SHORT REPORTS

A progress report on research into stone artefacts of the southern Arcadia Valley, central Queensland

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Abstract

We report on progress made to date on a collaborative project which aims to shed light on various aspects of lithic technology in the southern Arcadia Valley, central Queensland. Analysis of >4000 stone artefacts indicates that silcrete was an important lithic resource locally. Initial results from portable x-ray fluorescence analysis of a sample of artefacts suggests that this technique may be capable of characterising geochemical signatures for different silcrete sources. Gloss analysis suggests that 20–45% of the silcrete artefacts were heated prior to manufacture. Further use of this method, in combination with archaeomagnetism, is expected to provide more precise information about this practice.

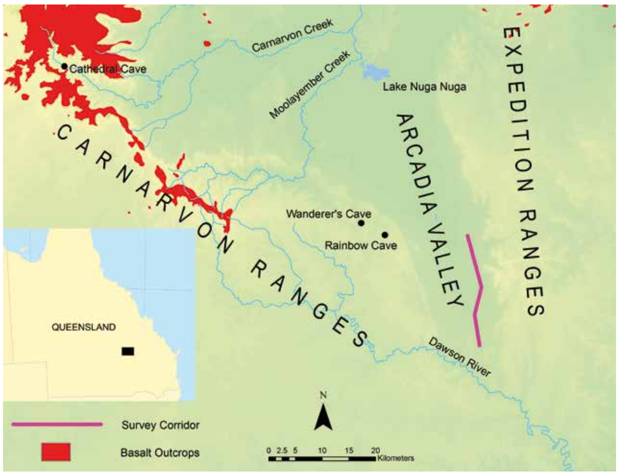

Figure 1 Location of the surveyed area and other notable archaeological sites in the southern Arcadia Valley and its surrounds.

Introduction

In 2010 a survey of a proposed pipeline corridor in the southern Arcadia Valley, central Queensland (Qld) (Figure 1), identified >4000 surface stone artefacts threatened with disturbance (ARCHAEO Cultural Heritage Services 2010, 2011). As part of the measures taken to assess the archaeological significance and mitigate the potential disturbance of these artefacts, the traditional owners (the Karingbal People) and the development proponent agreed upon a detailed programme of artefact collection, data recording and analysis.

The research questions formulated for this project were quite localised in nature. The focus was to be on the history of the use of stone in the southern Arcadia Valley, addressing three specific questions:

1. Where did the ancestors of the Karingbal People obtain stone?
2. What kinds of implements did they make and use?
3. How were these stone implements manufactured?

We have employed various strategies to address these questions (Cochrane 2011; Cochrane et al. 2012) and they provide the foundation for an ongoing collaborative research project. In this paper we focus on the preliminary results of two studies, each of which involves the application of new techniques to the study of Australian stone artefacts. The first study uses portable x-ray fluorescence (PXRF) to characterise geochemical variation in silcrete artefacts, with a view to identifying geochemical characteristics of discrete silcrete sources. The second study seeks to investigate the role of heat treatment in the manufacturing of silcrete implements through the complementary application of gloss analysis and archaeomagnetism.

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The Study Area

Arcadia Valley lies at the southern end of the Bowen Basin, an 85,500 km^2 sedimentary basin in central Qld that encompasses a diverse range of environments (L'Oste-Brown et al. 1998:12). Arcadia Valley differs from most of the Basin primarily because of its topographic context. While the elevation of the valley ranges from 250–400 m above sea level (asl), it is enclosed to the west and south by the Carnarvon Ranges (600–1200 m asl) and to the east by the Expedition Ranges (400–750 m asl). Hence, it is a relatively subdued landscape located in the midst of the steeply dissected slopes and high tablelands of the central highlands.

The Carnarvon Ranges are well-known for their rockshelter sites, which include Kenniff Cave, The Tombs, Rainbow Cave, Wanderers Cave, Cathedral Cave, Native Well and Turtle Rock. The lithic assemblages from these sites provided the basis for one of the first regional cultural sequences documented in Australia (Beaton 1977, 1991a, 1991b; Morwood 1981, 1984; Mulvaney and Joyce 1965). In the central lowlands of the Bowen Basin, many Aboriginal cultural heritage management studies have been conducted in conjunction with the proliferation of mining and other development activities. While uneven in their coverage, these studies have helped to document and model the distribution of Aboriginal cultural heritage places across the landscape (e.g. L'Oste-Brown et al. 1998). Both the excavated highlands sequences and the landscape modelling of the lowlands provide context for research into the stone technology of the Arcadia Valley.

The southern Arcadia Valley artefact assemblage was collected from a survey corridor ~20 km long and 100 m wide (Figure 1). While the distribution of artefacts was relatively continuous, artefact density varied throughout the corridor. This variation tended to be related to differences in ground surface visibility, which is in turn related to variable geomorphological processes, farming activities and their resulting effects on vegetation patterns (Finlayson and Kenyon 2007). Thus, while the stone artefacts collected during the survey have been notionally ascribed to 13 different 'sites' (or Significant Aboriginal Areas [SAAs]), the status of these areas as discrete spatial loci of past activities remains uncertain. The two studies that are presented in this report are based on relatively small samples of artefacts drawn from the total assemblage, rather than from a single SAA.

The southern Arcadia Valley artefact assemblage was not derived from any dateable contexts. In the Carnarvon Ranges rockshelter sites, certain retouched artefact types—including pirri points, eloueras and thumbnail scrapers—tend to be restricted to the period from ca 4300–2000 BP (Morwood 1984). The presence of these artefact types in the southern Arcadia Valley assemblage suggests that at least some of the stone artefacts were deposited on the landscape >2000 years ago.

Study 1: Use of PXRF to Investigate Silcrete Procurement Strategies

The importance of silcrete in the southern Arcadia Valley is very clear, with it accounting for 91% of the artefact assemblage. However, the precise source or sources of the silcrete are not readily apparent. Silcrete in the region generally has a close spatial relationship to basalts and is commonly known as 'sub-basaltic' silcrete (Webb and Golding 1998). In the Carnarvon Ranges, uplifted Mesozoic sandstones are capped in places by Tertiary basalt flows. In many locations silcrete has formed between the basalt and sandstone layers. Subsequent erosion has exposed some of this silcrete in the form of steep outcrops, which were quarried by Aboriginal knappers (Webb and Domanski 2008:568; Young and Wray 2000).

Tertiary basalt flows are also a prominent feature of the surface geology in the flat to rolling downs country to the north of the Arcadia Valley (e.g. Elliott 1973). In this subdued terrain the presence of large silcrete outcrops exposed by erosion is less likely. However, silcrete nodules, commonly known as 'floaters', often occur in the cracking clay soils associated with basalt or mudstone lithologies in central Qld basins. Examples of these have been noted in the area west of Rolleston, approximately 75 km north of the Arcadia Valley (L'Oste-Brown et al. 1998:167).

Unlike these neighbouring areas, the Arcadia Valley was not affected by Tertiary basalt flows and its underlying geology consists entirely of Triassic sandstones (Finlayson and Kenyon 2007:248). The formation of silcrete in these conditions would be inconsistent with current theoretical models. Neither outcrops nor floaters of silcrete were observed in the Arcadia Valley during our fieldwork and so we conclude that the presence of local sources of silcrete in these forms is very unlikely.

However, there is a strong likelihood that silcrete was obtained from local streambed sources. The presence of smooth, waterworn cortex on ~30% of the artefacts, and the rarity of any other type of cortex, lends strong support to this proposition. Mapping of the Carnarvon Ranges basalt/sandstone contact zones and the drainage channels that flow from these zones down into the valley (Figure 1) indicates three channels are possible local sources of silcrete cobbles: the Dawson River, and Moolayember and Carnarvon Creeks.

A more precise model of silcrete procurement would require stronger evidence that one or more of these channels were discrete sources of silcrete in the Arcadia Valley landscape. As a first step in this investigation, PXRF was utilised to identify geochemical differences amongst the silcrete artefacts. Thus far this technology has mainly been used on igneous rocks, particularly obsidian (Craig et al. 2007); however, recent research conducted on silcretes from New South Wales (NSW) has shown that PXRF can identify geochemical distinctions on a broad regional basis (May 2010).

A subsample of 40 silcrete artefacts was randomly drawn from the southern Arcadia Valley assemblage. These artefacts were firstly classified according to three silcrete types based on appearance: medium-grained (0.25–0.5 mm quartz clasts), fine-grained (<0.25 mm quartz clasts) and artefacts that appeared to have been heat treated. A Bruker Tracer-III PXRF having a rhodium tube and a Si-PIN detector with a resolution of ca 170 eV FHWM for 5.9 keV X-rays (at 1000 counts per second) in an area of 7 mm^2 was then used to measure the elemental composition of each artefact. Each sample was analysed twice to gain more accurate readings of both heavy and light elements. The first analysis was conducted at 40 keV (15 mA) using a 0.076 mm (green) filter of 0.006" Cu, 0.001" Ti and 0.012" Al. The second analysis was without the filter, at 30 keV (15 mA) and with a Bruker vacuum pump, which allowed more accurate readings of the lighter elements below Fe. More accurate readings were also gained by measuring each x-ray path using a 180-s live-time count. The readings from the PXRF were directly transferred to a laptop showing the spectrum interface, and then calibrated using S1CALPROCESS.

The results indicate that differences in the elemental composition of the medium-grained and fine-grained artefacts could be discerned using this method. This is best illustrated through the scatterplot diagram showing relative amounts of strontium (Sr) and zirconium (Zr) in each of the artefacts (Figure 2). Most of the medium-grained artefacts fall within a tight cluster with lower Sr and Zr values, while the fine-grained artefacts are more dispersed with higher values. The artefacts that appeared to have been heat treated (not included in Figure 2) tend to be situated amongst the cluster of lower values. Principal components analysis (PCA), using a broad range of elements, revealed a similar pattern. The apparent linear relationship between Sr and Zr has not been observed in data from previous analyses of various Australian and South African silcretes. It may reflect a common property

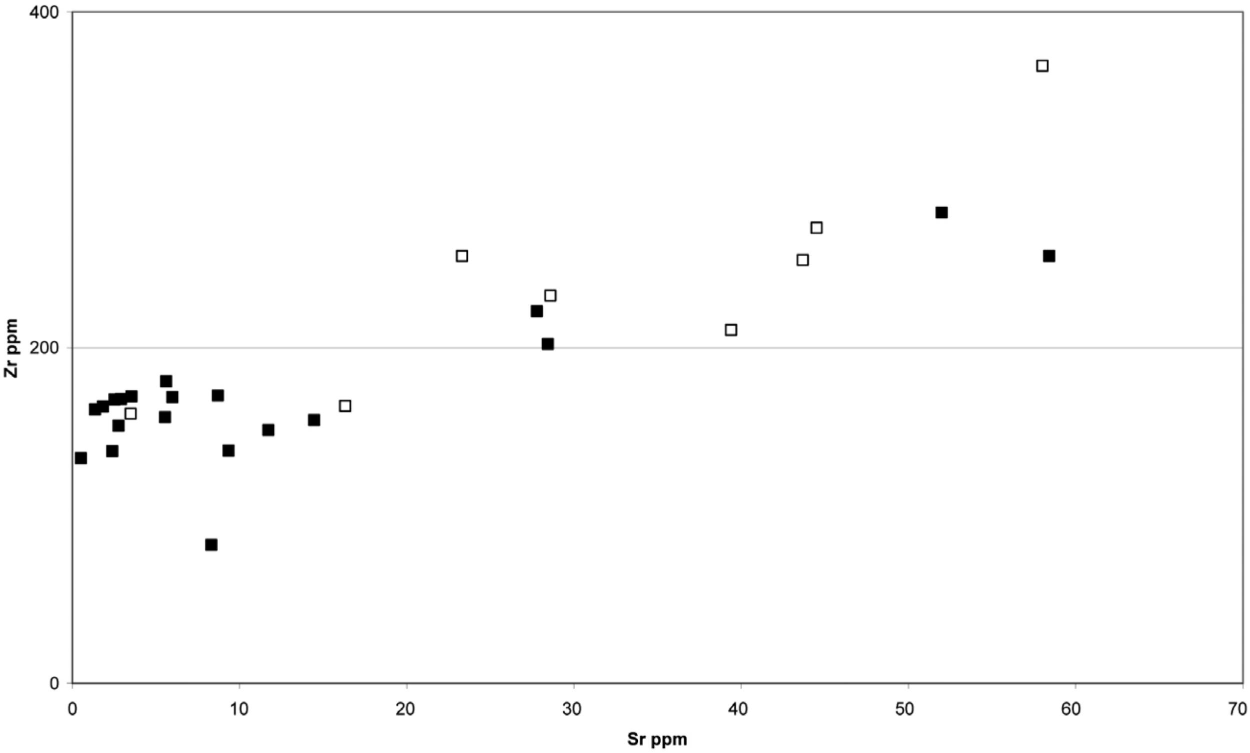

Figure 2 Scatterplot showing comparative amounts of strontium and zirconium in medium-grained (black squares) and fine-grained (white squares) silcrete artefacts from the southern Arcadia Valley.

in the clays that were present in the sandstone of this region prior to silicification. This would be consistent with the evidence that the finer-grained silcretes contained more of these elements.

Study 2: Use of Gloss Analysis and Archaeomagnetism to Investigate Heat Treatment of Silcrete

It has been suggested that a number of mid- to late Holocene aged Australian assemblages display evidence for the heat treatment of silcrete (e.g. Akerman 1979; Akerman et al. 2002; Hanckel 1985; Hiscock 1993; Moore 2000), but such studies have rarely provided evidence beyond the purely visual appearance of the artefacts. A considerable number of the artefacts from Arcadia Valley had a lustrous texture and dark red colour, features that are often suggested to be indicative of deliberate heat treatment (Domanski and Webb 1992). However, experimental analysis has shown that the heating of silcrete does not always result in changes visible to the naked eye (Brown et al. 2009). Further, natural processes such as silica sheen and desert polish can also sometimes produce changes in appearance similar to those caused by heating, including reddening. Hence, while there were strong indications that heat treatment was practiced in the valley, we wanted a more precise indication of the extent of the practice.

Aside from subjective assessment of surface features, some authors have attempted other methods to identify heat treatment of Australian stone tools. These include the use of scanning electron microscopy (SEM) and the use of a modified Thellier method normally used for reconstructing palaeointensity estimates of the Earth's magnetic field (Herries et al. 2007; Rowney 1994; Rowney and White 1997). Rowney and White (1997) found that SEM was not reliable and, although the Thellier method did not produce false positives, they concluded that a combination of methods should ultimately be used if possible.

We intend to apply two methods to a sample of artefacts from Arcadia Valley: gloss analysis and archaeomagnetism, the latter involving use of the palaeomagnetic vector method (Brown et al. 2009; Herries 2009; Herries and Fisher 2010). These methods should complement each other, because, while gloss analysis provides a means for evaluating the likelihood that an artefact was deliberately heated, archaeomagnetism can definitively identify whether some form of heating has occurred. At this early stage of research into the southern Arcadia Valley artefacts, only the preliminary gloss analysis has been conducted and preliminary results are presented herein.

Gloss analysis involves the use of a glossometer to measure the reflectance of artefact surfaces and is 100% non-destructive. Brown et al. (2009) showed that, in an experimentally heat treated South African silcrete assemblage, the flaked surfaces of heat treated rock, the unflaked surfaces of heat treated rock, and unheated rock all had different expected ranges of gloss values. They found that the flaked surfaces of heated rock should have a higher gloss value than the unflaked surfaces, which actually become dulled by heating and show slightly lower values than unheated material. Thus, it can be inferred that, if flaked surfaces have high gloss values, then the sample was heat treated; conversely, if the flaked surfaces have low values, it is possible that the stone tool was either accidentally heated or not heated at all. If high values occur on unflaked surfaces, then it is likely that the gloss is due to other processes, such as weathering. By comparing gloss values on flaked and unflaked surfaces it should in theory be possible to distinguish deliberately heat treated, accidentally heated and unheated stone tools. However, the range of gloss values may vary according to raw material and so this must be established in each specific research context. Experimental studies conducted thus far have also shown some overlap in the gloss values of these three categories, and so there are limits to the precision of the method (Brown et al. 2009).

Gloss measurements were taken of a sample of 115 silcrete artefacts selected to encompass the spectrum of colours and textures represented in the assemblage. One hundred were also selected to have a maximum dimension no greater than ~20 mm so that they would fit in the magnetometer when the PVM analysis was conducted. None of the artefacts used in the PXRF study were included in the sample.

The artefacts had gloss measurements that ranged between 0.1 and 5.1 Gloss Units (GU) (Figure 3). As such, they are generally lower than those seen in a combination of heated and unheated South African silcrete by Brown et al. (2009), which ranged between 2.2 and 5.7 GU, although only two samples had values above 5.0 GU in that study. Brown et al. (2009) defined GU values above 2.7 as having been heat treated and below 2.2 as not heat treated. Those in between were ambiguous.

Using a cut-off point of 2.7 GU, only 20% (23 out of 115) of the southern Arcadia Valley sample showed evidence of being heated. However, there was a complete continuum of measurements between 0.1 and 5.1 GU, which makes defining two definite populations of heated and unheated artefacts impossible. In the experiments of Brown et al. (2009), experimentally heat treated artefacts gave overall ranges between 2.2 and 5.7 GU, while archaeological ones that were defined as heat treated using thermoluminescence (TL) and archaeomagnetism gave values between 2.0 and 5.6 GU. Using this range, between 35 and 45% (40 and 52 of 115 artefacts, respectively) of the southern Arcadia Valley artefacts may have been heated.

Future Research

PXRF Analysis

It now remains for us to establish whether the geochemical distinctions that were apparent among the silcrete artefacts occur within a source or whether they can be used to distinguish between sources. The next step in the PXRF study will be to conduct a thorough search for silcrete cobbles in the three prospective silcrete source locations, and determine whether they produce consistent PXRF signatures that match the artefact silcrete types. Silcrete samples from more distant sources, including the Carnarvon Ranges and the basin to the north, will also be tested.

Archaeomagnetism and Gloss Analysis

The gloss analysis results draw upon gloss parameters that were established through experimental heat treating, TL and archaeomagnetism of South African silcrete. When suitable samples of silcrete from southern Arcadia Valley sources are obtained, we intend to apply similar approaches to establish local gloss parameters. These will allow us to determine heat treatment with greater certainty, and will also provide an indication of the comparability of Australian and South African silcrete gloss characteristics.

The preliminary gloss analysis was also hampered by a number of issues related to the occurrence of potential mineralisation surfaces on some of the artefacts' cortical surfaces and unreadable flaked surfaces. As such, there is the potential for false positive identification of heat treatment if samples and their

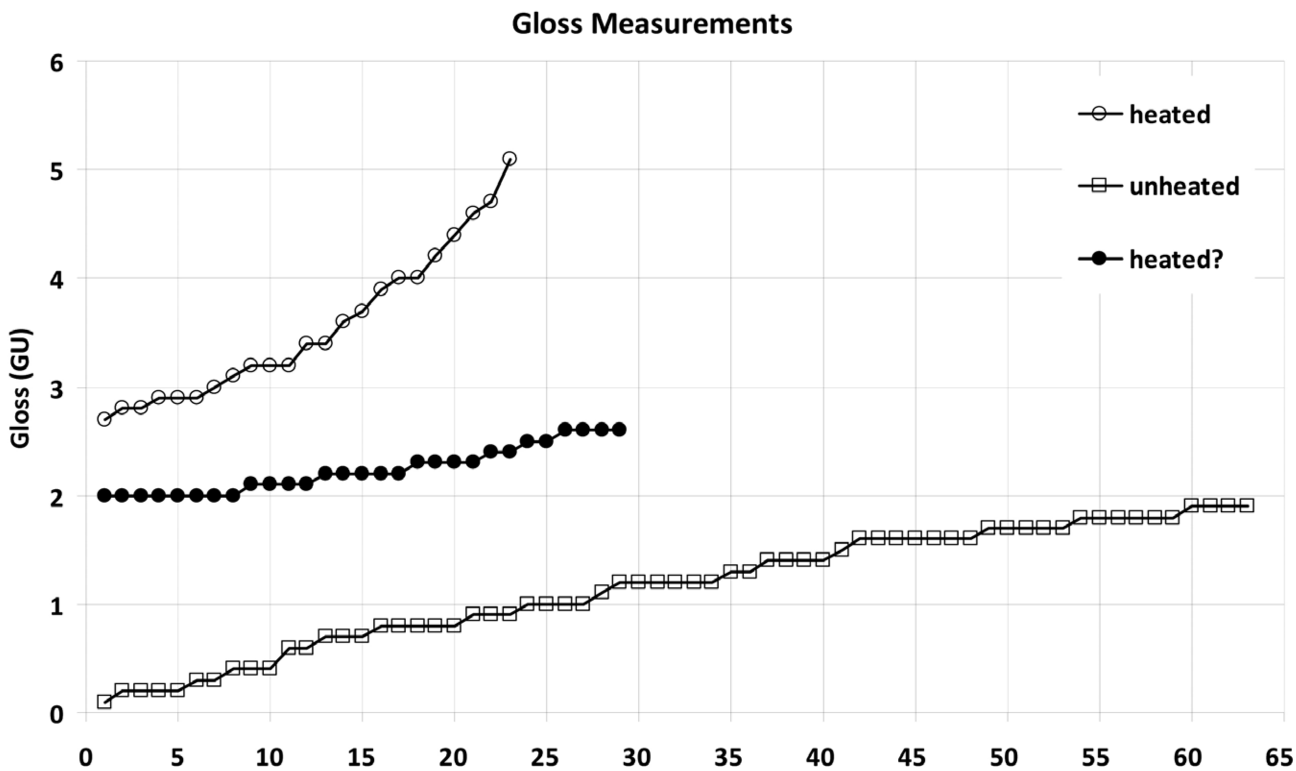

Figure 3 Gloss measurements from southern Arcadia Valley artefacts.

gloss values are not evaluated on a sample by sample basis. In the next phase of analysis, an archaeomagnetic study of 100 artefacts from the same sample will be conducted. This will definitively indicate whether the artefacts identified as being heated in the gloss study in fact were and, if so, to what temperature they were heated. The archaeomagnetic study will also help to resolve the ambiguous results obtained thus far. We will then conduct further sampling to investigate why silcrete was heat treated in some circumstances but not in others.

Conclusion

While both studies presented in this paper are preliminary in nature, they provide new information about the Aboriginal use of silcrete in the southern Arcadia Valley and provide a strong direction for future research into silcrete procurement and heat treatment. It appears likely that one or more local channels were utilised as silcrete sources. The PXRF study suggests that silcrete artefacts can be classified into two groups based on geochemical characteristics. If these same characteristics can be used to distinguish silcrete sources, then the technology will have great potential for investigating how these sources structured land use, mobility and technological strategies. The gloss analysis study suggests that 20–45% of silcrete artefacts were heat treated. Further research will enable us to provide a more precise estimate, and to investigate the circumstances where heat treatment was most likely to have been practiced.

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