Holocene scraper reduction, technological organization and landuse at Ingaladdi Rockshelter, Northern Australia

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Abstract

This paper proposes a reduction sequence for 'scrapers' found at Ingaladdi rockshelter, Northern Territory. The sequence is based on the proposal that distinctive 'types' represent stages in a continuum and hence may be transformed from one to another as retouching continues. Examining changes in scraper reduction along with raw material selection and core reduction at Ingaladdi through time allows for identification of apparent major changes in land-use and mobility throughout the Holocene.

Introduction

In a series of papers, Dibble (1984, 1987a, 1987b, 1988; 1995; Dibble and Rolland 1992; Rolland and Dibble 1990) has outlined a reduction sequence model that may account for much of the variation in scraper form observed for the Middle Palaeolithic of Europe and the Near East. Many researchers (including Dibble himself) have since begun to test this model of scraper reduction and to explore reduction models for assemblages in other parts of the world (Barton 1988; Close 1991; Dibble and Holdaway 1993; Gordon 1993; Hiscock 1996; Holdaway 1991; Holdaway et al. 1996; Kuhn 1992; McPherron 1994; Neeley and Barton 1994).

Despite a wealth of information collected on typological variation in Australia over many years, reduction sequence models for Australian retouched implements are still few in number (but see Hiscock 1993, 1994a; Hiscock and Attenbrow In Press; Hiscock and Veth 1991). This is despite the great potential that reanalysis of older typological data may offer in developing regional models of stone tool manufacture, use and discard. In many cases, reexamination of this existing database may circumvent the need for time-consuming reanalysis of entire assemblages, and may also offer alternative explanations for assemblage variability at sites that have been central to the construction of Australian spatio-temporal industries.

In this paper, the unpublished data from Sanders' (1975) MA Thesis on scraper variation at Ingaladdi rockshelter is reexamined. The analysis develops a model of Holocene scraper reduction for the site that may be later tested against other sites in the region (Clarkson 2001). Using a number of variables, the analysis examines whether increasing reduction correlates to a consistent progression of morphological changes in 513 retouched artefacts classified into eleven scraper classes. Scrapers are found throughout the Ingaladdi sequence, dated by Mulvaney (1976) to a maximum age of around 7000 years BP.

Placing changing levels of scraper reduction in the context of broader technological changes at Ingaladdi, as documented by Cundy (1990), also illustrates the potential of reduction sequence models to add to our understanding of changing mobility patterns and intensity of site use through time.

Methods of ranking stone artefact reduction

Developing reduction sequence models for retouched implement types requires robust measures of retouch intensity that are independent of blank size and shape. Kuhn's (1990) geometric index of unifacial reduction provides one such technique that is suited to the measurement of the marginal unifacial retouch typically found on Ingaladdi scrapers. A version of this index can be calculated for each of Sanders’ scraper classes by dividing the mean height of retouch by the mean thickness of artefacts. The resulting ratio ranges between 0 (unretouched) and 1 (extensively retouched) and measures the changing geometry of the cross-section of flakes as retouch removes mass from their edges (Figure 1). As the index used here is different to Kuhn's published technique in so far as it uses group means rather than individual artefact measurements, it will be referred to as the ‘average index of unifacial retouch’ (AIUR). This index provides a means of tracking changes in aspects of flake morphology that are sensitive to retouch intensity.

Sanders’ scraper classes

Sanders defined scrapers as 'tools' possessing more than three adjacent retouch flake scars and that were not points, blades, reused points or burins. As Sanders aimed to explore the relationship between tool form and func-
duty chopping tasks (Sanders 1975:21). The way in which Sanders combined size and edge angle to form a variety of scraper classes is depicted in Figure 2.

Sanders also classified scrapers according to a number of secondary variables, such as the type and shape of retouch, to try and identify hafting and the types of materials worked. For example, artefacts with undercut, step flaked edges were inferred to reflect use as hafted wood working implements and were classified as 'adzes' (Sanders 1975:74). Artefacts with concave edges, on the other hand, were argued to have likely functioned as 'spokeshaves' (Sanders 1975:23). Concave edged forms were separated into those with single concavities (notches) and those with multiple overlapping concavities forming a distinctive 'nose' (concave/nosed scrapers).

Sanders also used the names 'casual' and 'deliberate' to distinguish between artefacts believed to represent expedient retouch and discard and those that seemed better designed and executed. 'Deliberate' forms, for instance, were considered more likely to have been hafted, shaped into desired forms, manufactured from 'quarried' stone, widely transported and to have served longer use-lives (Sanders 1975:91).

Notably, Sanders' use-wear analysis did not reveal distinctive patterns of use-wear for each scraper class (see Anderson-Gerfaud [1990] and Beyries [1988] for a similarly poor form-function correlation for European scraper assemblages). In fact, 95% of all use-wear found on retouched artefacts consisted of edge-rounding, a type of wear Sanders followed Kammersa (1971:83) in attributing to the action of 'scraping'. The non-patterning of use-wear traces has important implications for this paper, as it means that variation in retouched implement form must be better accounted for by factors other than tool function.

Sanders was herself aware that resharpening of a tool edge could drastically alter its form throughout its use-life (Sanders 1975:23). Unfortunately, reliable methods for the measurement of retouch intensity did not exist at that time. In the next section the proposition that variation in scraper morphology at Inguladdi could be partly explained in terms of the amount of retouch a specimen has received is examined.

**Reduction intensity as a partial determinant of scraper morphology**

It is possible to develop a reduction sequence model for Inguladdi scrapers by observing changes in four of the attributes Sanders used to classify scrapers as the average index of unifacial retouch increases. These are edge angle, edge shape, retouch perimeter, and retouch type (Table 1). Demonstrating a consistent progression of changes in each of these variables allows each class to be ordered into its relative position in a hypothetical reduction sequence. To begin the analysis the relationship between the AIUR and edge angle is examined.

**Edge Angle**

<table>
<thead>
<tr>
<th>Weight</th>
<th>Small</th>
<th>Low Angle</th>
<th>Low</th>
<th>Casual</th>
<th>Steep Edge</th>
<th>Concave/Nosed</th>
<th>Notched</th>
<th>Steep Edge</th>
<th>Adzes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Large</td>
<td>Small Casual</td>
<td>Low Angle</td>
<td>High</td>
<td>Choppers</td>
<td>Deliberate</td>
<td>Edge Shape</td>
<td>Small Delicate</td>
<td>Small High Domed</td>
<td></td>
</tr>
</tbody>
</table>

Figure 2: Schematic diagram of the combination of attributes Sanders (1975) used to assign artefacts to one of eleven scraper classes.
<table>
<thead>
<tr>
<th>Type</th>
<th>N</th>
<th>AIUR</th>
<th>Median Edge Angle</th>
<th>% Perimeter Retouched</th>
<th>Mean Edge Curvature</th>
<th>% Step Retouch</th>
<th>% Chert</th>
<th>Mean Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small Casual</td>
<td>44</td>
<td>0.20</td>
<td>56</td>
<td>31</td>
<td>0.01</td>
<td>16.7</td>
<td>73.8</td>
<td>6.3</td>
</tr>
<tr>
<td>Low Angled</td>
<td>58</td>
<td>0.22</td>
<td>34</td>
<td>36</td>
<td>0.09</td>
<td>0.0</td>
<td>57.4</td>
<td>13.5</td>
</tr>
<tr>
<td>Large Casual</td>
<td>119</td>
<td>0.33</td>
<td>73</td>
<td>31</td>
<td>0.03</td>
<td>22.7</td>
<td>27.5</td>
<td>33.5</td>
</tr>
<tr>
<td>Small Deliberate</td>
<td>33</td>
<td>0.38</td>
<td>60</td>
<td>54</td>
<td>0.09</td>
<td>16.1</td>
<td>83.8</td>
<td>5.3</td>
</tr>
<tr>
<td>Notched</td>
<td>69</td>
<td>0.41</td>
<td>68</td>
<td>27</td>
<td>-0.22</td>
<td>34.7</td>
<td>53.7</td>
<td>12.2</td>
</tr>
<tr>
<td>Large Deliberate</td>
<td>47</td>
<td>0.50</td>
<td>77</td>
<td>56</td>
<td>0.15</td>
<td>34.1</td>
<td>21.9</td>
<td>51.1</td>
</tr>
<tr>
<td>Steep Edged</td>
<td>40</td>
<td>0.50</td>
<td>98</td>
<td>41</td>
<td>0.20</td>
<td>87.5</td>
<td>62.0</td>
<td>48.6</td>
</tr>
<tr>
<td>Adzes</td>
<td>101</td>
<td>0.55</td>
<td>70</td>
<td>56</td>
<td>0.16</td>
<td>53.4</td>
<td>98.6</td>
<td>4.1</td>
</tr>
<tr>
<td>Concave/Nosed</td>
<td>50</td>
<td>0.61</td>
<td>71</td>
<td>49</td>
<td>-</td>
<td>8.0</td>
<td>29.1</td>
<td>33.9</td>
</tr>
<tr>
<td>Small High Domed</td>
<td>42</td>
<td>0.75</td>
<td>81</td>
<td>54</td>
<td>0.30</td>
<td>54.8</td>
<td>95.9</td>
<td>5.5</td>
</tr>
</tbody>
</table>

Table 1: Summary statistics by scraper class.

<table>
<thead>
<tr>
<th>Spearman’s Rho</th>
<th>Correlation Coefficient</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>AIUR vs Edge Angle</td>
<td>.68</td>
<td>.03</td>
</tr>
<tr>
<td>AIUR vs % Stepped Retouch</td>
<td>.525</td>
<td>.12</td>
</tr>
<tr>
<td>AIUR vs % Stepped Retouch (excluding concave/nosed scrapers)</td>
<td>.72</td>
<td>.03</td>
</tr>
<tr>
<td>AIUR vs % Perimeter Retouched</td>
<td>.67</td>
<td>.04</td>
</tr>
<tr>
<td>AIUR vs Edge Curvature Index</td>
<td>.71</td>
<td>.03</td>
</tr>
</tbody>
</table>

Table 2: Spearman’s Rho rank correlation results for Ingaladji Scrapers.

Wilmsen (1968:160) have drawn attention to the likelihood of a relationship between edge angle and retouch intensity for unifacially retouched flakes. This is because unifacial retouching may reduce the width of a flake without reducing its thickness, in effect bringing the margins closer to the central or thickest plane of the artefact, and causing an overall increase in the angle of the retouched edge (Figure 1). To test whether such a relationship holds for the Ingaladji scrapers, a Spearman’s Rho rank-order correlation was performed between the AIUR and the median edge angle of each scraper class. As seen in Table 2, the result is strong and significant and indicates that edge angle does in fact increase as retouch intensity increases.

Step Terminated Retouch. Sanders also classified scrapers according to the type of retouch present on the margins of flakes, and noted that those with the most “deliberate” retouch often had extensively stepped edges. As the angle of the edge has been shown to increase with retouch, it is expected that step terminations would accrue with increasing frequency as force requirements change and terminations become more difficult to control (Dibble and Pelcin 1995; Pelcin 1997, 1998). A Spearman’s Rho test was conducted to determine whether the percentage of artefacts with step terminated retouch correlates with the AIUR for each class. The poor results for this test are shown in Table 2, and are attributable to a single outlier (concave/nosed scrapers) that exhibits low frequencies of step terminated edges, but quite a high retouch index. Removing this outlier returns a strong and significant result (Table 2). The low frequency of step terminated retouch for the concave/nosed class does, however, warrant some explanation.

White (1969:23) and Lenoir (1986) have both noted that heavily retouched and stepped edges can at times be rejuvenated by removing deep retouch flakes from the edge. The incidence of deep and adjacent concavities that define the concave/nosed class could then represent such an attempt to return a heavily stepped edge to its pristine state. While speculative, this hypothesis could explain both the plan shape of edges and the low incidence of stepped retouch scars in this scraper class. Individual artefacts must be examined in more detail to test this proposition.

Perimeter of Retouch. The proportion of the worked perimeter of an artefact might also be expected to increase if new and adjacent edges are used and resharpened as existing ones are exhausted. As seen in Table 2, a Spearman’s Rho test again confirms a significant positive correlation between the AIUR and the median percentage of edges retouched in each scraper class.

Edge Curvature. Sanders observed that retouch on the edges of scrapers ranged in shape from very concave through to very convex, and partly classified scrapers according to differences in edge shape. As retouch perimeter is observed to increase with retouch intensity, it might also be expected that the retouched edge would become increasingly curved as more of the perimeter is worked. Sanders recorded the number of flakes in each class that exhibited one of five edge shapes. As each of these categories was illustrated in Sanders’ thesis, they
can be converted into an index of edge curvature by dividing the depth of the illustrated curve by its diameter (Figure 3). Using this technique, concave edges result in a negative index while convex edges have a positive index. The results for each edge shape are: very concave (-0.42), concave (-0.18), straight (0), convex (0.18) and very convex (0.42). Because Sanders recorded the number of artefacts with different edge shapes in each scraper class, a mean index of edge curvature can be calculated for each class (Table 1).

A Spearman’s Rho test of the association between the AIUR and edge curvature proves significant (Table 2), and indicates that edges become increasingly curved as the average index of unifacial retouch increases.

Notches are the only class to show a negative (or concave) mean index of edge curvature. Sanders noted that notches were most often represented by a single deep retouch flake scar. It is therefore likely that notches represent early stages in the reduction process rather than a separate reduction sequence. Sanders’ (1975:44, 107) use-wear study also revealed a total absence of wear within these edge concavities, but noted its occurrence along portions of the adjacent margins. This supports the idea that ‘notches’ represent early stages of edge rejuvenation rather than functionally specific forms.

Summary of the effects of reduction intensity on scraper morphology. From the preceding tests it is clear that retouch intensity constitutes an important determinant of scraper morphology at Ingoladddi rockshelter. The morphological changes noted so far appear to take place in a consistent sequence that reflects the steady increase in reduction from relatively unworked through to relatively ‘exhausted’ forms. This sequence can be illustrated as a hypothetical reduction diagram, as seen in Figure 4, and depicts changes to the extent, angle and shape of retouched edges as retouch increases. ‘Notching’ and ‘nosing’ are portrayed as early and late stages in the sequence respectively, although as mentioned above, the relationship between edge concavities and reduction stage warrants further investigation.

Weight as a measure of reduction

Artefact weight was another primary variable employed by Sanders in the construction of scraper classes. Unfortunately, it is not possible to meaningfully examine the relationship between weight and the AIUR for the Ingoladddi scrapers. This is because Sanders’ weight statistics combined both chert and quartzite artefacts, despite noting differences in the size of artefacts made from each of these raw materials.

The difference Sanders observed in the mean size of chert and quartzite scrapers is confirmed by a Spearman’s Rho test of the relationship between mean weight and the proportion of chert artefacts in each scraper group. The results indicate that classes with high proportions of chert artefacts are much lighter on average than those with high proportions of quartzite artefacts (Table 2). Hence weight differences between material types likely disguise any that result from different levels of reduction within raw material types. It is how-

Figure 3: Procedures for calculating the index of edge curvature (retouch depth / retouch diameter). Index of Edge Curvature for a) = 0.45, and b) = -0.16.

Figure 4: Hypothetical reduction sequence of an Ingoladddi scraper, showing the nature of morphological transformation and the position in the sequence that each type best represents (e.g. a) notched, casual and low angled scrapers, b) deliberate and steep edged scrapers, c) adzes and small high domed scrapers, d) concave/nosed scrapers).
ever possible to determine whether mean weight might reflect differences in reduction intensity between raw materials.

**Differential raw material reduction**

Differences in the relative reduction of raw materials may be explored by investigating the frequency with which types representing different stages of reduction are manufactured from either chert or quartzite. Figure 5 plots the number of each raw material type in classes arranged from left to right in order of increasing AIUR. It appears from this chart that quartzite scrapers commonly represent the middle to lower end of the reduction spectrum, while chert scrapers mainly comprise the upper end.

A number of studies (Byrne 1980; Clarkson 2002, Hiscock 1988) have demonstrated that raw materials are often more intensively retouched as they are transported away from a stone source. It is conceivable that distance to stone source may therefore be one factor creating variation in the relative degree to which chert and quartzite scrapers are reduced. Cundy (1990:120–1) has noted that quartzite is local to Ingalaadhi rockshelter with large quarries located within 4km of the site. Good sources of chert, on the other hand, are available no closer than about 25km away. It is therefore likely that at least some of the variability in reduction intensity between raw materials relates to the increased maintenance and conservation of stone artefacts as they are transported further from the source and as replacement materials become more difficult to obtain.

**Changes in reduction intensity through time**

It is also possible to assess changes in relative intensity of reduction through time. Figure 6 plots the frequency of scrapers representing different relative stages of reduction (arranged left to right in order of increasing reduction index) found in the upper and lower units at Ingalaadhi. This graph indicates that higher levels of reduction tend to be present in the upper unit (post 2800 BP) than in the lower unit (pre 2800 BP). This trend is primarily driven by larger numbers of adzes in the upper unit and an abundance of large casual scrapers in the lower unit. As adzes are predominantly manufactured from chert (99%) and large casual scrapers from quartzite (73%), this trend may also indicate the increased use and reduction of higher quality chert materials in the upper assemblage.

**Changes in the organization of technology, mobility and landuse**

Changes to the intensity of scraper reduction and raw material use could reflect significant changes to the over-
increased use of what Cundy terms the ‘standing reserve’ — or the transported supply of material held in reserve for times or places of reduced availability (Cundy 1990:319).

Changes in the upper assemblage after c.2800 years ago represented a continuation of these trends, but most significantly took the form of a shift in the location of primary core reduction from on-site to off-site locations. Accompanying the rise in reduction intensity therefore was an overall decrease in the provisioning of the site with raw materials in the form of cores, which are virtually absent after about 2800 years ago.

Off-site reduction after c.2800 BP typically took place at large quarries and targeted the production of large numbers of standardized, lightweight lancelet flakes that could be incorporated directly into the standing reserve. Lancelet flakes were typically retouched into either highly formalized unifacial and bifacial points through invasive retouching, or into more expedient forms through marginal ‘scalar’ retouching.

Cundy argued that these long-term changes reflected a shift in settlement and land use patterns. This took the form of a shift from frequent, longer occupation episodes, where residents had time to ‘map-on’ to local lithic resources (Binford 1979), to low frequency, short duration occupations in which there was little time to obtain local resources, and hence more emphasis placed on ‘logistic’ procurement of standardized blank forms that served as the mainstay of a portable and maintainable toolkit (Cundy 1990:320; Bleed 1986; Kelly 1988; Kuhn 1995).

Changes in landuse were argued to likely reflect a shift in the structuring of economic activities (such as might be caused by changes to resource breadth or by climatic or environmental change) and could have created a disjunction between daily routine and lithic distribution, creating time-stress (Torrence 1983, 1989), or difficulties in the scheduling of various activities. The mechanism driving technological change might therefore have been increasing unpredictability in the timing and location of subsistence activities and a related increase in residential mobility.

The increased reduction of scrapers in the upper assemblage and the change to off-site core reduction might therefore reflect the increased use of a more intensively maintained and ‘curated’ toolkit that maximized the efficient use of raw materials (Bamforth 1986; Binford 1979; Parry and Kelly 1987; Shott 1986). The increased manufacture of scrapers from higher quality chert, at the expense of locally available quartzite, might also reflect the need for a more reliable toolkit in the face of greater uncertainty over access to replacement raw materials (Bleed 1986). Higher-quality materials probably proved more durable (Gould and Sagers 1985:131) and are typically more conducive to sustained resharpening (Goodyear 1989).

Cundy identified the likely effects that incorporation within the standing reserve would have on the morphology of scrapers. He stated that the ‘more highly structured and extended reduction of material in the standing reserve [produced]...a formal convergence consistent with the pseudo-typological regularity seen, for example, in Australian scraper classifications’ (Cundy 1990:341). This ‘convergence’ of form has been demonstrated in this paper to result from the progression of changes to the shape, angle, extent and type of retouch found on scrapers as a factor of retouch intensity.

Overall, the rise in the intensity of scraper reduction through time probably represents one facet of a broader solution to the increasing problem of maintaining a supply of tools and tool making potential in the face of increased mobility and/or unpredictable access to raw materials. The nature of technological changes at Ingaladdi therefore appear to fit well with Hiscock’s (1994b) argument that the increased use of standardized retouched toolkits in the mid-Holocene served as a ‘risk reduction’ strategy.

Conclusion

Examination of Sanders’ thesis data has allowed the construction of a hypothetical reduction model for the Ingaladdi scrapers. While this model is derived from fairly low resolution data collected for different purposes, it is nevertheless sufficient to identify the existence of the underlying reduction process as an important factor creating variation in retouched implements at the site. The explanation tentatively proposed for changes in stone technology and intensity of scraper reduction emphasizes the operation of ecological and economic processes taking place over many millennia, and suggests that technological changes could result from an increase in mobility and unpredictability of resource availability through time.

While the analysis has proven effective in modeling a reduction sequence for Ingaladdi scrapers, it is not yet possible to state with certainty whether all Ingaladdi scrapers fit within a single reduction sequence. A reanalysis of the individual artefacts would, however, help determine whether this is the case. Finally, while many researchers may be reluctant to make use of older typological data, this paper demonstrates that in at least some cases it may provide a valuable source of data for hypotheses that may be tested against new or original assemblages.

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References


Byrne, D. 1980 Dynamics of Dispersion: The place of silcrete in archaeological assemblages from the Lower Murchison, Western Australia. Archaeology and Physical Anthropology in Oceania 15:110–19.


Lenoir, M. 1986 Un mode d’obtention de la retouche "Quina" dans la Mousterien de Combe Grenal (Donme, Dordogne).


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