25.
Edge-ground hatchets on the southern Curtis Coast, central Queensland:

a preliminary assesment of technology, chronology and provenance

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Summary

A number of edge-ground hatchets were identified from various locations in central Queensland during recent investigations conducted as part of the Gooreng Gooreng Cultural Heritage Project. Macroscopic examination suggested that some hatchets were manufactured on a distinctive form of rhyolitic tuff which is restricted in occurrence to the Town of Seventeen Seventy - Agnes Water area on the southern Curtis Coast. The hatchets are distributed over an area of some 6000 km^2, centred on the town of Lowmead within the ethnohistorically documented linguistic borders of Gooreng Gooreng country. Laser ablation-inductively coupled plasma-mass spectrometry (LA-ICP-MS) was employed in an attempt to provenance the hatchets to particular outcrops of rhyolitic tuff on the basis of trace element geochemistry. Preliminary results confirm that all hatchets identified as rhyolitic tuff exhibit a similar geochemical signature. Moreover, this geochemistry can be correlated with the background samples from the Ironbark Site Complex, the only major rhyolite quarry known in the region. The study enhances our understanding of past Aboriginal lifeways in the region by situating strategies of stone procurement and use in the landscape.

Introduction

This study presents a preliminary description and analysis of a small rhyolitic hatchet assemblage from central Queensland (fig 25.1). After a brief overview of the archaeology and stone quarries of the southern Curtis Coast area, we present the distribution of

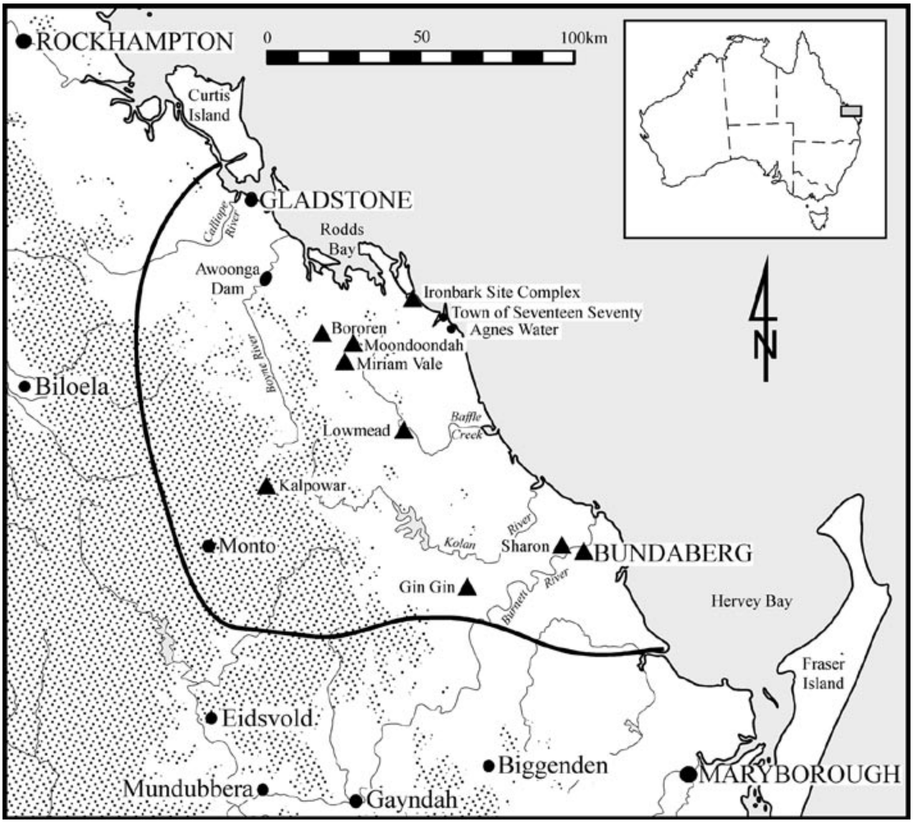


Figure 25.1

Location of Gooreng Gooreng Cultural Heritage Project study area in central Queensland showing places mentioned in the text. TCSC is Tom's Creek Site Complex. The heavy line encloses the general historical distribution of Gooreng Gooreng speakers (after Horton 1995; Williams 1981). For the purposes of this study, the southern Curtis Coast is defined as the coastal landscapes between the mouth of Baffle Creek and Rodds Bay.

rhyolitic hatchets, summarise the morphology and technology of the assemblage, discuss probable chronology ed and outline aspects of the regional geology. Finally, we sketch the experimental application of LA-ICP-MS to the assemblage and discuss the results. The LA-ICP-MS analysis confirmed that the stone for the hatchet came from the southern Curtis Coast, providing a basis for a discussion of the implications of the study for understanding patterns of stone raw material procurement and use across the landscape. Several areas for future research are identified. While the small sample size of the known rhyolitic hatchet assemblage and their wide distribution limits confidence in potential interpretations, various possibilities are explored.

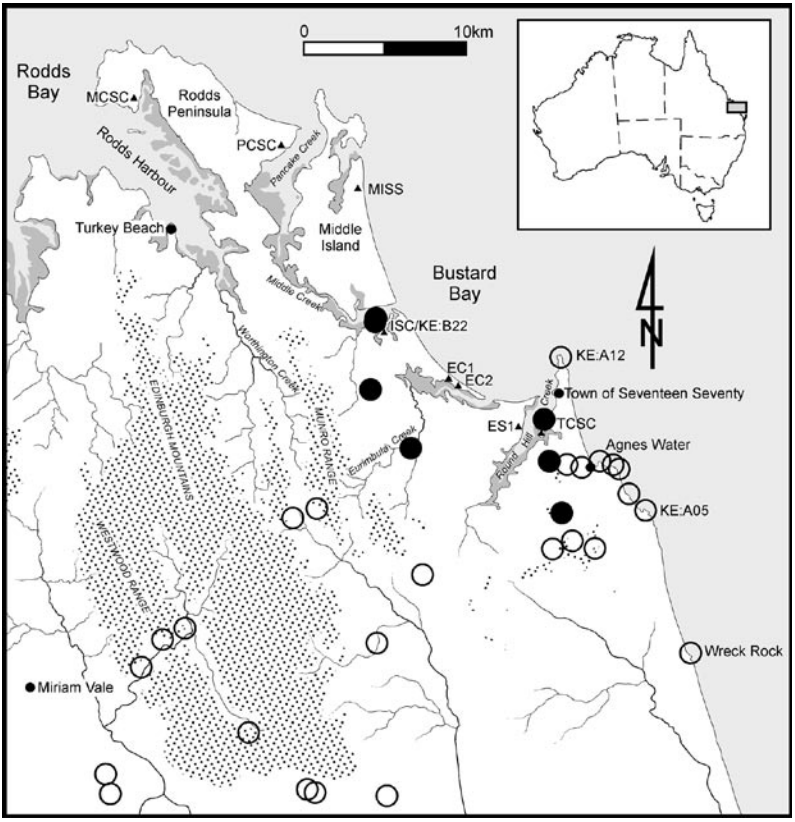


Figure 25.2
Spatial distribution of background geological samples from the Agnes Water Volcanics with the seven samples isolated from the Ironbark Site Complex–Tom's Creek Site Complex rhyolitic unit indicated by solid circles. This grouping illustrates the interpreted geological affinity of the samples as belonging to a single volcanic unit.

Geologically distinct rhyolitic tuff is restricted in distribution to coastal headlands and near-coastal outcrops in a 40 km long coastal zone between Wreck Rock in the south to Middle Creek in the north, on which the Ironbark Site Complex is situated (fig 25.2). Despite systematic examination of all coastal occurrences of this material, the Ironbark Site Complex is the only location where there is documented evidence for significant Aboriginal procurement of this material. On this basis, the nine hatchets macroscopically identified as rhyolitic tuff could originate from the Ironbark Site Complex. If this assumption were sustained by geochemical analyses, it would support the idea that at least the initial stages of edge-ground hatchet manufacturing occurred at the Ironbark Site Complex.

Background

Extensive surveys and selected excavations have been undertaken along the southern Curtis Coast in central Queensland since 1993 under the auspices of the Gooreng Gooreng Cultural Heritage Project (eg Ulm 2000, 2002a,b; Ulm et al. 1999a; Ulm and Lilley 1999). Preliminary analyses of excavated materials from 12 sites, aided by a series of 66 radiocarbon dates, suggest significant changes in stone artefact technologies and patterns of raw material procurement over the last 4000 years. Before c.1500 years ago stone artefact assemblages were characterised by high quality siliceous stone (including non-local materials) that was curated for maximum use-life. After 1500 years ago there was a shift towards the almost exclusive use of local stone resources (especially rhyolitic tuff and ignimbrite) associated with major increases in the number of sites occupied in the region and the intensity of use of individual sites. This localisation in the use of lithic raw materials is accompanied by an alteration in stone reduction strategies towards expedient tool manufacture, use and discard for utilitarian artefacts. Several indirect lines of evidence (see below) indicate that it was during this period that manufacture of edge-ground hatchets on local stone materials commenced.

Stone artefacts and quarries on the southern Curtis Coast

Archaeological surveys and excavations on the southern Curtis Coast have revealed that Aboriginal people used a restricted range of rock types to manufacture stone artefacts. In particular, a distinctive form of rhyolitic tuff — which only occurs in the area — dominates artefact assemblages of the recent past. Despite extensive surveys, only three stone quarry sites are known on the southern Curtis Coast. Rowland (1987) reported a minor quarry on Round Hill Head (KE:A12), located on the tip of the peninsula north of the Town of Seventeen Seventy (fig 25.2). KE:A12 consists of two large rhyolite boulders exhibiting approximately 30 negative flake scars with some scattered shell and flaking debris evident in surrounding rock crevasses. To the south, a minor silcrete quarry was recorded on the Rocky Point headland (KE:A05), exhibiting a high density artefact exposure and reportedly containing backed artefacts and hammerstones (see Burke 1993: 62). Some material was collected from the site and is lodged in the Queensland Museum (QE9829/1–6). In 1997, Gooreng Gooreng Cultural Heritage Project surveys identified a large quarry-midden site complex on the southern bank of the lower reaches of Middle Creek, subsequently named the Ironbark Site Complex (KE:B22) (Lilley et al. 1997). Quarried rhyolitic tuff is evident over about 1000 m^2 along a narrow beach bordering the mangrove fringe. It is adjacent to an extensive, shallow (<70 cm) midden deposit which covers an area of more than 150,000 m^2 (15 hectares), with cultural material exposed intermittently in a low erosion bank for some 1.5 km along the margin of Middle Creek. Although artefact densities vary across the quarry exposure from 9500 to fewer than

10 artefacts/m^2, the entire exposure is estimated to contain at least one million artefacts. Radiocarbon dates from the Ironbark Site Complex suggest that the major period of site use occurred in the last 1500 years (Ulm and Reid 2000).

Reid (1998) analysed a sample of the lithic assemblage excavated from the Ironbark Site Complex quarry and adjacent midden deposits, demonstrating a level of standardisation of the reduction sequence in several technological and descriptive indices. On the basis of this study, Reid (1998) suggested that the quarry may have functioned primarily as a place of manufacture of edge-ground hatchets. The Ironbark Site Complex quarry was not used exclusively for the production of hatchets, however, as numerous flaked pieces, cores and flakes sourced to the quarry have been recovered from sites throughout the region, making it difficult to separate quarried hatchet blanks from stone reduced for other end-products (Dickson 1981: 34).

The rhyolitic hatchet assemblage

Nine bifacially flaked edge-ground hatchets manufactured from rhyolitic tuff, such as that found at the Ironbark Site Complex, have been located in museum collections and during field surveys (table 25.1, fig 25.1). One hatchet was found at the Ironbark Site Complex during surveys c.100 m east of the quarry exposure (figs 25.3c,d). Five more hatchets are held by the local Miriam Vale Shire Historical Society Museum in Agnes Water. They were collected from: Lowmead (45 km from the Ironbark Site Complex), Kalpowar (79 km), Moondoondah (25 km), Miriam Vale (30 km), and Bororen (31 km). Although little documentation is associated with these samples, most are associated with property names in the district, suggesting a level of confidence in the general location of collection. Further south, hatchets held by the Queensland Museum were collected from Bundaberg (100 km; figs 25.3a,b), Gin Gin (97 km), and Sharon (96 km). The hatchet from Bundaberg is only provenanced to the 'Bundaberg District'. With the exception of the Ironbark Site Complex hatchet, all specimens are assumed to derive from surface contexts.

Although the sample of edge-ground implements in the collection is very small, a number of generalisations can be made about their overall size, shape and manufacture (table 25.1). The fact that only one artefact shows signs of breakage aids in the identification of overall trends. Although these artefacts at first appear to be fairly rough and unstandardised, a metric analysis demonstrated that they in fact reflect a fairly consistent pattern of manufacture (see also Reid 1998).

All nine implements appear to be bifacially worked cores that have been ground along a portion of the margin to produce a sharpened edge with an edge angle of between

Specimen	Provenance	Complete?	Weight (g)	Lenngth (mm)	Proximal Width (mm)	Medial Width (mm)	Distal Width (mm)	Thickness (mm)	% Cortex	Cortex Type	Index of Invasiveness	Length of Edge (mm)	% Edge Flaked	% Edge Ground	% Surface Ground	Depth of Grinding	# Ground Facets	Edge Angle	% Edge Rejuvenated?
QE10553	Gin Gin	Y	582	123	83	87	49	33	30	Flat	0.84	375	100	33	15	39	4	80	0
A2	Kalpowar	Y	291	99	63	75	51	24	0		1	292	100	29	35	46	6	80	0
A1	Lowmead	N	663	130	84	91	64	44	0		1	236	100	50	55	76	6	70	50
A4	Moondoondah	Y	682	133	54	88	83	39	0		0.84	395	100	22	35	60	6	85	10
QE3131	Bundaberg District	Y	594	116	66	91	78	38	0		1	333	100	23	45	90	5	85	0
A5	Miriam Vale	Y	793	137	46	84	74	44	8	Pitted	0.94	369	100	30	40	62	5	80	0
QE790	Sharon	Y	609	131	48	78	59	41	20	Pitted	0.75	332	100	24	30	40	7	80	0
FS2747	Ironbark Site Complex	Y	630	121	63	86	61	36	35	Pitted	0.78	335	100	21	25	60	3	75	0
A10	Bororen	Y	485	137	87	91	54	32	35	Flat	0.53	415	81	13	5	26	2	45	0

Table 25.1
Summary statistics for edge-ground hatchets manufactured on rhyolitic tuff.
FS = Gooreng Gooreng Cultural Heritage Project collection;
QE = Queensland Museum; A = Miriam Vale Historical Society Museum

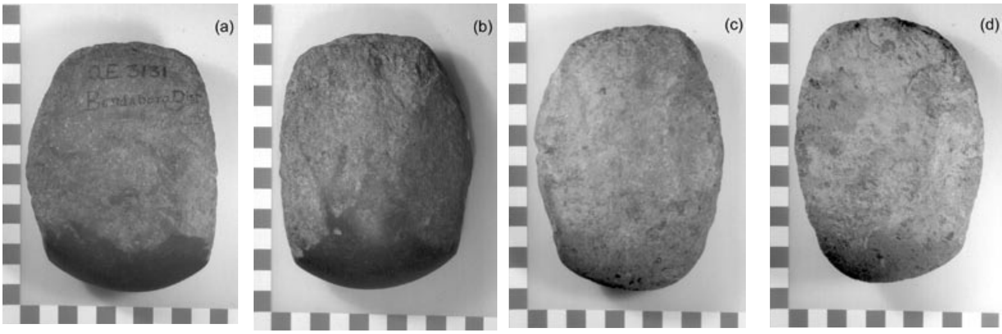


Figure 25.3 Examples of edge-ground hatchets manufactured on rhyolitic tuff. *Photo: Paul Aurisch*
(a) and (b) two sides of hatchet from the Bundaberg district housed in the Queensland Museum collection (QE3131).
(c) and (d) two sides of hatchet located during field surveys at the Ironbark Site Complex (SCCRAP FS2747). Scale = 1cm.

70 and 85 degrees (measured as the best approximation of the overall angle at the centre of the ground edge). They were all initially shaped and thinned through extensive invasive flaking around the perimeter of the blank to create a relatively thick, ovate disc that is widest at its medial point. The size of these edge-ground implements also exhibits a fairly narrow range, with coefficients of variation (which express the standard deviation as a percentage of the mean) for length and width of less than 10%, and around 15% for thickness and perimeter of edge. This may reflect design criteria that in part relate to function, portability and/or the requirements of hafting.

The total absence of original ventral surfaces as well as the presence of cortex on opposed faces in several cases suggests that hatchets were made from weathered nodules or angular blocks rather than large flakes (Reid 1998). As the raw material is poorly suited to percussion flaking, abrupt and battered margins have formed on many pieces from multiple failed attempts to detach invasive thinning flakes from the edges of implements.

Grinding was limited on average to around 27% of the edge (length of grinding divided by length of edge), and covered around 34% of the surface area of each face (ground surface area was estimated rather than measured). On average, each artefact exhibited five grinding facets, representing changes to the angle and width of grinding. Different grinding facets probably represent various attempts to smooth irregular surface morphologies that result from the bifacial 'roughing out' of the blank, as well as the formation of a cutting edge at the distal end. The abrupt edges adjacent to the ground portion were rarely if ever ground. Although no direct evidence for hatchet grinding has been found on the southern Curtis Coast, sandstone exposures along drainage lines to the west and south-west exhibit numerous grinding sites (eg Westcott et al 1999: figs 4, 18, 19).

Another possibility is that in the absence of sandstone, portable grinding stones were employed (eg Dickson 1981: 43–4), such as those found on several sites in the region (eg Ulm and Lilley 1999: fig 14).

Edge-ground artefacts typically require a large investment of labour in their manufacture and maintenance, and are often thought to have been extensively curated, transported and/or traded over long distances in the course of their lifetime. We might therefore briefly consider whether evidence exists to support the idea that differences in the morphology of each implement in the sample could reflect different stages in a sequence of manufacture and edge rejuvenation, or whether each simply represents a 'finished product' that remains unaltered throughout its use-life.

Strong correlations exist between five variables that should reflect the degree to which each implement has been flaked and ground. These are the relationship between the index of invasiveness, which measures the amount of flaking an implement has received (Clarkson 2002), and (1) the depth to which grinding extends back from the bevelled edge, (2) the angle of the ground edge, (3) the number of grinding facets, and (4) the percentage of the margin that has been ground. All show extremely high r^2 values and highly significant results (table 25.2). Regression analysis therefore supports the notion that differences in form could reflect different stages of manufacture and intensity of rejuvenation. Additional support for a resharpening/regrinding hypothesis is provided by one implement that has had one side of the ground edge completely retouched off, leaving remnant areas of grinding behind the most recent retouch scars. Two other implements also exhibit retouch scars that have removed older areas of grinding, some of which were later ground a second time (cf Dickson 1981: 47). Figure 25.4 shows the reduction in the mean length of hatchets as the number of grinding facets on each artefact increases. The overall reduction in length is slight, and accounts for the low coefficients of variation for length, but nevertheless suggests that hatchets were gradually worked back toward the butt end as they were rejuvenated and resharpened.

Test	r	r^2	p
Index vs Ground Edge Angle	0.992	0.985	<0.0001
Index vs % of Edge Ground	0.965	0.932	<0.0001
Index vs # of Grinding Facets	0.971	0.943	<0.0001
Index vs Depth of Grinding	0.973	0.947	<0.0001

Table 25.2
Regression statistics for the relationship between intensity of bifacial flaking and the extent of grinding

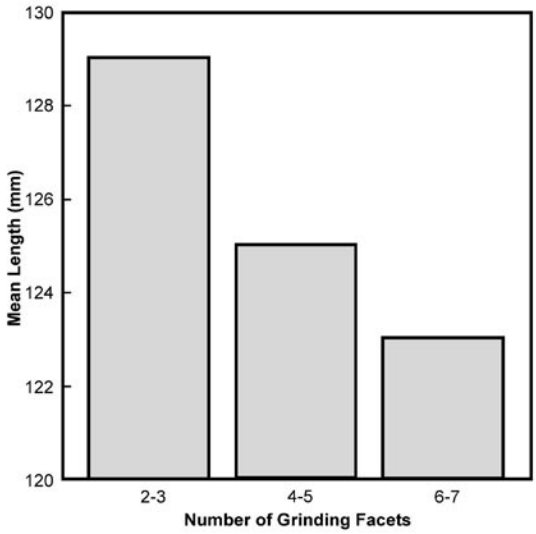


Figure 25.4
Hatchet morphology: relationship of mean length of hatchets to the number of grinding facets on each artefact

Overall, the edge-ground implements exhibit a consistent method of manufacture, resulting in reasonably regular forms that display morphological variation consistent with the amount of flaking and grinding each has received. Successive phases of resharpening/reshaping and regrinding might be explained as the maintenance and rejuvenation of a costly, much transported and heavily curated implement.

Edge-ground hatchets are items of material culture which are likely to be represented in museum and private collections as they are immediately recognisable as Aboriginal artefacts by both professional archaeologists and amateur collectors. Curiously, however, despite continued examination of museum and private collections beyond the study region (eg from the Maryborough, Eidsvold, and Rockhampton areas) no edge-ground hatchets manufactured on rhyolitic tuff have been located beyond the historically documented linguistic boundaries of the Gooreng Gooreng language group, despite hatchets featuring prominently in accounts of regional assemblages of material culture. Hiscock (1982), for example, mentions local farmers collecting many hatchets from their properties around the Boyne River, just north-west of the study area, which is supported by Curr's (1887) description of the region 100 years earlier. However, examination of the material collected and excavated by Hiscock (1982) near Awoonga Dam, held by the Queensland Museum, did not reveal any artefacts manufactured on rhyolitic tuff.

The presence of edge-ground hatchets manufactured on rhyolitic tuff within the Gooreng Gooreng language group area and the absence of this material in adjacent regions is suggestive of localised and focused distribution patterns. Although broad social and linguistic similarities existed between Gooreng Gooreng and their western and southern neighbours (Clarkson et al. nd), there appears to have been a distinct alliance network and linguistic boundary north and north-west of Gooreng Gooreng country (Lilley and Ulm 1995). Intergroup gatherings could have provided a forum for exchange of material culture such as hatchets, and Gooreng Gooreng people are known to have participated in gatherings in the Bunya Mountains, north-west of Brisbane (Petrie 1904: 11). Such intergroup gatherings provided a regular venue for the distribution of ideas and material culture, implying that the flow of goods may have been directed by social affiliations (cf McBryde 1984: 279). The fact that Gooreng Gooreng speakers are known to have participated in such exchanges even though no rhyolitic hatchets have been located beyond Gooreng Gooreng country raises the possibility that these artefacts were manufactured specifically for use and distribution solely within the country of Gooreng Gooreng people.

Hatchet chronology

Despite the ubiquity of hatchets in museum and private collections, their chronology is poorly understood, with very few examples recovered from datable contexts. Edge-ground hatchets appear to have been restricted in distribution to northern Australia until the mid-Holocene, with examples recovered from south-east Cape York Peninsula and Kakadu dating to more than 30,000 years ago (Morwood and Trezise 1989). The earliest evidence for edge-grinding technologies appear in central Queensland highlands assemblages after 4300 BP (Morwood 1981), and after 2500 BP in south-east Queensland (Hiscock and Hall 1988).

Only one of the nine known hatchets manufactured on rhyolitic tuff was located *in situ*. All other specimens are assumed to derive from surface contexts in the absence of information to the contrary. The *in situ* hatchet was found eroding out of the top of a low bank during pedestrian transect surveys bordering Middle Creek at the Ironbark Site Complex. Radiocarbon dates obtained from nearby excavations into this bank at Squares O-P and Q-R indicate that the top 30 cm of the deposit dates to the last 500 years, which provides a maximum age for this hatchet (Ulm and Reid 2000).

Indirect age estimates for rhyolitic hatchet manufacturing can also be derived by establishing a minimum age for quarrying activities at the Ironbark Site Complex (see fig 25.1). Charcoal samples associated with stone artefacts in the basal deposits of the bank immediately adjacent to the exposed quarried material (Square M) were submitted for radiocarbon dating. A date of 1640±150 BP (Wk-6361) represents initiation of use of the bank adjacent to the quarry as a discard area and, by implication, provides a minimum age for associated quarrying activities. The date for these activities, however, is not necessarily synchronous with initiation of reduction at the quarry itself. Stone artefacts manufactured from rhyolitic tuff geochemically consistent with the Ironbark Site Complex raw material have been recovered from the basal levels of Square E2 at Eurimbula Site 1, located some 11 km to the south-east, dating to 3020±70 BP (Wk-3945), raising the possibility that the quarry was in use at a much earlier date (Ulm et al. 1999a). No hatchets, hatchet fragments or evidence of edge-ground artefacts have been identified in excavated assemblages, however, reinforcing the impression that rhyolitic hatchet manufacturing is of more recent origin.

There is also evidence for continuity of use of the Ironbark Site Complex area into the post-contact period, in the form of three glass bottle bases used as cores and dating to around AD 1900 (Ulm et al. 1999b). It is therefore possible that the manufacture of rhyolitic edge-ground hatchets post-dates European invasion of the area, perhaps representing a post-contact transformation in Aboriginal behaviour. A late pre-contact chronology seems most probable, though, given the rapid introduction of European steel hatchets into exchange networks in many areas of Queensland by the mid-nineteenth century. Steel hatchets were given as gifts to Aboriginal people at Keppel Bay, just to the north, by Flinders' expedition in August 1802 (Good 1981: 86; Lee 1915: 174). Mitchell (1848: 325) also noted the presence of steel hatchets at the junction of the Alice and Barcoo Rivers to the west of Gooreng Gooreng country long before any substantial contact had been made with Europeans in the area.

Geochemical sourcing

Geology and geomorphology

Stevens (1968) described a sequence of acid to intermediate volcanic units outcropping along the southern Curtis Coast. In the absence of geochronological determinations, these units were assigned a Triassic age and termed the Agnes Water Volcanics. The base of the sequence, exposed at the type locality, is sandstone (and shale with plant remains). Rhyolitic ignimbrite and trachyte are intercalated with vent-infilling breccias and rhyolitic tuffs and rest unconformably over the sandstone facies. Minor flow-banded rhyolite with fault-bounded contacts and near-vertical flow-banding are interpreted as later intrusions (Stevens 1968). Petrographically, the rhyolitic ignimbrite, rhyolitic tuff and breccias appear to be consistent over 40 km of outcrop, containing trachyte or rhyolite fragments, K-feldspar, plagioclase, partly devitrified glass with minor accessory quartz, pyrite, altered biotite and iron oxides.

The Agnes Water Volcanics unconformably overlie undifferentiated granites of Permian to Triassic age and adjacent Palaeozoic sediments (Ellis and Whitaker 1976). Recent geological mapping of this boundary indicates there is a substantial time interval between the emplacement of the granitic stock, subsequent erosion of overlying sediments, ferruginisation and development of a weathering profile upon this granite and finally re-burial by rhyolitic tuffs of the Agnes Water Volcanics. Importantly, the Agnes Water Volcanics are modelled as draping an uneven granitic land surface, with the thickest accumulations infilling palaeo-topographic lows that now persist as the headlands along the modern coastline.

The quarry at the Ironbark Site Complex is located within an outcrop of rhyolitic tuff to ignimbrite flows that accumulated within one of the palaeo-topographic lows. The rocks are aphyric, containing minor sanidine and/or quartz micro-phenocrysts, and dark green, partly devitrified glass. Lithic fragments of trachyte or rhyolite are noticeably absent from this suite of flow units compared to other outcrops of Agnes Water Volcanics along the coastline, with the greater proportion of glassy material enhancing the viability of geochemical characterisation.

Methods and preliminary results

Sourcing of the hatchets based solely on macroscopic identification raises at least two areas of uncertainty. Firstly, extensive modification of the stone during the manufacturing process (ie flaking, grinding, and polishing) can obscure raw material attributes and may lead to incorrect identification (Wallin 1993: 19). Secondly, all outcrops of rhyolitic tuff on the southern Curtis Coast are visually similar in composition, precluding effective provenancing of hatchets to individual outcrops on the basis of macroscopic examination alone. Conventional forms of petrographic analysis, such as thin-section microscopy, x-ray fluorescence spectrometry and particle induced x-ray emission/particle induced gamma emission (PIXE/PIGE), requiring the physical destruction of a visible part of the artefact, were considered inappropriate because the hatchets are highly valued by contemporary Gooreng Gooreng people.

Laser ablation-inductively coupled plasma-mass spectrometry (LA-ICP-MS) represented an alternative rapid, low-impact technique for obtaining trace element geochemical data at highly sensitive levels and offered a means to provenance the rhyolitic artefacts (Guerra et al. 1999). Moreover the LA-ICP-MS technique is more sensitive to diagnostic elements and elemental ratios, particularly the high field strength elements, large ion lithophile elements and rare earth elements, than the PIXE/PIGE techniques widely applied in artefact sourcing studies (Fraser 1995). Furthermore, Mallory-Greenough et al. (1998) and Gratuze (1999) demonstrated the superiority of ICP-MS when compared to instrumental neutron activation analysis. This paper provides summary details of the first known attempt to use laser ablation-inductively coupled plasma-mass spectrometry (LA-ICP-MS) to provenance artefacts in an Australian context.

LA-ICP-MS is essentially non-destructive, requiring less than 0.2 µm of ablated material for three replicate samples. A further advantage of the technique is that no pre-treatment is required (although sonic cleaning with distilled water is recommended), so analysis does not damage artefacts or introduce contaminants which would affect use-wear and residue studies. The main physical limitation of the technique is the size limits imposed by the sample chamber available (Henderson 2000).

To establish a baseline characterisation of outcrop geochemistry in the region, 60 geological samples were collected from outcrops throughout the region, 31 of which were attributed to the Agnes Water Volcanic sequence. These background samples were analysed by LA-ICP-MS with elemental ratios calculated for each sample. A subset of this group (15 samples) was randomly selected, powdered, and submitted to Becquerel Laboratories for instrumental neutron activation analysis.

In the second component of the study, the nine edge-ground hatchets were analysed by LA-ICP-MS. Before analyses could precede, a custom-made chamber had to be constructed for the LA-ICP-MS to accommodate the large size of the samples. The sampling protocol established during the analysis of the background samples in targeting only areas of more glassy matrix was adopted. For both the background and hatchet assemblage datasets, the 22 elemental ratios generated from the LA-ICP-MS analysis (table 25.3) were reduced to principal components using the statistical package SPSS (v.10.0).

Mg/Ti	Sc/Y	Rb/Cs	Sr/Ba	Y/Nb	Cd/Sn	La/Ce	Ce/Ce*	Tb/Lu	Tl/Pb	Th/Cs
Sc/Ti	Cu/As	Rb/Sr	Sr/Y	Nb/Ta	Cs/Sc	La/Lu	Eu/Eu*	Yb/Lu	Th/U	Ce/Th

Table 25.3
List of elemental ratios calculated and applied as variables in the statistical analysis. *Ratios marked with an asterisk are chondrite normalised ratios calculated after German and Elderfield (1990) and Murray et al (1994)*

Preliminary results from statistical analyses are presented below. The background samples, when reduced to the 1st and 2nd factors and presented in two-factor space, form a partial separation into two clusters. Geological samples obtained from outcrops in the vicinity of two archaeological site complexes, Ironbark Site Complex and the Tom's Creek Site Complex, group together and are separate from all other background samples obtained in this study (fig 25.5). When observed from a geographical perspective, these seven samples outline a palaeo-topographic low infilled with a thick sequence of ignimbrite to rhyolitic tuff bounded by granitic intrusions to the north, west and intermittently to the south (fig 25.2). On this basis, the material in the vicinity of known archaeological sites at Ironbark Site Complex and Tom's Creek Site Complex is sufficiently dissimilar from outlying samples to enable the characterisation of a localised deposit of rhyolitic tuff.

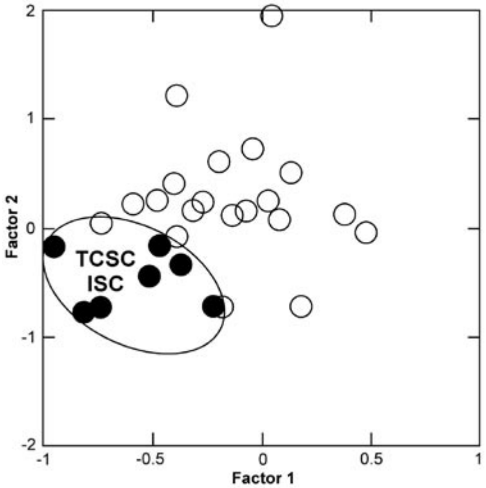
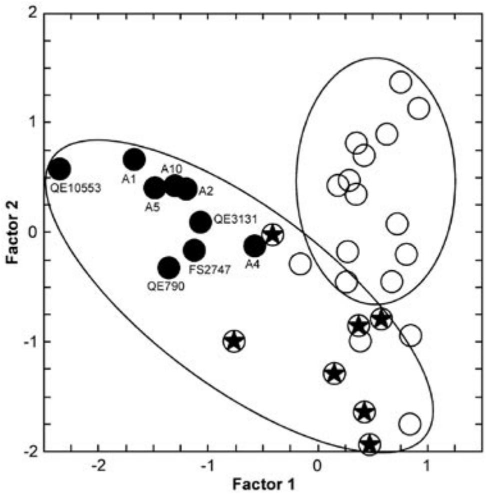


Figure 25.5 *(above)*
Scatter plot of background geological samples after statistical reduction of the ratio variables in factor-factor space demonstrating the grouping of those samples from the Ironbark Site Complex (ISC) and Tom's Creek Site Complex (TCSC) areas. *Open circles denote background geological samples from other locations*

Figure 25.6 *(below)*
Scatter plot of the 1st and 2nd factor scores extracted by principal component analysis of the edge-ground hatchet dataset. *Open circles = background geological samples. Open circles containing stars = the Ironbark Site Complex–Tom's Creek Site Complex rhyolitic unit. Solid circles = hatchet samples with laboratory codes*



The results of the analysis of the edge-ground hatchets are presented in a covariation diagram using the factor scores for the 1st and 2nd factors extracted (fig 25.6). These factors explain 40% of the variance within the dataset. The clustering of the edge-ground hatchet data with the Ironbark Site Complex background geochemical data, but disassociated from the other background samples, lends support to the localisation of the resource to the quarry previously identified.

While the analysis was unable to determine the individual outcrop from which the hatchets were derived, it did indicate the specific region. Significantly, based on the determination of its unique geochemical signature, the LA-ICP-MS successfully discriminated the Ironbark Site Complex quarry from all other known sources of rhyolite within the area. Although all mapped occurrences of rhyolitic tuff have been surveyed for evidence of Aboriginal use, the quarry at the Ironbark Site Complex is the only major Aboriginal quarry of this material that has been located in the entire region, suggesting that most of the hatchet assemblage can be assigned to the Ironbark Site Complex quarry.

Discussion

> Such features of the distribution [of quarried stone] argue that more is involved in the movement of these goods than drives to supply a highly valued technological resource … one could hypothesise the operation of social factors determining the direction of the flow of goods, and providing for re-distribution which influences the fall-off curves (McBryde 1984: 269–70).

The known distribution of rhyolitic hatchets is worthy of comment. The distribution array does not suggest an emphasis on production for local use, as rhyolitic hatchets are not distributed evenly around the possible raw material sources. In fact, only one hatchet is located within the immediate area of known rhyolitic tuff occurrences, with the next example located some 25 km to the west. This impression is reinforced by the absence of hatchets, broken hatchets and edge-ground fragments in excavated and surface stone artefact assemblages observed on the southern Curtis coast (eg Carter et al. 1999; Ulm et al. 1999a; Ulm and Lilley 1999). Resource availability was clearly not the sole determinant of hatchet distribution either, as the area over which rhyolitic hatchets are distributed includes geological sources of other raw materials suitable for hatchet manufacture (eg basalts). Moreover, rhyolitic hatchets do not exhibit any significant reduction in size with increasing distance from the source (see table 25.1), suggesting curation of the artefacts as 'valued goods' (see McBryde 1984: 278; McBryde and Harrison 1981: 201–6). These patterns raise three immediate possibilities:

(1) The distribution array reflects the land-using area of group(s) with direct access to the source materials.

(2) The group/s with direct access to the raw materials were visitors to the areas where discard took place, or

(3) Rhyolitic hatchets (or at least hatchet blanks) were manufactured exclusively for exchange, with direct access groups participating in exchange systems where rhyolitic hatchets were not exchanged beyond groups of related language speakers, perhaps denoting one component of a regionalised interaction sphere.

The restricted distribution suggests that rhyolitic hatchets did not enter secondary exchange networks (cf McBryde 1978: 365), despite the documented participation of people from the region in intergroup gatherings where exchange and redistribution might have taken place. This might mean that conscious choices were made to limit distribution to closely related groups. Alternatively, the limited distribution may reflect a very late chronology for axe manufacture: there simply may not have been sufficient time for widespread distribution between the commencement of rhyolitic hatchet production and local demographic collapse caused by European invasion (see Ulm and Lilley 1999). These speculations are, of course, limited by the extremely small sample size and a lack of data on the distribution of hatchets manufactured on other raw materials and their respective sources. Further, it is possible that the rhyolitic hatchets considered in this study date from the post-contact period. Alternatively, it could be that the probable late chronology of rhyolite hatchet production relates to other late pre-European patterns in the region, such as increasing numbers of sites and increasing rates of site use (cf Morwood and Trezise 1989: 85). A late onset of rhyolitic hatchet manufacture is coincident with other changes in local stone technology after 1500 BP, including an increasing emphasis on local stone resources and expedient technology. In fact, the rhyolitic hatchets are one of the few curated (ie non-expedient) tools represented in the post-1500 BP stone artefact assemblage on the southern Curtis Coast.

Although no specific ethnographic information exists, it is probable that a major resource such as the quarry at the Ironbark Site Complex was owned by a member or members of the local group(s), with rights of access structurally controlled and defined by membership of the local group. Given the specificity of the location of the raw material source in the landscape and its uniqueness the choice of rhyolitic tuff for hatchet manufacture might itself be a marker of corporate social identity. A larger sample size may help resolve whether the distribution array limited to the west and south of the quarry reflects the actual dispersal of the artefacts and therefore denotes land-use and/or exchange strategies.

This project is the first known attempt to use laser ablation-inductively coupled plasma-mass spectrometry (LA-ICP-MS) to establish the provenance stone artefacts in Australia. The study confirms that LA-ICP-MS provides a rapid and virtually non-destructive means of provenancing artefacts. Although the LA-ICP-MS analysis was unable to provenance hatchets to specific outcrops of rhyolite, the technique successfully sourced artefacts to a limited geographical area, thereby enhancing our understanding of regional stone procurement strategies. Furthermore, the technique successfully discriminated between the source areas of the only two rhyolite quarries known in the region. These results are encouraging in the attribution of provenance to rhyolitic sources since it has hitherto been an under-utilised raw material in provenance studies, despite its frequent occurrence in archaeological stone artefact assemblages. The encouraging results presented in this paper suggest that LA-ICP-MS may provide a low-impact alternative to other trace element analysis techniques requiring larger sample sizes.

Further studies will attempt to characterise additional distribution arrays through systematic examination of museum and private stone artefact collections to locate further rhyolitic hatchet specimens and expand this preliminary study by considering the distribution of hatchets manufactured on other raw materials. An expanded sample may help elucidate whether the preliminary distribution array of rhyolite material identified in this study reflects past patterns of residence and/or exchange on the landscape.

Acknowledgements

Excavations and radiocarbon dates at the Ironbark Site Complex were funded by Australian Institute of Aboriginal and Torres Strait Islander Studies Research Grants. LA-ICP-MS provenance analyses were funded by an Australian Research Council Small Grant. LA-ICP-MS analyses were undertaken at the School of Resource Science and Management, Southern Cross University. The construction of the chamber for the LA-ICP-MS to accommodate the hatchets was funded by the Aboriginal and Torres Strait Islander Studies Unit, University of Queensland, and the School of Resource Science and Management, Southern Cross University. Construction of the chamber was undertaken by Redings Engineering, Lismore. For supporting this study we thank members of the Gooreng Gooreng community, especially Colin Johnson, Cedric Williams, and Michael Williams. For making hatchets available for this study we thank the Queensland Museum (especially Dr Richard Robins), the Miriam Vale Historical Society (especially Val Growcott), and Mathew Jamieson.

Our desire to contribute a paper on edge-ground hatchets to this volume reflects the singularly important contribution of Isabel McBryde to our understandings of Australian hatchet production, manufacture, use and exchange and the adoption of a conjunctive approach which encompasses ethnography, typology and petrology.

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