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Elemental differences: Geochemical identification of aboriginal silcrete sources in the Arcadia Valley, eastern Australia

Grant W.G. Cochrane [a], John A. Webb [b,*], Trudy Doelman [c], Phillip J. Habgood [d,e]

[a] 15/52–58 Meta St, Mooloolaba, Queensland 4557, Australia
[b] Environmental Geoscience, Department of Ecology, Environment and Evolution, La Trobe University, Bundoora, Vic 3086, Australia
[c] Department of Archaeology, University of Sydney, NSW 2006, Australia
[d] ARCHAEO Cultural Heritage Services, PO Box 333, The Gap, Queensland 4061, Australia
[e] School of Social Science, The University of Queensland, St Lucia, Queensland 4072, Australia

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ABSTRACT

Portable X-ray Fluorescence (PXRF) analysis was applied to silcrete artefacts from surface concentrations in the southern Arcadia Valley, eastern Australia. These artefacts were manufactured from river cobbles, as shown by the waterworn cortex, and could have been obtained from three sources: Dawson River, Carnarvon Creek and/or Clematis Creek. PXRF analyses of cobbles from these sites, evaluated using nonparametric statistics (because the data are skewed) and confidence ellipses, showed that the three sources can be distinguished by their Fe and Zr concentrations. Comparison with artefact analyses showed that many artefacts were probably sourced from Clematis Creek, with a substantial number from Dawson River but few, if any, from Carnarvon Creek. The sourcing pattern indicates that Aboriginal people in the Arcadia Valley were influenced not only by proximity when procuring silcrete, but also quality, cobble size and traditional mobility strategies. Carnarvon Creek was ignored because of its distance from the artefact sites and lower quality silcrete. Clematis Creek was the most favoured source because although distant from the artefact sites, it contained large silcrete cobbles (sufficient for the manufacture of large scrapers and knives), and was probably visited frequently due to its central location in the traditional country of the Karingbal People.

1. Introduction

Silcrete was the most common and widespread lithology used by Australian Aborigines for making flaked stone tools (e.g. Hughes et al., 1973; Sullivan and Simmons, 1979; White and O'Connell, 1982; Hiscock, 1993; Webb et al., 2013; Holdaway and Fanning, 2010; Doelman et al., 2015). This was due to its often high quality flaking properties (Webb and Domanski, 2008) and its abundance. Silcrete occurs across almost the entire Australian continent as two distinct geographical associations: in the inland arid regions (e.g. Wopfner, 1978; Thiry and Milnes, 1991; Doelman, 2008), and throughout the more humid parts of eastern Australia (e.g. Young, 1985; Webb and Golding, 1998) where it mostly outcrops close to basalts (Langford-Smith, 1978).

In Australia there has been a long-standing perception that silcrete artefacts cannot be accurately traced back to their source, because silcrete types are difficult to distinguish in hand specimen and silcrete is elementally impoverished, making geochemical sourcing problematic. However, silcrete contains significant levels of a variety of trace elements (Webb and Golding, 1998), and geochemical sourcing has been successfully undertaken in southern Africa (Nash et al., 2013a, 2013b). Furthermore, recent advances in analytical technology, particularly the widespread availability of Portable X-Ray Fluorescence (PXRF), have made sourcing studies easier. PXRF is in many ways ideal for silcrete sourcing, because it is non-destructive, portable, and can analyse the major and trace element composition of solid samples, including in situ, so that large numbers of analyses can be rapidly obtained, even in the field (e.g. Goodale et al., 2012; Nazaroff et al., 2010; Sheppard et al., 2010, 2011). PXRF has been successfully used for lithic sourcing of obsidian (e.g. (Torrence et al., 2013), because individual sources of obsidian tend to be chemically homogeneous and therefore distinctive (Craig et al., 2007). However, detection limits, spectral interferences and analytical artefacts mean that perhaps only 7–12 elements can be reliably measured by PXRF (Grave et al., 2012), and there are difficulties with analysis of heterogenous samples. Nevertheless, these limitations can be overcome by employing multiple analyses of individual samples and non-parametric statistics (as discussed below).

Archaeological investigations of Aboriginal sites in Australia are required by law to be conducted in consultation with traditional owners, who are frequently interested in lithic sourcing studies but prefer

* Corresponding author.
E-mail addresses: gcochrane221@gmail.com (G.W.G. Cochrane), john.webb@latrobe.edu.au (J.A. Webb), trudy.doelman@sydney.edu.au (T. Doelman), phabgood@archaeo.com.au, p.habgood@uq.edu.au (P.J. Habgood).

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approaches that avoid the destruction or disturbance of stone artefacts. The portability and non-destructive nature of PXRF analysis means that it allays these concerns and its use is becoming more common. In this paper we report on the use of PXRF to determine the sources of silcrete stone artefacts in the southern Arcadia Valley within the central Queensland highlands in eastern Australia. This study is grounded within a solid understanding of the regional geology coupled with strict procedures for the collection and analysis of geochemical data. It not only opens up new avenues of research within an Australian context but adds to a growing bank of research into the archaeological use of silcrete worldwide.

2. Background

Silcretes form by surface or near-surface low-temperature silicification of soil or unconsolidated sediments (Summerfield, 1983); the input of silica fills the original porosity as a crystalline quartz cement and/or replaces the original clays to form a matrix of microcrystalline quartz. Many elements are mobile during silcrete formation (Nash and Ullyott, 2007), including those traditionally regarded as immobile like Al and Cr; nevertheless the geochemistry of silcretes reflects to some extent the composition of the host soil/sediment. In particular, detrital zircons are inherited within a silcrete, so Zr is largely immobile during silicification, and Ti, Rb and Sr are immobile to varying extents in Australian eastern silcretes (Webb and Golding, 1998). This is true despite the substantial amount of additional silica introduced during formation of the eastern Australian silcretes (up to 60%; Webb and Golding, 1998), which was probably supplied by weathering of the mafic minerals, volcanic glass and feldspars in the nearby basalt (Eggleton et al., 1987).

Therefore, if distinctively different materials are silicified it is likely that the resulting silcretes will be geochemically distinct, so there are valid reasons why silcretes can yield different geochemical signatures. This means that it may be possible to geochemically distinguish silcrete sources used by Australian Aborigines, thereby determining the distance that particular silcrete types were transported or traded, and shedding new light on the complex ways that hunter-gatherers procured, worked and transported their raw materials.

2.1. The central Queensland highlands

The central Queensland highlands are an extensive area of low-relief plateaus at an elevation of around 1100 m, situated just south of the Tropic of Capricorn and 400–500 km from the coast (Fig. 1). They consist of horizontal, Lower Jurassic interbedded sandstones and shales that were uplifted and eroded in the Late Mesozoic - Early Paleogene (Young and Wray, 2000), and capped by extensive basalt lavas in the mid-Paleogene (Webb and McDougall, 1967; Sutherland, 1985). Silcrete occurs discontinuously throughout the central Queensland highlands (Gunn and Galloway, 1978; Webb et al., 2013), typically as layers up to 3 m thick immediately beneath the basalt or at most a few hundred metres away. The silcrete outcrops are exposed in the cliffed gorges and steep-sided valleys that have been eroded into the highlands, and shed large blocks downslope and into nearby creeks.

Archaeological evidence shows that Aboriginal occupation in the central Queensland highlands dates back at least 20,000 years. Around 4000 years ago there was an increase in occupational intensity and a marked change in the types of artefacts, with the appearance of small implement types like backed artefacts, thumbnail scrapers and pirri points (the Small Tool Industry ~4300–2000 BCE; Bowler et al., 1970; Gould, 1969; Morwood, 1984). The Recent Industry (<2000 BCE) was characterised by an apparent reduction in deposition rates, the disappearance of backed blades, pirri points and thumbnail scrapers, and the appearance of Juan knives and large scrapers of unconventional type (Morwood, 1984). As a result, particular artefact types are relatively reliable temporal markers in central Queensland.

Although a range of siliceous rocks was used for tool manufacture in the central Queensland highlands (L'Oste-Brown et al., 1998; Morwood, 1981), recent reanalysis of stone artefacts from a number of stratified rockshelter sites in the Carnarvon Range has indicated that silcrete was the dominant artefact lithology (Webb et al., 2013). It was quarried directly from outcrops beneath the basalt or from displaced blocks and scree (Morwood, 1981; Mulvaney and Joyce, 1965), and many archaeological sites in the highlands are located in close proximity to such silcrete quarries. Sites located at greater distances from silcrete quarries show a greater use of other rock types such as quartz and chert, but silcrete still appears to have been transported long distances (>80 km) for the manufacture of some tool types (Webb et al., 2013).

2.2. The Arcadia Valley

Within the central Queensland highlands the Arcadia Valley forms a narrow, north-south belt of lowlands (~250–400 m asl), enclosed to the south and west by the Carnarvon Range (~600–1200 m asl) and to the east by the Expedition Range (~400–750 m asl) (Figs. 1, 2). Dawson River flows close to the southern end of Arcadia Valley, Moolayember and Carnarvon Creeks flow into the valley from the Carnarvon Range to the west, and Clematis Creek from the Expedition Range to the east. These streams have deposited extensive alluvial fans where they flow from the highlands into the valley, as the sudden drop in gradient diminishes the ability of the streams to transport sediment (Finlayson and Kenyon, 2007). The stream channels are gravelly along the flanks of Arcadia Valley, but sandy across the central valley floor.

There are extensive Late Neogene gravelly fans on hilly country in the western and eastern parts of the Arcadia Valley, most notably in the area around Rewan adjacent to the Carnarvon Range (Galloway, 1967a). These high level boulder terraces were deposited by ancestral courses of the present streams, and have been reworked to some extent by the present streams (Galloway, 1967b).

In the lowland areas adjacent to the central Queensland highlands like the Arcadia Valley, stratified archaeological deposits are rare and most evidence of pre-European Aboriginal occupation comes in the form of surface artefact concentrations. In the southern Arcadia Valley, an archaeological survey of open sites along a proposed pipeline corridor in 2010 found >4000 artefacts in 12 artefact concentrations along with numerous isolated artefacts over a 12 km stretch of the survey corridor (Fig. 1). A detailed programme of artefact collection and analysis was undertaken to determine the types of stone that were utilised and the strategies of procurement that were employed (Cochrane, 2014; Cochrane and Habgood, 2013; Cochrane et al., 2012).

In the southern Arcadia Valley assemblage, the presence of backed artefacts, thumbnail scrapers and pirri points of the Small Tool Industry (~4300–2000 BP) indicates that at least some of the artefacts were discarded >2000 years ago. However, most artefacts cannot be assigned to any particular period on typological grounds. The majority probably date to the mid- to late Holocene, because the surface exposure of Pleistocene artefacts is unlikely due to the rapid accumulation of the extensive alluvial fans in the Arcadia Valley (Finlayson and Kenyon, 2007).

Hand specimen examination of the assemblage found that 91% of the stone artefacts were silcrete, and the remainder included petrified wood, sandstone, quartz, chert, chalcedony, basalt, quartzite and volcanic breccia. About 30% of the silcrete artefacts have a smooth, rounded, waterworn cortex, often with small subcircular fractures (percussion marks; Fig. 3) formed by the impact of saltating (bouncing) bedload clasts against each other in fluvial channels (Wilson and Lave, 2013). Other types of cortical surfaces are rare, indicating that the silcrete was obtained predominantly or entirely as river cobbles and boulders.

All of the stream beds are gravelly on the hilly flanks of the Arcadia Valley, and examination of the gravels located silcrete cobbles in Dawson River and Carnarvon Creek but not Moolayember Creek. High level gravels near Carnarvon Creek and Clematis Creek, inferred to be

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