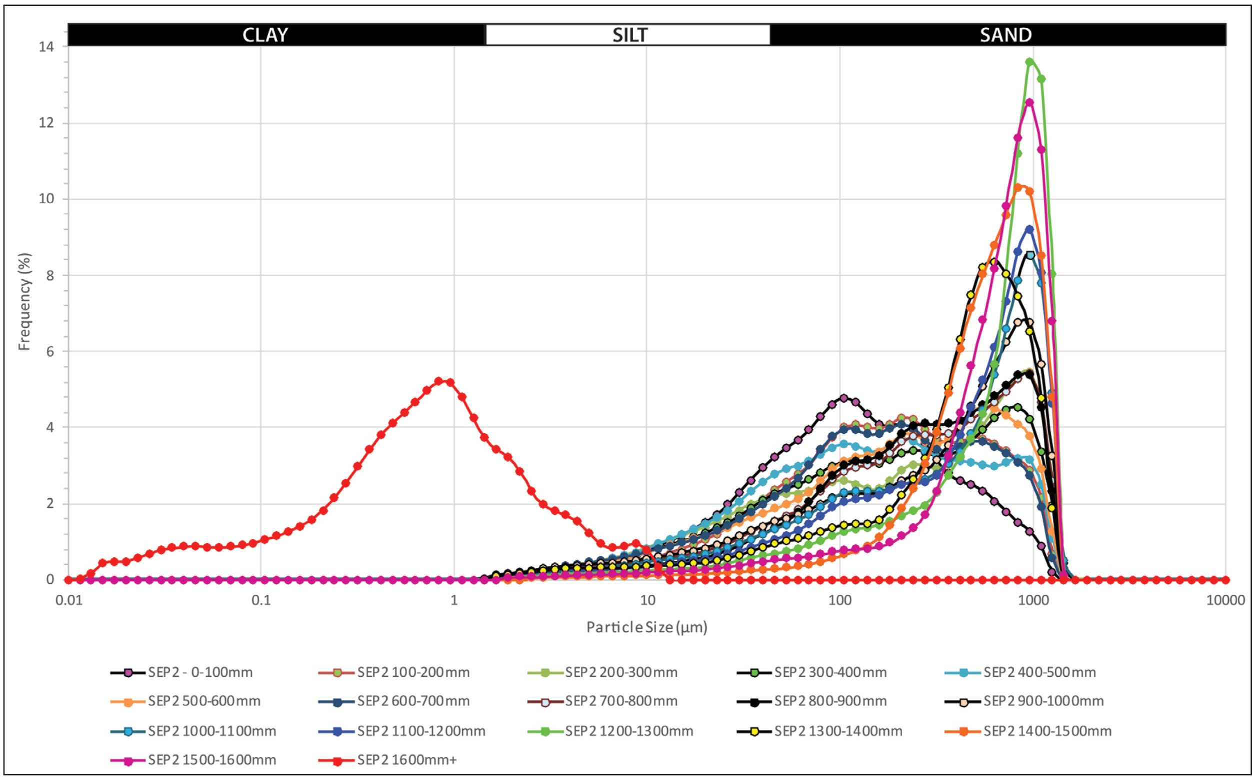

Figure 3. Particle size distribution for each 100 mm spit of SEP 2

	0–100 mm	100–200 mm	200–300 mm	300–400 mm	400–500 mm	500–600 mm	600–700 mm	700–800 mm	800–900 mm	900–1000 mm	1000–1100 mm	1100–1200 mm	1200–1300 mm	1300–1400 mm	1400–1500 mm	1500–1600 mm	1600+ mm
% clay	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	82
% silt	33	23	27	25	30	23	26	18	15	19	16	13	8	12	4	7	18
% sand	67	77	73	75	70	77	74	82	84	81	84	87	92	88	96	93	0

Table 1. SEP 2 percentage of sand, silt, and clay per spit

The upper 900 mm is characteristic of soil formation processes. Stratigraphically, the soil profile is dominated by silty sand, with fluctuating proportions of silt as the minor size fraction (**Figures 3** and **4**). Compared to the lower part of the profile (>900 mm), there is less evidence for deflation having winnowed out the fine sand and silt particles from the profile. It is likely that these sediments were deposited fairly rapidly by aeolian processes and stabilised shortly after, preventing finer particles from being removed. This also suggests that the deposit was derived locally, as deposits which travel long distances are generally well-sorted (Folk 1951; Lewis 1984). Combined with the presence of indurated sand formation in the lower part of the upper 900 mm of the soil profile, there is little evidence that this part of the soil profile has been subject to other processes besides pedogenic processes following deposition.

The lower 900–1600 mm indicates that aeolian processes, in particular deflation, have reworked the deposit. Over time, as low to moderate wind speeds transported the sand deposit via saltation and some suspension, the sand sheet was reworked, and the wind removed the finer grained particles, leaving a coarser grained lag deposit. This is typical of a sand sheet feature, which has been formed by reworking of older dune deposits. Due to the low proportions of fine-grained sand and silt, and the absence of clay, it is likely that the sediment had been transported slowly across the landscape, gradually losing the fine-grained component of the sediment before being deposited

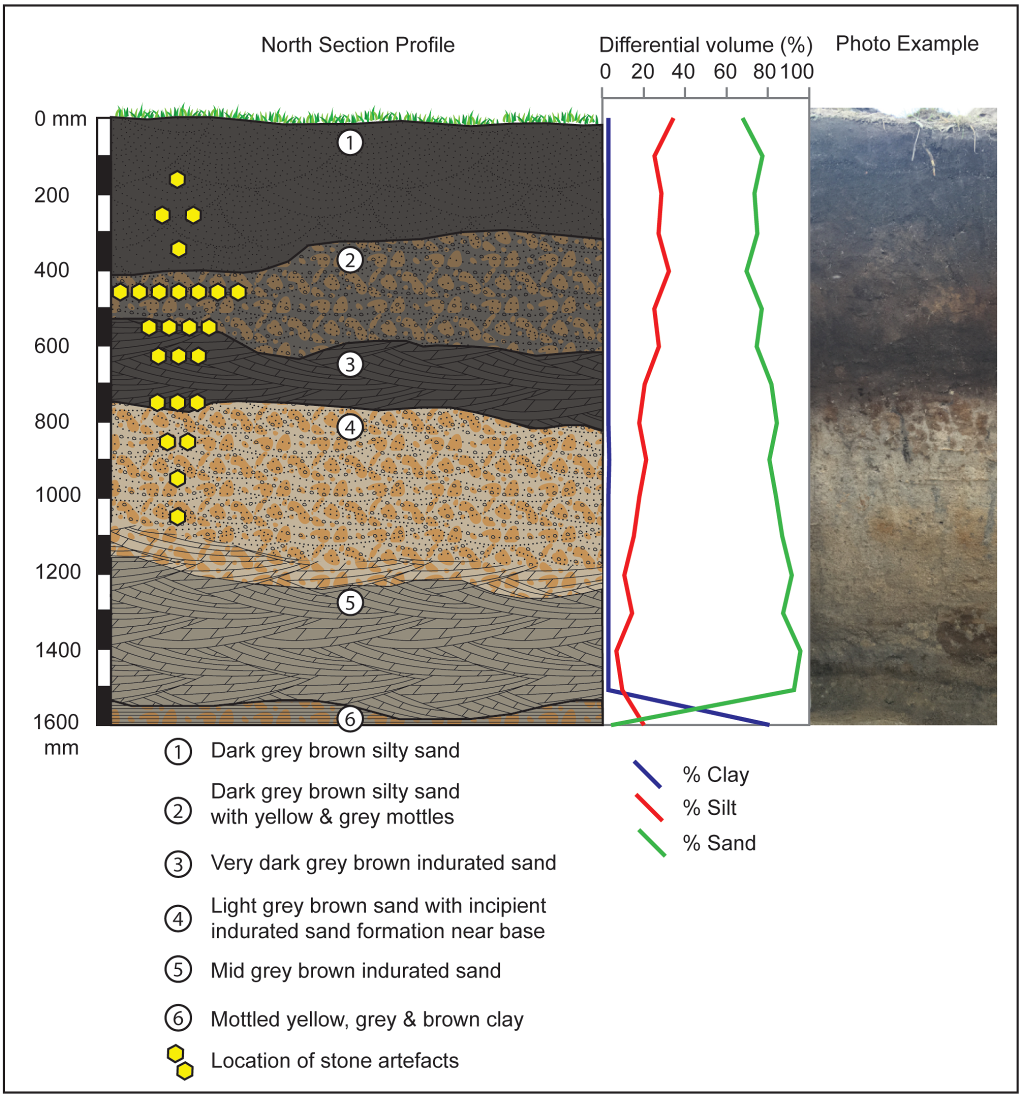

Figure 4. SEP 2 stratigraphic soil profile and particle-size distribution with indicative location of stone artefacts

within the activity area as a reworked sand sheet or lag deposit dominated by coarser material. This is further supported by the absence of bedding planes within the soil profile (although these may have been removed as a result of bioturbation).

The soil profile has also been subject to two periods of indurated sand (coffee rock) formation. This particular soil horizon is typical of sandy podosols, and forms over time at the interface between the water table and the downward movement of rainwater carrying dissolved organics (Conacher and Stanley 2000:331). Indurated sand is present at depths between 510 and 780 mm (indurated sand 1) and between 1090 and 1590 mm (indurated sand 2) (**Figure 4**). The upper unit (indurated sand 1) is characterised by a higher proportion of organics when compared to the lower unit (indurated sand 2). This is potentially due to the formation of indurated sand 1 prior to development of indurated sand 2, whereby the upper unit blocked downward transportation of organic material to the lower unit. The horizontal positioning of these units indicates that indurated sand 1 was formed during a period when water tables were higher, while indurated sand 2 was likely formed during a more recent period of lower water tables. The intact nature of these units further supports the absence of anthropogenic disturbance to the soil profile.

There is some evidence for bioturbation having reworked parts of the deposit, present as worm and root traces throughout the soil profile. Although numerous, these traces are generally discrete in area, and are therefore not detectible in the particle-size data. However, the movement of worms and roots throughout the profile are likely to have resulted in some form of mixing of sediment.

Aboriginal cultural heritage

A total of 26 stone artefacts were excavated from SEP 2 in subsurface contexts and from different squares, at discontinuous depths between 150 and 1100 mm below the ground surface (**Figures 4–5**). The largest part of the assemblage was identified at depths between 450 and 500 mm (n=7) (**Figure 4**). Most of the artefacts are silcrete (n=11) and quartz (n=9), followed by chalcedony (n=3), quartzite (n=2), and crystal quartz (n=1).

A single 'knapping group' was identified, comprising two artefacts made on a distinct light-brown silcrete of relatively homogeneous texture (**Figure 6**). The two artefacts comprise one complete flake (650–700 mm depth) and one distal flake used as a unidirectional core (750–800 mm depth). These artefacts were identified in different grid squares, approximately 2 m apart. While they do not refit, their identical colour and texture, and close proximity to one another, suggest that they derive from the same core, and that the other artefacts from the same core were taken away, and/or remain in unexcavated parts of the study area. The larger size of the overall assemblage from this pit (cf. SEP1, described below), its extended vertical distribution, and the presence of a knapping group and artefacts made on different rocks and minerals, suggests that Aboriginal people visited this location on more than one occasion, potentially over long periods of time, and that the assemblage remains reasonably intact.

The results of the particle-size analysis, and the features of the stratigraphic profile, lend support to this interpretation. The sediments enveloping the assemblage reflect natural, rather than anthropogenic, processes, including soil formation and sand sheet

Figure 6. The single knapping group identified in SEP 2, comprising two silcrete artefacts. The artefact on the left is a complete flake, and the artefact on the right is a distal flake that was used as a unidirectional core

Figure 5. Stone artefacts identified during the salvage excavation at VAHR 7921-1715. The three artefacts in the bottom row were recovered from SEP 1, and the 26 artefacts in the upper three rows were excavated from SEP 2

working. The assemblage from this pit therefore generates more meaningful information about the stone tool technologies that Aboriginal people used at this location, and the environmental conditions that prevailed as the assemblage accumulated over time. In this instance, the bulk of the assemblage accrued when conditions were relatively stable and humid, creating more favourable conditions for occupation. In contrast, few artefacts were made and/or left behind when sand sheet reworking was underway, and conditions were likely more adverse.

SEP 1

Particle-size analysis

This data for SEP 1 show distribution curves that differ significantly from each other, indicating a wide range of different particle-size distributions throughout the soil profile which had likely been affected by significant depositional processes over time. The particle-size distribution of SEP 1 shows a wide range of sizes within the profile, as shown by the multiple peaks in **Figure 7.** The dominant size fractions change multiple times throughout the soil profile, with silt dominating in the upper 200 mm, increasing from 66 to 96%, whereupon sand becomes the dominant size fraction from 200 to 500 mm, ranging from 71% at 200–300 mm, 59% at 300–400 mm, and 79% at 400–500 mm depth. Silt becomes dominant again at 500-600 mm (65%), before dropping again at 600–700 mm, where sand becomes dominant (63%). Clay remains very low in the soil profile between 0 mm and 700 mm, whereupon it becomes dominant at the base (700 mm+) (**Figure 7; Table 2**).

Four samples follow a negatively-skewed distribution typical of deflated sand deposits, differing from the remaining three distributions. They are comprised predominantly of sand; these are at 200–300 mm, 300–400 mm, 400–500 mm, and 600–700 mm depth (**Figure 7**). These samples have a slight bimodal distribution, with peaks occurring in medium to coarse silt (~15–60 µm) and at the boundary between fine- and medium-grained sand (~70–420 µm). The remaining samples

	0–100 mm	**100–200 mm**	**200–300 mm**	**300–400 mm**	**400–500 mm**	**500–600 mm**	**600–700 mm**	**700+ mm**
% clay	0	0	0	0	0	1	0	76
% silt	67	96	28	40	20	66	37	24
% sand	33	3	72	59	80	33	63	0

Table 2. SEP 1 percentage of sand, silt, and clay per spit

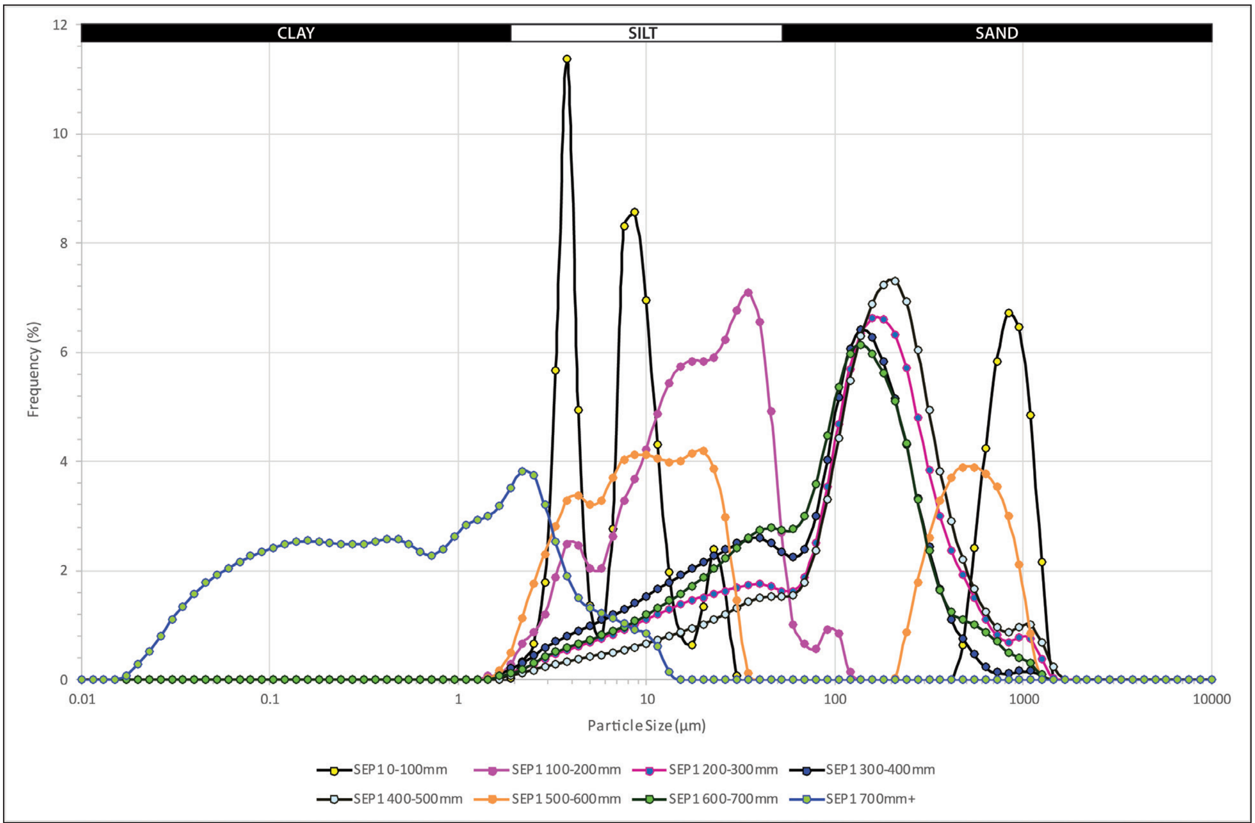

Figure 7. Particle size distribution for each 100 mm spit of SEP 1

have multiple peaks, two of which are skewed positively in the silt size fraction (0–100 mm and 500–600 mm; **Figure** 7).

Comparison of stratigraphic evidence vs particle-size analysis data

Stratigraphically, SEP 1 comprised a mixed soil profile, with inclusions of gravel, clay and indurated sand (coffee rock) nodules (**Figure 8**). Combined with data from the particle-size analysis, which shows a variable, poorly sorted composition of clay, silt and sand, the soil profile has been disturbed, probably from anthropogenic actions such as earthmoving. Only parts of the SEP 1 profile appear to show minimal soil disturbance in the particle-size data; these occur at 200–300 mm, 300–400 mm, 400–500 mm and 600–700 mm depth (**Figure 8**). At these spits, the soil profile comprises silty sand, and appears to represent a normal negatively-skewed distribution of particle-sizes as would be expected in a relatively well-sorted sand-sheet soil profile. However, combined with stratigraphic data, the particle-size distribution does not account for the gravels and clay nodules identified at these depths. This indicates that the whole profile has been disturbed. As a result, it is likely that there has been either:

a) Several periods of disturbance and mixing of the soil profile in SEP 1 mixing multiple sources or types of material; or,

b) One period of disturbance and mixing of the soil profile in SEP 1 with multiple sources of material, each comprising different combinations of particle-sizes.

Given the absence of obvious structures or signs of other forms of ground disturbance surrounding SEP 1, it is not possible to further refine the sources of disturbance. However, given the scale of the disturbance,

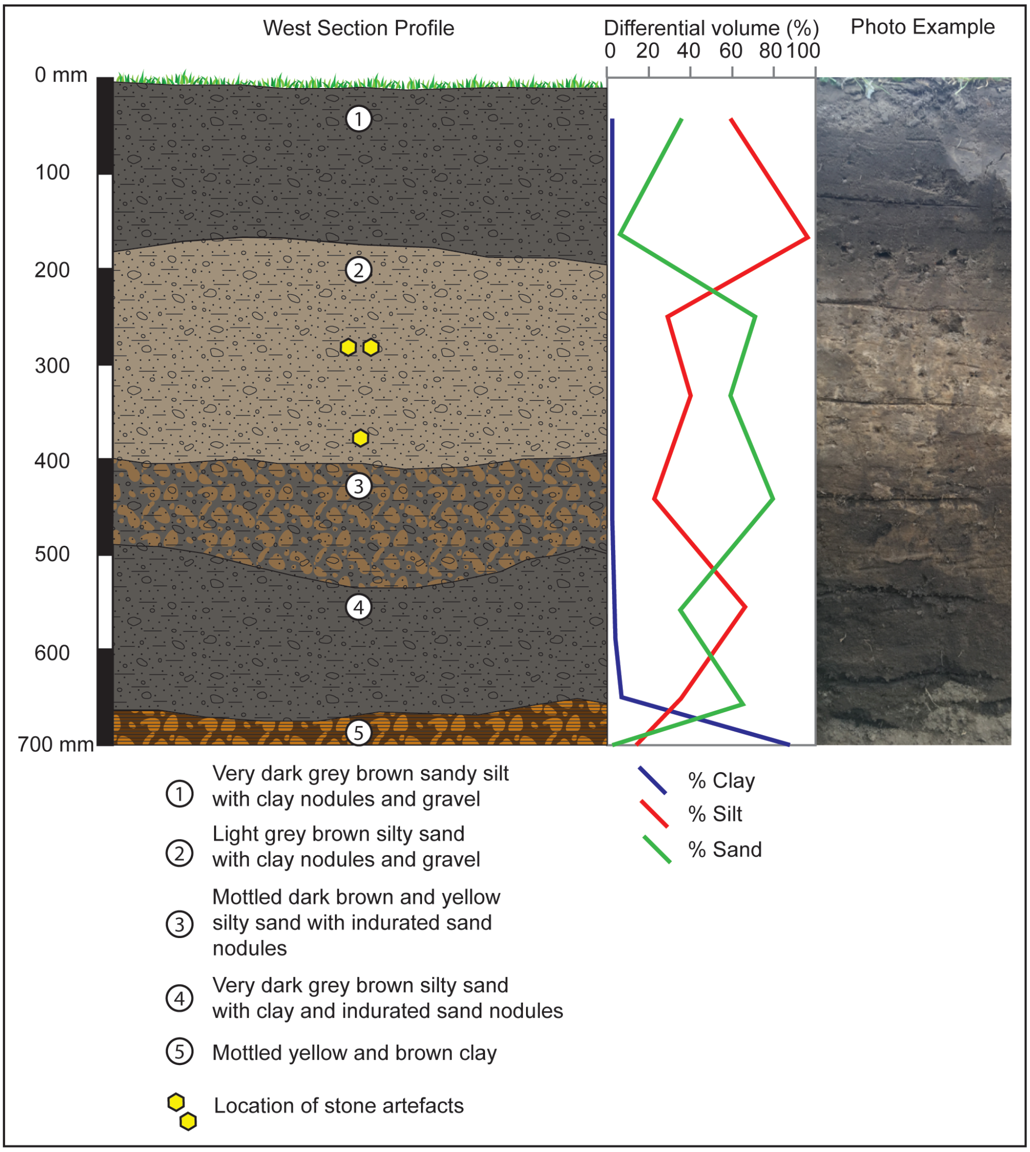

Figure 8. SEP 1 stratigraphic soil profile and particle-size distribution with indicative location of stone artefacts

it is likely that earth-moving machinery was involved.

Aboriginal cultural heritage

Three stone artefacts were recovered from SEP 1 in subsurface contexts and from different squares, at depths between 250–300 mm (n =2) and 350–400 (mm) below the ground surface (**Figures 5 and 8**). These artefacts comprise two complete silcrete flakes and one silcrete blade flake. The visual characteristics of the silcrete artefacts are dissimilar, and the artefacts could not be refitted. This suggests that the assemblage from SEP 1 represents the products of at least three different stone-working and/or discard events. Initially, the small number of artefacts identified in this pit and the absence of knapping groups/refit sets suggest that Aboriginal people did not spend much time, or leave substantial activity traces, at this location. However, when considered against the results of the particle-size analysis, and the stratigraphic profile of this pit, the history of disturbance at this location offers a more likely explanation for the nature and distribution of this assemblage. As a result, it is difficult to draw inferences about the nature of Aboriginal occupation at this location from the assemblage as it does not appear to be intact.

Discussion

The stratigraphic profiles of SEP 1 and SEP 2 show dramatically different particle-size distributions; SEP 1 is dominated by anthropogenic (probably earth-moving) disturbance, while SEP 2 is dominated by natural soil formation processes and sand-sheet reworking. The evidence for Aboriginal occupation in SEP 1 is therefore less intact, and not necessarily representative of what occurred at the location at the time of deposition. SEP 2, however, shows relatively intact evidence for Aboriginal occupation, providing a stronger basis for generating information about past Aboriginal occupation and the environmental conditions that prevailed at the time. There is an absence of archaeological material in the lower portions of the profile in this pit, where conditions are inferred to have been drier and cooler. It appears that Aboriginal occupation at this location coincided with conditions that appear to have been more stable and humid than at present. While no dating was undertaken as part of the salvage, it is possible that the sediments making up the lower part of the stratigraphic sequence accumulated during the Last Glacial Maximum, which was a period of significant aeolian activity in the region. On the other hand, the deposits identified in the upper part of the stratigraphic sequence, which contain Aboriginal cultural heritage, probably accumulated during the Holocene.

Similar inferences using the results of particle-size analyses have been made in the past during the Bend Road investigations (Hewitt and Allen 2010; Orr 2006). Orr's analysis of the Bend Road sand profiles was important in understanding not only the depositional history of the sand profile, but also the taphonomy of the archaeological material found at the site. Following particle-size analysis of two pits excavated during the investigation, Orr (2006) was able to conclude that the two soil profiles had different depositional histories. Bend Road 1 contained a bimodal particle-size distribution typical of aeolian processes with little post-depositional modification of the profile (Orr 2006). In contrast, the Bend Road 2 profile contained a unimodal particle-size distribution at depths of 0–700 mm while deeper deposits were bimodal; this indicated that the upper parts of the profile had been reworked, while deeper sediments had been subject to typical dune-formation processes such as saltation (bouncing particles) and creep (rolling particles) (Orr 2006). It was this understanding of the site formation processes that informed the in-depth analysis of the archaeological material which otherwise would not have been possible.

By comparison, the current study has established that mostly unimodal particle distribution dominates the more natural soil profile of SEP 2, which indicates that reworking was the main formation process. This is in contrast to Orr's (2006) results showing bimodal particle-size distribution at Bend Road 1, and in the deeper deposits of Bend Road 2, which was representative of normal dune-building processes that transported particles by a variety of processes, allowing a wider variation of particle-sizes to be deposited. The difference between the results from both studies highlights that dune and sand-sheet formation processes are dynamic and largely controlled by localised environmental conditions. Furthermore, the localised nature of disturbance identified through particle-size analysis, both in this study and that undertaken by Orr (2006), shows that results from a small number of excavation pits cannot be applied across an entire area; in order to understand landscape-level taphonomic processes, particle-size analysis on multiple soil profiles should be performed.

The results of the analyses broadly conform to the available information on sand-sheet contexts in southeast Melbourne. Given the archaeological signature can be affected to a significant degree by the taphonomic processes acting on that deposit, the environmental history has thus been controlled to a significant degree by aeolian processes in the form of sand-dune and sand-sheet deposition and reworking during drier climatic periods. This is particularly illustrated in SEP 2 where the lower part of the profile contains a particle-size signature characteristic of reworked sand sheets. Furthermore, the upper part of the profile provides evidence of the processes which dominated when climates warmed, and precipitation increased; such conditions occurred in the Early–Middle Holocene. These conditions stabilised sand deposits and prompted pedogenic processes to dominate. During this stage, the archaeological signature in SEP 2 is most abundant; by comparison, many previous assessments show concentrations of archaeological material in the Holocene. Furthermore, the influence of more recent human activity is highlighted at SEP 1, which contains a minimal archaeological signature and an anthropogenically disturbed soil profile. This information has therefore provided insight into the at-times highly localised geomorphic processes which have affected the archaeological material of the study area in southeast Melbourne.

Conclusion

The analysis of two sand-dominated soil profiles at Clyde East illustrates how particle-size analysis, and the investigation of knapping groups and refitting stone artefacts, can assist with understanding the taphonomic processes of an archaeological site. Rather than making assumptions about the disturbance history based on a simplified stratigraphic profile or a geological chronology, this approach has generated information about specific processes, particularly in the context of SEP 2, revealing instances of deflation and reworking of a sand sheet that were not visible at the scale of a stratigraphic profile. Furthermore, by understanding the environmental conditions at the time of creation of the archaeological site, richer interpretations of contemporary environments can be made rather than focusing only on an analysis of stone artefact use and discard. This investigation further provides detail on the geomorphological history of a sand sheet in southeast Melbourne, adding to our understanding of past environments and the effects these had on the movement of archaeological material.

Acknowledgements

We would like to thank the following individuals and organisations for their assistance in this project:

Bunurong Land Council Aboriginal Corporation, Wurundjeri Woi-Wurrung Cultural Heritage Aboriginal Corporation, and Yaluk-Ut Weelam Elders Council Aboriginal Corporation for their input and participation during the conduct of the CHMP and the salvage program. Balcon Group Pty Ltd for Sponsoring the CHMP and salvage program. Petra Schell for reviewing this manuscript and providing valuable feedback, and Jodi Turnbull for her mapping. Krista Whitewood, Jacqueline Anderson, Melathi Saldin, Cassandra Kiely, Thanos Matanis for their assistance during the salvage program. John Webb and the Department of Ecology, Environment and Evolution for their assistance in accessing the particle-size facilities at La Trobe University. Finally, thank you to the organisers of the Victorian Archaeological Colloquium for organising a platform to present this work, and to the two reviewers for providing useful feedback on an earlier version of this paper.

References

Allen, J., G. Hewitt, J. de Lange and A. Long 2008 Report on Bend Road Archaeological Investigations: Bend Road Phases 1 to 3. Unpublished report prepared for Thiess John Holland

Balek, C.L. 2002 Buried artifacts in stable upland sites and the role of bioturbation: a review. *Geoarchaeology* 17(1):41–51

Barndorff-Nielsen O. and C. Christianson 1988 Erosion, deposition and size distributions of sand. *Proceedings of the Royal Society of London. Series A, Mathematical and Physical Sciences* 417(1853):335–352

Bell, G., K.G. Bowen, J.G. Douglas, J.S. Hancock, J.J. Jenkin, P.R. Kenley, J.L. Knight, J.L. Neilson, D. Spencer-Jones, J.A. Talent, D.E. Thomas and R.G. Whiting 1967 *Geology of the Melbourne District, Victoria*. Geological Survey of Victoria Bulletin 59. Melbourne: Mines Department

Bernhardt, I.C. 2012 *Particle Size Analysis: Classification and Sedimentation Methods*. Dordrecht: Springer Science & Business Media

Blott, S.J. and K. Pye 2012 Particle size scales and classification of sediment types based on particle size distributions: review and recommendations. *Sedimentology* 59:2071–2096

Boggs Jr, S. 1987 *Principles of Sedimentology and Stratigraphy*. Melbourne: Merrill Publishing Company

Bowler, J.M., R. Jones, H.R. Allen and A.G. Thorne 1970 Pleistocene human remains from Australia: a living site and human cremation from Lake Mungo. *World Archaeology* 2:39–60

Broome, R. 2005 *Aboriginal Victorians: A History Since 1800*. Crows Nest, NSW: Allen and Unwin

Cahen, D., L.H. Keeley and F.L. Van Noten 1979 Stone tools, toolkits, and human behavior in prehistory. *Current Anthropology* 20:661–683

Cahen, D. and J. Moeyersons 1977 Subsurface movements of stone artefacts and their implications for the prehistory of central Africa. *Nature* 266:812–815

Clark, I. 1990 *Aboriginal Languages and Clans: An Historical Atlas of Western and Central Victoria, 1800-1900*. Monash Publications in Geography 37. Melbourne: Department of Geography and Environmental Science, Monash University

Clark, P., A.S. Dyke, J.D. Shakun, A.E. Carlson, J. Clark, B. Wohlfarth, J.X. Mitrovica, S.W. Hostetler and A.M. McCabe 2009 The Last Glacial Maximum. *Nature*

325:710–714

Conacher, P.A. and R.J. Stanley 2000 Soils and coastal dune management. In P.E.V. Charman and B.W. Murphy (eds), *Soils: Their Properties and Management,* 2nd edition, pp. 328–335. Melbourne, Oxford: Oxford University Press

Conard, N.J. and D.S. Adler 1997 Lithic reduction and hominid behavior in the Middle Paleolithic of the Rhineland. *Journal of Anthropological Research* 53(2):147–175

Coutts, P.J.F. 1972 Interpretation of archaeological material eroded from coastal dune sites. *Journal of the Royal Society of New Zealand,* 2(3):407–412

Czastka, J. and S. Canning 2015 Salvage Excavations for Australand's Proposed Residential Subdivision 865 Cranbourne-Frankston Road, Cranbourne, Victoria. Unpublished report prepared for Australand Holdings Limited

Dodson, J.R. and S.D. Mooney, 2002 An assessment of historic human impact on south-eastern Australian environmental systems, using late Holocene rates of environmental change. *Australian Journal of Botany* 50:455–464

Dowdell, M., C. Montero-Lopez, C. Spry and K. Whitewood 2018 Residential Subdivision: Pattersons, Hardys & Pound Road Properties, Clyde East. CHMP 11740. Unpublished report prepared for Balcon Group

Ellender, I. and R. Leubbers 2009 The Royal Botanic Gardens, Cranbourne, Victoria. Completion of Landscape Development in the Australian Garden Stage Two. CHMP 10038. Unpublished report prepared for The Royal Botanic Gardens, Cranbourne

Eshel, G., G.J. Levy, U. Mingelgrin and M.J. Singer 2004. Critical evaluation of the use of laser diffraction for particle-size distribution analysis. *Soil Science Society of America Journal* 68(3):736–743

Fanning, P. and S. Holdaway 2001 Stone artifact scatters in western NSW, Australia: geomorphic controls on artifact size and distribution. *Geoarchaeology* 16(6):667–686

Fisher, P., C. Aumann, K. Chia, N. O'Halloran and S. Chandra 2017 Adequacy of laser diffraction for soil particle size analysis. *PLOS ONE* 12(5):e0176510

Filihia, M., P. Kucera, R. Minos and K Oataway 2016 Salvage Excavations at VAHR 7921-1151 'Lyndhurst Inland Port 6': Carrum Swamp: Analysis of the Archaeological Assemblage. *Excavations, Surveys and Heritage Management in Victoria.* 5, pp.7–15

Fitzsimmons, K.E., N. Stern and C.V. Murray-Wallace 2014 Depositional history and archaeology of the central Lake Mungo lunette, Willandra Lakes, southeast Australia. *Journal of Archaeological Science* 41:349–364

Foley, E., C. Spry and N. Stern 2017 Establishing the integrity and stratigraphic origin of stone artefact scatters on the surface of the Lake Mungo lunette in south-eastern Australia. *Journal of Archaeological Science: Reports* 13:547–557

Folk, R.L. 1951 Stages of textural maturity. *Journal of Sedimentary Petrology* 21:127–130

Folk, R.L. 1968 *Petrology of Sedimentary Rocks*. Austin, Texas: University of Texas & Hemphills

Folk, R.L. and W.C. Ward 1957 Brazos River Bar: a study in the significance of grain size parameters. *Journal of Sedimentary Petrology* 27(1):3–26

Friedman, G.M. 1961 Distinction between dune, beach, and river sands from their textural characteristics. *Journal of Sedimentary Petrology* 31(4):514–529

Frison, G.C. 1974 *The Casper Site: A Hell Gap Bison Kill on the High Plains*. New York: Academic Press

Gaughwin, D. 1983 Coastal Economies and the Western Port Catchment. Unpublished MA thesis, La Trobe University, Melbourne

Gaughwin, D. and H. Sullivan 1984 Aboriginal boundaries and movements in Western Port, Victoria. *Aboriginal History* 8(1):80–98

Gee, G.W. and D. Or 2002 Particle-size analysis. In R. Horton Jr (ed.), *Methods of Soil Analysis: Part 4 Physical Methods*, pp.255–293. Madison, Wisconsin, USA: Soil Science Society of America

Gunson, N. 1968 *The Good Country; Cranbourne Shire*. Melbourne: F.W. Cheshire Publishing Pty Ltd

Hewitt, G. and J. Allen 2010 Site disturbance and archaeological integrity: the case of Bend Road, an open site in Melbourne spanning pre-LGM Pleistocene to late Holocene periods. *Australian Archaeology* 70:1–16

Hewitt, G. and J. de Lange 2007 Report on Bend Road Archaeological Investigations. Bend Road 2 Phases 1 to 4. Unpublished report prepared for Thiess John Holland

Hibbins, G.M. 1984 *A History of the City of Springvale: Constellation of Communities*. Port Melbourne: City of Springvale in Conjunction with Lothian Publishing Company

Hiscock, P. 1990 How old are the artefacts in Malakunanja II? *Archaeology in Oceania* 25(3):122–124

Jankowski, N.R., N. Stern, T.J. Lachlan and Z. Jacobs 2020 A high-resolution late Quaternary depositional history and chronology for the southern portion of the Lake Mungo lunette, semi-arid Australia. *Quaternary Science Reviews* 233:106224

Jenkin, J.J. 1981 Evolution of the Victorian coastline.

Proceedings of the Royal Society of Victoria, 92(1):37–54

Johnson, D.L., D.N. Johnson, D.W. Benn and E.A. Bettis III 2008 Deciphering complex soil/site formation in sands. *Geomorphology* 101:484–496

Keble, R.A. 1968 *The Mornington Peninsula*. Memoir 17. Memoirs of the Geological Survey of Victoria. Melbourne: Department of Mines

Kelly, R.L. 1985 Hunter-gatherer Mobility and Sedentism: A Great Basin Study. Unpublished PhD thesis, Department of Anthropology, University of Michigan, Ann Arbor

Kershaw, P. 1995 Environmental change in greater Australia. *Antiquity* 69:656–675

Lancaster, N. 2011 Desert dune processes and dynamics. In D.S.G. Thomas (ed.), *Arid Zone Geomorphology: Process, Form and Change in Drylands,* pp.487–515. Chichester: John Wiley & Sons Ltd

Larson, M.L. and E.E. Ingbar 1992 Perspectives on refitting: critique and a complementary approach. In J.L. Hofman and J.G. Enloe (eds), *Piecing Together the Past: Applications of Refitting Studies in Archaeology*. BAR International Series no. 578, pp.151–162. Oxford: Archaeopress

Larson, M.L. and M. Kornfeld 1997 Chipped stone nodules: theory, method and examples. *Lithic Technology* 22:4–18

Lewis, D.W. 1984 *Practical Sedimentology*. New York: Hutchinson Ross Publishing Company

Light, A. 2010 135 Evans Road, Cranbourne West (Residential Subdivision). CHMP 10714. Unpublished report prepared for Peet Cranbourne Syndicate Ltd

McGuire, F. 1991 *They Built a River: A Short History of the Carrum Swamp, its People and its Reclamation.* Chelsea: City of Chelsea Historical Society

McLaren, P. and D. Bowles 1985 The effects of sediment transport on grain-size distributions. *Journal of Sedimentary Petrology* 55(4):457–470

Murphy, B.W., D.J. Eldridge, G.A. Chapman and D.J. McKane 2000 Soils of New South Wales. In P.E.V. Charman and B.W. Murphy (eds), *Soils: Their Properties and Management,* 2nd edition, pp.133–149. Melbourne, Oxford: Oxford University Press

Murphy, A. and T. Rymer 2011 Victorian Desalination Plant Transfer Pipeline Corridor Wonthaggi to Cranbourne Salvage Excavation. Unpublished report to Thiess Degremont Nacap

Northcote, K.H., G.D. Hubble, R.F. Isbell, C.H. Thompson and E. Bettenay 1975 *A Description of Australian Soils*. Clayton, Victoria: CSIRO

Orr, M. 2006 Appendix B Particle Size Analysis Report: Bend Rd sites Bend Rd 1 and Bend Rd 2 Pit C. In G. Hewitt and J. de Lange 2007 Report on Bend Road Archaeological Investigations Bend Road 2 Phases 1 to 4. Unpublished report prepared for Thiess John Holland

Peacock, E. and D.W. Fant 2002 Biomantle formation and artefact translocation in upland sandy soils: an example from the Holly Springs National Forest, north-central Mississippi, USA. *Geoarchaeology* 17(1):91–114

Petraglia, M.D. 1992 Stone artifact refitting and formation process at the Abri Dufaure, an Upper Paleolithic site in southwest France. In J.L. Hofman and J.G. Enloe (eds), *Piecing Together the Past: Applications of Refitting Studies in Archaeology*. BAR International Series no. 578, pp.163–178. Oxford: Archaeopress

Plomaritis, T.A., I. Puyana-Cruces, J. Benavente and S. Rodriguez-Polo 2013 Can grain size trend analysis be used to identify aeolian sediment transport pathways? The case of Bolonia dune (SW Spain). In D.C. Conley, G. Masselink, P.E. Russell and T.J. O'Hare (eds), *Proceedings 12th International Coastal Symposium* (Plymouth, England), *Journal of Coastal Research* 65:1325–1330

Richards, T., C. Pavlides, K. Walshe, H. Webber and R. Johnston 2007 Box Gully: new evidence for Aboriginal occupation of Australia south of the Murray River prior to the Last Glacial Maximum. *Archaeology in Oceania* 42(1):1–11

Roebrooks, W. 1988 From Find Scatters to Early Hominid Behaviour: A Study of Middle Palaeolithic Riverside Settlements at Maastricht-Belvédère (The Netherlands). Unpublished PhD thesis, Leiden, University of Leiden

Roebroeks, W., Kolen, J., Poecke, M.V. and A.L. Van Gijn 1997 Site J: an early Weichselian (Middle Palaeolithic) flint scatter at Maastricht-Belvedere, The Netherlands. *Paléo* 9(1):143–172

Ross, A. 1981 Holocene environments and prehistoric site patterning in the Victorian Mallee. *Archaeology in Oceania* 16(3):145–155

Schiffer M.B. and W.L. Rathje 1973 Efficient exploitation of the archaeological record: penetrating problems. In C.L. Redman (ed.), *Research and Theory in Current Archaeology*, pp.169–179. New York: Wiley-Interscience

Smith, L. 1991 *Berwick-Pakenham Corridor: Aboriginal Archaeology*. Melbourne: Victoria Archaeological Survey, Department of Conservation and Environment

Spencer-Jones, D., M.A.H. Marsden, C.M. Barton and J.J. Carrillo-Rivera 1975 Geology of the Westernport Sunkland. *Proceedings of the Royal Society of Victoria*

87(1):43–67

Stein, J.K. 1983 Earthworm activity: a source of potential disturbance of archaeological sediments. *American Antiquity* 48(2):277–289

Stern, N., J. Tumney, K.E. Fitzsimmons and P. Kajewski 2013 Strategies for investigating human responses to changes in landscape and climate at Lake Mungo in the Willandra Lakes, southeast Australia. In D. Frankel, J. Webb and S. Lawrence (eds), *Archaeology in Environment and Technology: Intersections and Transformations*, pp. 31–50. New York: Routledge

Thorne, A.G. and P.G. Macumber 1972 Discoveries of late Pleistocene man at Kow Swamp. *Nature* 238:316–319

Van Noten, F.L., D. Cahen and L.H. Keeley 1980 A Palaeolithic campsite in Belgium. *Scientific American* 242:48–55

VandenBerg, A.H.M. 2017 Depositional facies and extent of the Late Neogene Sandringham Sandstone in southern Victoria, Australia. *Proceedings of the Royal Society of Victoria* 128:7–24

Victorian Resources Online (VRO) Accessed May 2019 via < http://vro.agriculture.vic.gov.au/dpi/vro/vrosite.nsf/pages/vrohome >

Villa, P. 1982 Conjoinable pieces and site formation processes. *American Antiquity* 47:276–290

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

White, S. and M.M. Mitchell 2003. Palaeoclimates: the influence of continental drift and latitude change on climate. In W.D. Birch (ed.), *Geology of Victoria*, pp.563–571. Sydney: Geological Society of Australia (Victorian Division), Geological Society of Australia, Special Publication 23

Williams, A.N., F. Atkinson, M. Lau and P.S. Toms 2014 A glacial cryptic refuge in south-east Australia: human occupation and mobility from 36,000 years ago in the Sydney Basin, New South Wales. *Journal of Quaternary Science* 29:735–748