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Tenuous Types: Scraper Reduction Continuums in the Eastern Victoria River Region, Northern Territory

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Abstract
To better understand the relationship between changing retouched implement morphology and intensity of reduction, archaeologists must develop measures of morphological change that work outside of, and challenge, existing typologies. This paper attempts such an approach by exploring changes in four aspects of implement morphology as retouch increases, using a population of 'scrapers' - or non-formally retouched flakes - from four rockshelters in northern Australia. The results allow the formulation of a reduction model that accounts for many of the differences in implement morphology that underlie most traditional scraper typologies. The results provide the basis for a critique of an early but influential scraper typology that underlies most Australian classifications in use today.

Introduction

The relationship between implement form and intensity of reduction is emerging as a key issue in international debates concerning the factors contributing to assemblage variation in a wide range of archaeological contexts. Recent studies demonstrate that in many cases a great deal of variation in implement form can be explained in terms of the amount of retouch an artefact has received, rather than simply stylistic or functional differences *per se* (Clarkson 2002a; Dibble 1984, 1987a, b, 1988, 1989, 1995; Gordon 1993; Hiscock 1994, 1996, 2002; Hiscock and Attenbrow In Press-b; Holdaway *et al.* 1996; McPherron 1994; Morrow 1997; Neeley and Barton 1994). These studies strike at the heart of traditional essentialist/typological thinking and challenge the notion that certain common stone artefact morphologies are real, discontinuous and immutable kinds that directly reflect mental templates or the desired end-products of the manufacturer (Dibble 1995; Dunnell 1986; Hiscock 2001, 2002; Lyman *et al.* 1997; O'Brien 1996). In place of those typologies, archaeologists have begun considering ways in which the effects of sequential reduction processes on implement variation might best be depicted (e.g. staged or continuous (Bleed 2002)), as well as the ways in which these processes may expose the non-reality of rigid typologies.

One approach to teasing out the continuums that underlie and connect various implement forms has been to develop sequence models that order individual artefacts according to the amount of reduction they have received, as measured in a variety of ways (see Hiscock and Clarkson, this volume). Somewhat ironically, many of these studies remain locked within the normative typological schemes they effectively undermine. This is best seen in the analyses of changing implement morphology that are undertaken through comparison of measures of central tendency between the type classes themselves, rather than using individual specimens removed from a typological framework.

While these type-based approaches nevertheless go some way toward demonstrating the mutability of implement forms, they are neither the most powerful nor useful means of depicting reduction continuums. This is because the type classes employed are not specifically designed to investigate reduction issues, and hence are unlikely to reveal sequential patterns to maximum effect. As Kuhn (1992b) states, type classes are "created to describe formal variation as observed in the archaeological record, and not to measure the results of some specific prehistoric phenomenon or process. As such [they are] likely to embody the effects of *many* independent influences on artefact form".

An alternative approach to depicting reduction continuums is adopted in this paper. This explores the presence or absence of reduction continuums through the analysis of a series of changes to a number of important aspects of flake morphology as reduction intensity increases. Reduction intensity is here measured using Kuhn's (1990) Geometric Index of Unifacial Reduction. This index has been demonstrated by Hiscock and Clarkson (this volume) to be a robust measure of unifacial reduction for non-invasively retouched artefacts that is relatively unaffected by blank size and shape. The results of this analysis also serve as a spring board from which to evaluate the reality and utility of an influential Australian scraper typology that has served as the basis for many current Australian classificatory systems. The study employs a sample of 338 retouched flakes from four stratified rockshelter sites in the study region, located around 120km southwest of Katherine in the Northern Territory (Figure 1). The principle site, Ingaladdi, has played a key role in defining the industrial sequence for this part of northern Australia (Cundy 1990; Mulvaney 1969; Mulvaney and Kamminga 1999; Sanders 1975).

The need for sequence models in Australia has reached new heights in recent times. At present, most Australian classifications fail to incorporate any understanding of

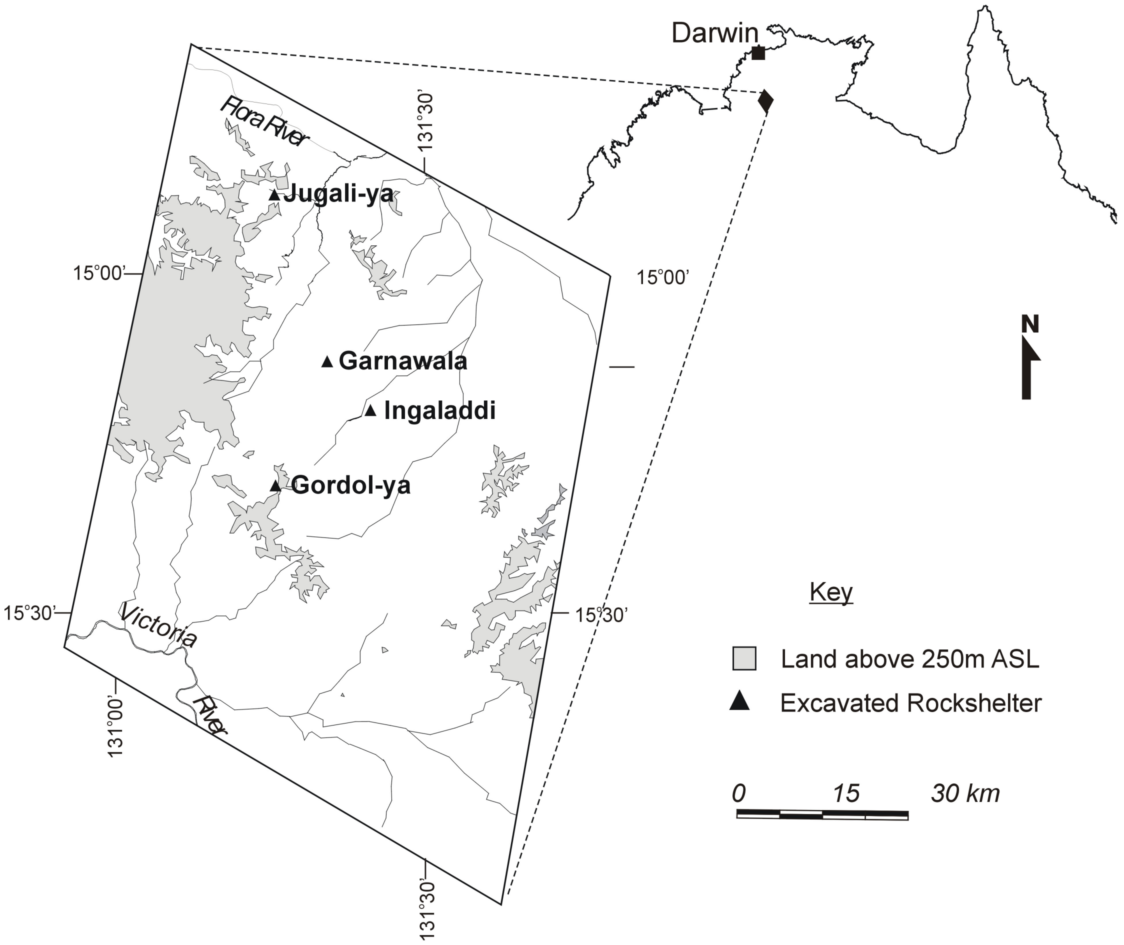

Figure 1. Map showing the location of the study region and the four stratified rockshelters from which the scraper sample is derived.

manufacturing technology, and most take little or no account of the effects that differential reduction may have on assemblage variability despite the growing number of studies that draw attention to this fact (Clarkson 2002a; Hiscock 1994; Hiscock and Attenbrow 2002, 2003, In Press-a, This Volume; Hiscock and Veth 1991). This is particularly alarming since Australian prehistory is largely built on the record of changes in assemblage content over space and time. Consequently, Australian prehistory is fast reaching a point at which it must either tackle the vast gaps in empirical knowledge that surround the causes of assemblage variability in different spatial and temporal contexts, or face stagnation as far as its ability to use stone artefacts to provide meaningful statements about the past. A starting point in redressing this problem lies in the formulation and testing of reduction sequence models at regional scales. This would allow determination of the nature and number of reduction sequences present across space and time, the ways in which knappers responded to situational demands by modifying sequences or switching strategies, as well as the relatedness of individual sequences found in different parts of the continent. This paper offers a step in this direction and contributes to a small but growing corpus of studies that present sequence models for a variety of implement forms from different parts of the country (e.g. Hiscock and Attenbrow 2002, 2003, In Press-a, This Volume; Lamb This Volume; Law This Volume)

Australian Approaches to Scraper Classification

Archaeologists have grappled with the interpretation and classification of scraper variability, or the 'amorphous' dorsally retouched flakes found in many assemblages, since archaeology began. This is best seen in Australia in the multitude of largely incompatible scraper typologies that found their most elaborate form in the period spanning the 1940s to 1970s. At this time scrapers were typically classified and named according to the location of retouch (e.g. side, end, side and end, double side and end etc), the nature of retouch (e.g. nosed, notched, denticulate), assumed function (e.g. knives, drills, piercers, adzes, choppers, planes, scrapers, spokeshaves), the curvature of the retouched portion (e.g. straight, round, convex, concave) overall shape and size (thumbnail, horsehoof, flat) and the steepness of the edge

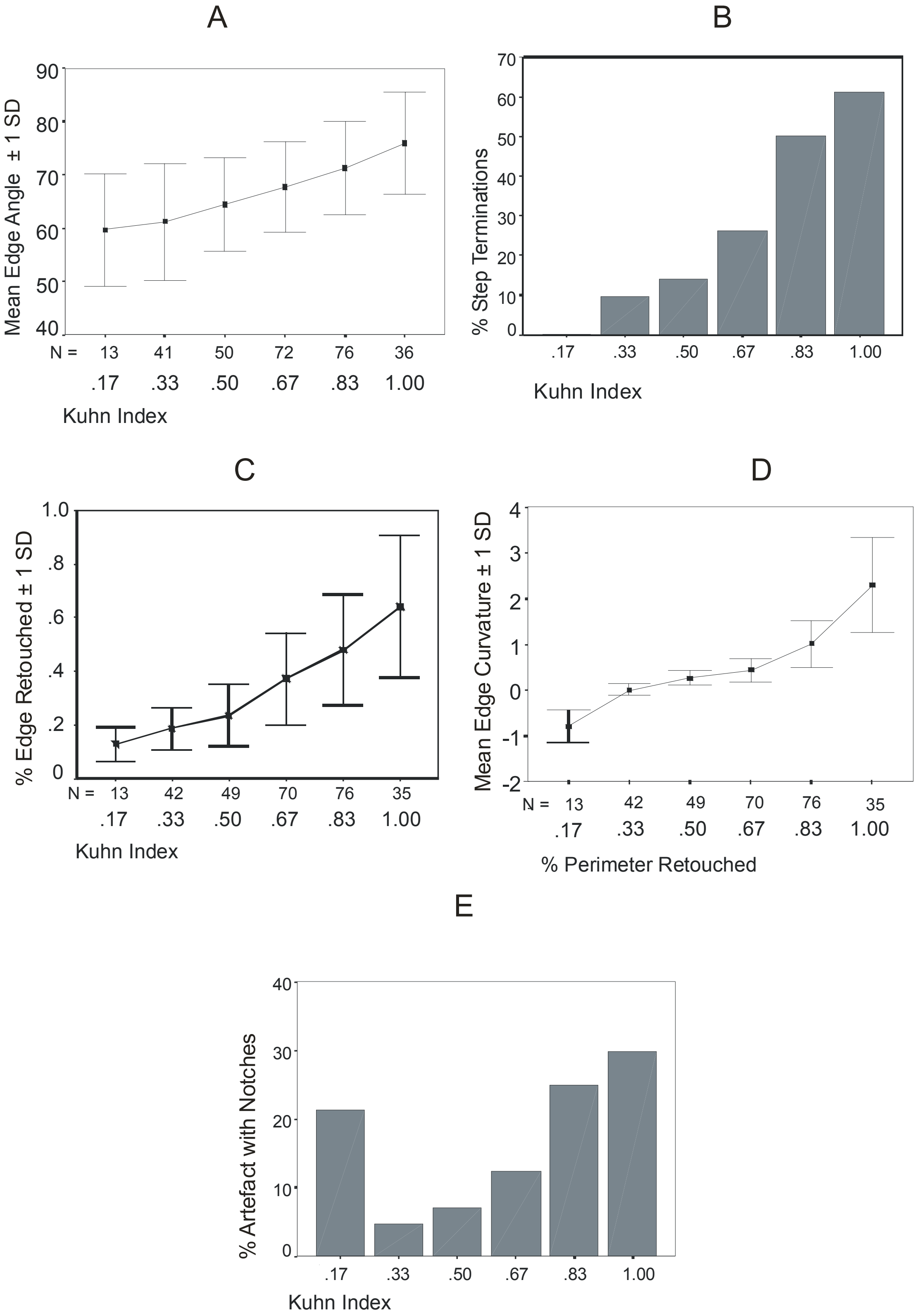

Figure 2. Graphs showing mean changes to scraper morphology as reduction increases.
Intervals of the Kuhn Index are rounded up from 0.166.

(e.g. low angled, steep edged) (Allen 1972; Bowler *et al.* 1970; Clegg 1977; Flood 1973, 1974; Jones 1971; McCarthy *et al.* 1946; Mulvaney and Kamminga 1999; Sanders 1975; White 1969). Combinations of these attributes and names were also employed at various times, usually in unsystematic ways, and often ending in large and confusing taxonomies. Mirroring global trends, Australian archaeologists have tended to attribute the diversity of retouched forms to stylistic or ethnic variation (Bowdler 1981; McCarthy 1948; McCarthy 1949, 1958; Mitchell 1949; Tindale 1957; White and O'Connell 1982), the functional efficiency of tool edges (usually tied to edge angle and edge shape) (Sanders 1975; White 1969), seasonal constraints on toolkit design (White 1971; White and Peterson 1969), efficiency of raw material use (Hiscock 1993; Morwood and Hobbs 1995):183), or design requirements related to hafting (Mulvaney and Joyce 1965).

Characterising Scraper Reduction

The first section of this paper illustrates the possibility of developing a reduction sequence model for north Australian scrapers that accounts for much of the observed variation in implement morphology, by building on past observations of the interplay between various aspects of flake shape and fracture mechanics. This is achieved by observing changes in four aspects of flake morphology as retouch increases, measured using Kuhn's (1990) Reduction Index. These are edge angle, edge shape, retouch perimeter, and retouch termination type - the same four variables that are frequently used to classify scrapers into types (Clarkson 2002). Demonstrating a consistent progression of changes in each of these variables allows flakes to be ordered into a relative position in a single reduction continuum.

Edge Angle

A number of researchers (Dibble 1995; Hiscock 1982; Morrow 1997; Wilmsen 1968:60) have drawn attention to the likely relationship that exists between retouched edge angle and the amount of unifacial retouch a flake has received. In many cases, unifacial retouching reduces the width of a flake without reducing its thickness. This in effect moves the margins closer to the thickest (often central) section of the artefact, causing an overall increase in the angle of the retouched edge.

To examine whether such a relationship holds for the sample of scrapers, edge angle was recorded at the same three locations where retouch height and flake thickness were taken for measurement of Kuhn's Index (see Hiscock and Clarkson, this volume). Figure 2a plots the mean edge angle and standard deviation of scrapers for six intervals along the Kuhn index, and indicates that mean edge angle increases appreciably over the reduction sequence, with all means showing an increase relative to the previous Kuhn interval. The standard deviations, on the other hand, overlap to some degree, indicating that a single morphological continuum underlies these sequential changes.

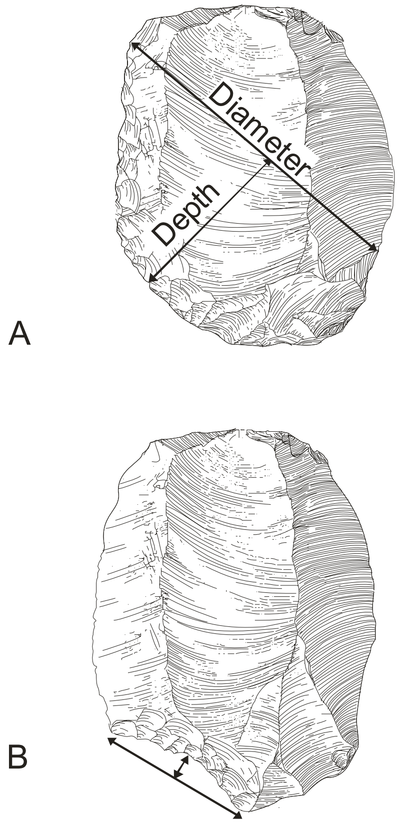

Figure 3. Procedures for calculating the index of edge curvature (retouch depth / retouch diameter). The index of edge curvature for A = 0.5, and B = -0.16.

Step Terminated Retouch

As the angle of the retouched edge is shown to increase with retouch, it is expected that step terminations should accrue with increasing frequency as force requirements change, inertia thresholds are reached, and terminations become more difficult to control (Dibble and Pelcin 1995; Pelcin 1997a, 1998). To explore this relationship, the frequency of scrapers with pronounced stepped retouching is again plotted at six intervals on the reduction index in Figure 2b. This graph reveals a gradual increase in the frequency with which areas of step terminated retouch build up on the edges of flakes as reduction continues.

Perimeter of Retouch

The proportion of the artefact perimeter that is worked might also be expected to increase if new and adjacent edges are used and resharpened as existing ones become exhausted. Figure 2c plots this relationship and reveals a strong trend toward use of more of the perimeter as Kuhn's Index increases. Standard deviations also reveal the existence of continuous variation that underlies and unites the observed changes in central tendency.

Edge Curvature

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. Edge curvature is here calculated by dividing the depth of retouch by its diameter (Figure 3). Using this technique, concave edges give a negative result while convex edges give a positive one. Figure 2d indicates that edge curvature, which begins as a slightly concave edge, becomes highly convex as the Kuhn Index increases.

Notching

Notches, or deep retouched concavities on an otherwise straight or curved margin, are found on a small number of scrapers (N=55, 16%). In her study of the function of scrapers from Ingaladdi, Sanders (1975:44) noted that notches were most often represented by a single deep retouch flake scar, with a total absence of use-wear within these edge concavities, despite noting its occurrence along portions of the adjacent margins. In these cases it seems more likely that notches either represent early stages in the retouching process, and/or early stage edge rejuvenation, rather than a functionally specific feature.

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 notches on the margins of flakes could then also represent an attempt to return a heavily stepped edge to its pristine state. It might also be expected that deep rejuvenating blows of this kind would have a significant subsidiary effect of reducing the average edge angle as well as the number of step terminations remaining on the margin.

Examining the incidence of notching throughout the sequence of reduction reveals that edge concavities are most common in the earliest and the latest stages of reduction (Figure 2e). This trend appears to confirm the operation of two separate reduction processes that may both create concavities on scraper edges: single deep flake scars added to the edge at the outset of retouching, and deep rejuvenating blows delivered to remove stepped and exhausted sections of margins from more heavily reduced scrapers.

Retouch Location

In Figure 4, the changing frequency and distribution of retouch found around the perimeter of flakes is shown as Kuhn's Index increases. For this test, flakes were divided into eight segments of equal length, with the central three segments divided into 'left' and 'right' cells. The light and dark shading is used in this diagram to illustrate the evenness with which retouch is distributed across each of the eight segments. The number in each cell indicates the frequency (expressed as a percentage of all retouched segments) with which that segment is retouched for that interval of the Kuhn Index. The results show a trend from an earlier uneven distribution of retouch that is centred on the distal end and left margin, to a later and more even distribution of retouch around the entire perimeter of the flake.

A Reduction Model for Non-Formal Retouched Flakes

From the preceding tests it is clear that retouch intensity constitutes an important determinant of scraper morphology in the study region. To test the significance of the observed changes in implement morphology, t-tests were performed on adjacent Kuhn Index categories for mean retouched edge angle, the percentage retouched perimeter and the index of edge curvature. The results are presented in Table 1 and indicate that almost all comparisons return significant results. The two comparisons that do not yield significant results are those between 0.17 and 0.33, and 0.33 and 0.5 for mean

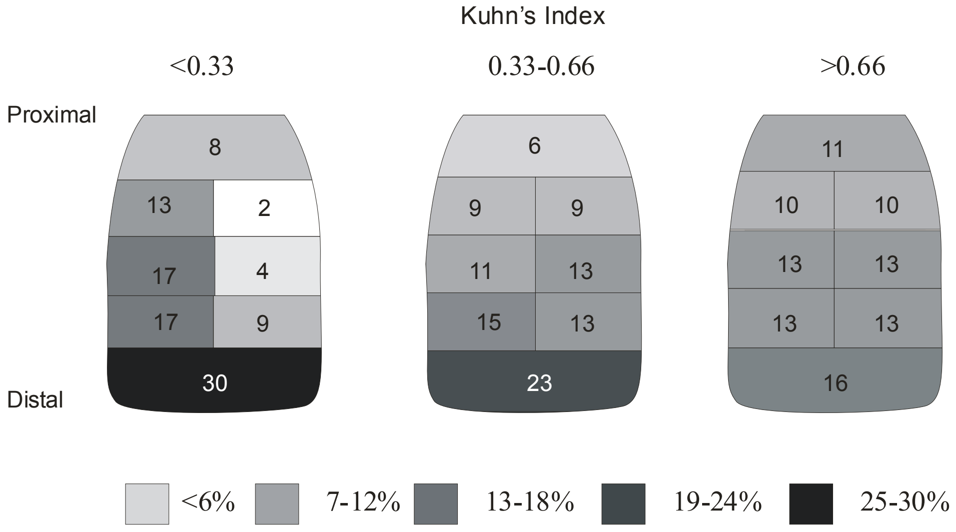

Figure 4. Graphic depiction of changes to the frequency and evenness with which retouch is distributed across eight segments as retouch increases.

retouched edge angle. This result is understandable given that some flakes are steep edged even before retouching begins, and these will naturally overlap to some degree with flakes at later stages of reduction. This problem appears to have disappeared, however, once flakes reach values of >0.5 on the Kuhn Index, and all comparisons return significant results thereafter.

Chi-Square tests were also performed to measure the significance of changes in the frequency of step terminations, notches and the evenness of retouch distribution over the sequence of reduction. The results are shown in Table 2 and indicate the changes over the reduction sequence are highly significant. The correlation between Kuhn's Index and all measures of morphological change also give Spearman's r and Kendell's tau results of 1, and are significant to the 0.01 level.

Thus the morphological changes described above 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 is illustrated in the reduction diagram shown in Figure 5, and depicts the changes to the extent, angle, shape, and location of retouch demonstrated to occur as reduction increases.

A typical sequence might therefore begin with the removal of a single deep flake scar on the left distal, or distal end of the flake, creating a small concavity or 'notch' (Figure 5a). This concavity is subsequently removed as retouch expands around more of the margin, creating a convex edge with a steeper edge angle (Figure 5b). By the time retouch spans around 50% of the perimeter, edge curvature and edge angle have both increased dramatically (Figure 5c). Towards the end of the sequence, retouch has increased to span the entire margin, become very steep and exhibits areas of overlapping stepped scars in several places (Figure 5d). At this stage, edge rejuvenation may be attempted to remove accumulations of step terminations by delivering deep and forceful blows to the edge. This often creates a number of adjacent concavities that can give the implement a distinctive 'nosed' appearance (Figure 5e).

Typological Distinctions and Reduction Continuums

The preceding analysis has allowed the construction of a reduction model that explains much of the variation found in retouched implement morphology. Yet this morphological continuum demonstrated in this case to be causally linked to reduction intensity, is traditionally broken up into a number of discrete scraper types, commonly held to represent real, discontinuous and internally consistent kinds. This can be seen for instance in an early Australian scraper typology devised by McCarthy *et al* (1946), that still forms the basis of many typologies in use today.

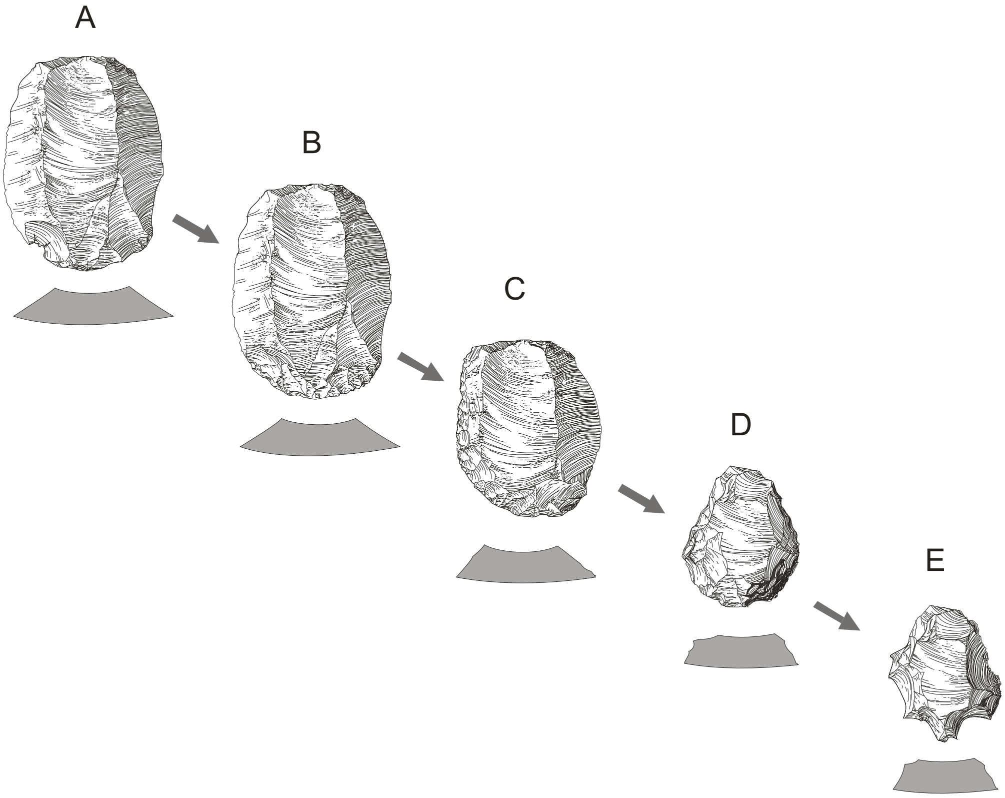

Figure 5. A reduction model for scrapers from the study region.

McCarthy *et al.'s* (1946) typology was primarily constructed around the location of retouch on one or more margins of an artefact, resulting in the creation of eight classes: *Side*, *End*, *Side and End*, *Double Side*, *Double End*, *Double Side and End*, *Double End and Side*, and *Double Side and Double End*. McCarthy *et al.* (1946) also employed five categories to describe the nature and degree of curvature in the plan-shape of retouched edges: straight, convex (slightly curved), semi-discoidal (quite curved), discoidal (very curved), and concave. Combining these two classificatory principles gave classes with labels such as *Semi-Discoidal Double Side and End* scrapers, or *Straight-Edged End* scrapers.

As one of the first comprehensive typologies developed in Australia, McCarthy *et al.*'s system has had a profound influence on later typologies, with many types imported wholesale into later schemes, while the concern for location and shape of the retouched portion also continues to pervade most recent typologies. Size and edge angle are often added to later typologies, however, due to the importance placed on these features as presumed measures of tool function.

Testing the Typology

By plotting each of McCarthy *et al.*'s type classes against measures of both reduction intensity and morphological change, it is possible to evaluate the utility of the typology as an analytical tool in three respects. First, whether type classes provide an accurate depiction of the nature of implement variation as previously demonstrated from individual specimens; second, whether types can justifiably be treated as discrete and tightly bounded entities; and finally, whether typologies focussed on the location and number of retouched margins can provide an effective measure of reduction intensity, as they have been used in the recent literature (Close 1991; Dibble 1987a, 1995; Gordon 1993; Kuhn 1992a; Rolland and Dibble 1990). To address these questions, the same population of 338 retouched flakes was assigned to one of McCarthy *et al.*'s eight scraper classes, using the principles outlined above. As only two *Double End* scrapers were identified in the sample this class was omitted from the following analysis. The mean and standard deviations for Kuhn's Index, percentage perimeter of retouch and the index of edge curvature were then calculated for each class and plotted in Figures 6 and 7.

Both figures reveal that the type classes reflect to some degree the relationships between Kuhn's Index, percentage edge retouched and edge curvature found for individual specimens in the previous section. It is also clear, however, that it is the number of retouched margins rather than retouch location that is driving this trend, as all types with the same number of retouched margins share similar means and even standard deviations in some cases. McCarthy *et al.*'s use of retouch location as a primary classificatory variable therefore serves to split the sample into a number of sets of overlapping groupings that obscure the underlying reduction continuum.

Table 1. t-test results for changes in measures of implement morphology for adjacent Kuhn intervals. Asterisks indicate results are significant at the .05 level. t-test results are calculated using separate variance.

Kuhn Interval	**df**	**t**	**F**	**p**
Mean Retouched Edge Angle				
0.17 - 0.33	49	-.504	.194	.551
0.33 – 0.50	89	-1.527	.657	.139
0.50 – 0.67	120	-2.022	.036	.047*
0.67 – 0.83	146	-2.497	.002	.014*
0.83 – 1.00	110	-2.588	.022	.015*
% Perimeter Retouched				
0.17 - 0.33	53	-3.228	2.087	.003*
0.33 – 0.50	89	-2.425	3.477	.018*
0.50 – 0.67	117	-5.169	10.281	<.0005*
0.67 – 0.83	144	-3.435	2.702	.001*
0.83 – 1.00	109	-3.487	3.967	.002*
Index of Edge Curvature				
0.17 - 0.33	51	-4.269	5.977	<.0005*
0.33 – 0.50	85	-2.249	.111	.028*
0.50 – 0.67	109	-4.178	7.596	<.0005*
0.67 – 0.83	135	-3.404	16.529	.001*
0.83 – 1.00	103	-2.635	8.031	.03*

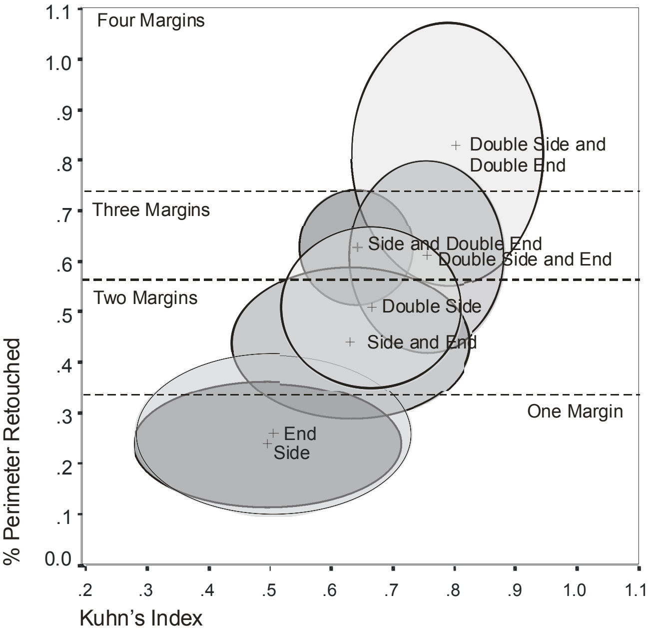

Figure 6. Scattergram showing the relationship between Kuhn's Index and the percentage perimeter of flake margins that have been retouched for each of McCarthy *et al.*'s scraper types. Crosses indicate the mean while circles enclose the standard deviation for that group. The broken lines approximate the point at which new margins are retouched.

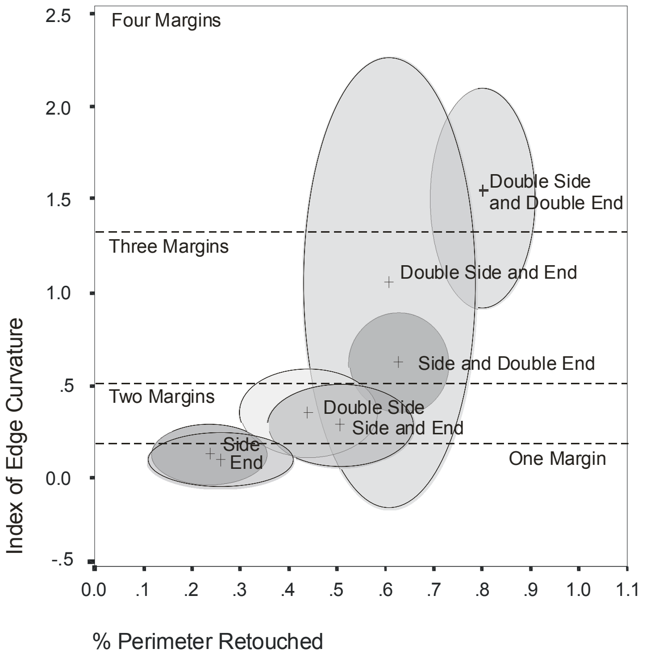

Figure 7. Scattergram showing the relationship between Kuhn's Index and the index of edge curvature for each of McCarthy et al.'s scraper types. Crosses indicate the mean while circles enclose the standard deviation for that group. The broken lines approximate the point at which new margins are retouched.

Table 3. t-test results for comparisons of morphological changes between adjacent types ranked according to their mean Kuhn Index. Asterisks indicate results are significant to the .05 level. t-test results calculated using separate variance.

Type Comparison	**df**	***t***	**F**	**p**
Index of Edge Curvature				
End vs Side	158	-2.12	1.30	0.036*
Side vs Side and End	118	-6.16	6.60	0.001*
Side and End vs Double Side	65	0.79	0.05	0.430
Double Side vs Side and Doule End	11	-2.40	0.18	0.035*
Side and Double End vs Double Side and End	28	-0.76	1.90	0.452
Double Side and End vs Double Side and Double End	41	-1.42	1.55	0.165
Kuhn Index				
End vs Side	171	-0.33	0.09	0.740
Side vs Side and End	123	-3.93	2.87	0.001*
Side and End vs Double Side	68	-5.67	1.30	0.573
Double Side vs Side and Doule End	13	0.34	1.48	0.738
Side and Double End vs Double Side and End	30	-2.06	0.58	0.049*
Double Side and End vs Double Side and Double End	44	-1.05	2.13	0.322
Mean Retouched Edge Angle				
End vs Side	167	1.16	0.01	0.250
Side vs Side and End	122	-3.12	0.21	0.020*
Side and End vs Double Side	68	2.02	0.09	0.070*
Double Side vs Side and Doule End	13	-1.64	0.04	0.130
Side and Double End vs Double Side and End	30	-0.56	0.29	0.646
Double Side and End vs Double Side and Double End	44	-2.08	0.12	0.047
% Perimeter Retouched				
End vs Side	167	0.47	0.76	0.640
Side vs Side and End	123	-8.77	3.80	0.001*
Side and End vs Double Side	68	-1.38	0.14	0.209
Double Side vs Side and Doule End	13	-1.59	1.49	0.136
Side and Double End vs Double Side and End	30	0.21	1.62	0.836
Double Side and End vs Double Side and Double End	44	-3.16	1.19	0.005*

Comparing *t*-test results for morphological changes in adjacent types (ranked according to their mean Kuhn Index) (Table 3) also shows typological divisions to be poorly separated in comparison with those obtained for divisions of the Kuhn Index, with only 37.5% of type comparisons proving significant, as opposed to 87% for Kuhn's Index.

It follows that McCarthy *et al.*'s typology cannot provide an effective measure of reduction intensity, as the criteria employed in the classification (number and location of retouched margins) result in types that directly overlap one another, subsume artefacts from quite different parts of the reduction continuum, and contain vast amounts of variation. In combination, these tests serve to demonstrate that McCarthy *et al.*'s types provide a clouded depiction of the reduction continuum and constitute an unreliable set of categories with which to measure reduction intensity.

Furthermore, standard deviations for all of McCarthy *et al.*'s types in Figure 6 overlap with at least one other class, and in the case of *Double Side* scrapers, overlap the means of five surrounding classes (*End*, *Side and Double End*, *Double Side and End*, *Side and Double End* and *Side and End* scrapers). The same trend can be seen in Figure 7, where *Double Side and End* scrapers overlap the standard deviations of four of its surrounding classes, as well as the means of two adjacent ones. The level of overlap between types can also be illustrated by plotting the distribution of artefacts making up both the least and most heavily reduced classes (*End* and *Double Side and Double End*) against Kuhn's Index and the percentage perimeter retouched. Both types overlap by nearly 50% and contain artefacts that are widely separated from the mean. The extent of overlap in the means and standard deviations of types therefore indicates that the notion that types represent real, discrete and discontinuous 'kinds' that are tightly bounded and internally consistent must be rejected.

That the typology reveals any relationship between reduction intensity and morphological change is not entirely surprising given it is constructed around the number of retouched margins, and this is itself a crude measure of reduction intensity. However, it is also clear that its apparent success in depicting gross changes in implement morphology is only revealed by having independent and quantitative measures of morphology and reduction in the first place.

It may also be the case that far better correlations between the typical (mean) characteristics of types and levels of reduction have been obtained in this study than might be expected in the majority of cases. This is because, in practice, typologists commonly classify artefacts according to 'the most significant' portion of retouch, usually determined according to how 'deliberate' each area of retouch appears, and typically with a view to identifying the 'working edge'. In such cases, it is entirely conceivable that a flake with more than one retouched margin might be classified as a side scraper due to the presence of heavy retouch on a single margin only. Hence, the level of success that any typology will hold as a measure of reduction intensity is also dependent on the degree to which its theory is consistently applied, and the degree to which subjective judgments about tool function or the knapper's intentions are avoided.

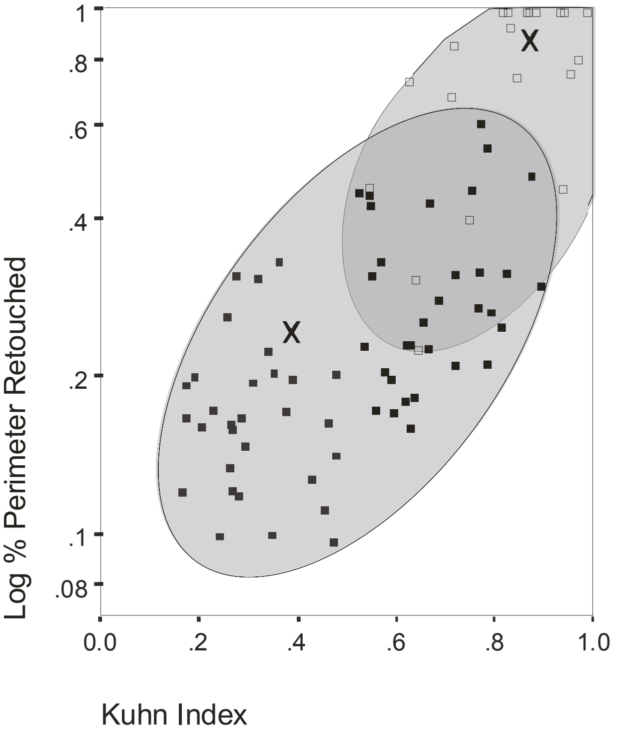

Figure 8. Scatter plot showing the overlap in two of McCarthy et al.'s scraper types (End and Double Side and Double End) that sit at opposite ends of the reduction continuum. Crosses indicate the mean for each type.

Discussion

The conclusion that may be drawn from both the technological and typological analyses presented in this paper is that reduction intensity provides a parsimonious explanation of scraper form, and that tool function or stylistic convention need not be invoked to explain much of this variation. Revealing the continuum that underlies individual typologies illustrates not only that types are not real kinds in and of themselves, but that typologies are unlikely to be effective tools for measuring reduction intensity in most cases.

Taking this point a step further, this study suggests it is unlikely that typologies built primarily around the location of retouch (such as Bordes' (1961; 1972) scheme that includes such classes as side, double side, convergent and transverse scrapers) will provide accurate depictions of the reduction process, particularly compared to analyses that examine continuous morphological variation for individual specimens removed from a typological framework. This suggests, for instance, that a better understanding of Middle Paleolithic scraper reduction sequences could be obtained from technological analyses that explore morphological variation in retouched flakes in relation to a number of independent and quantitative measures of retouch intensity, rather than retaining traditional categories that obscure these processes, as Dibble's (1995) recent analysis of the scrapers from Biache demonstrates.

Turning to the overall significance of reduction continuums as interpretive tools, an important question inevitably arises from studies of this kind; that is, if common implement morphologies are not real and immutable kinds manufactured to predetermined mental templates, or to meet specific functional requirements, but more simply reflect the amount of retouching they have received, then what can this tell us about past human behaviour?

Bleed (2001) points out that in many cases sequence models have come to be associated, at least implicitly, with discussions of risk (Bamforth 1986; Bamforth and Bleed 1997; Myers 1989; Torrence 1989), cost (Bleed 1996), and efficiency (Jeske 1992) in past technological systems. These discussions build on the assumption that the differential distribution of sequential steps and stages through space and time will reflect aspects of planning, land use, ecology and settlement and subsistence patterns effecting people's daily lives (Kuhn 1995; Nelson 1991). It may be then that the recurrence of specific forms in certain times and places tells us more about the degree to which people have had to conserve and extend the reduction of the materials to hand in order to meet novel circumstances or anticipate future needs, than it does about people's cultural preferences or even the functions for which tools are optimally suited.

The growing number of use-related studies that demonstrate poor form-function relationships certainly suggests the need to search for explanations of morphological variability that look beyond tool function alone (Anderson-Gerfaud 1990; Beyries 1988; Bienenfeld 1985; Cantwell 1979; Moss 1983; Salls 1985; Siegel 1984; Spenneman 1986). Furthermore, sequential models provide good reason to consider what effect changes in artefact morphology over the use-life of an implement might have on functional efficiency (see also Hiscock and Attenbrow, this volume).

The ability to document specific reduction sequences also raises the question of whether patterns of technological actions in time and space might encode information about degrees of contact, similarity and distance between the peoples that created different assemblages. This does seem a profitable avenue to explore in future, and particularly since studies of interregional contact and differentiation have recently become popular in Australian archaeology (David and Chant 1995; McNiven 1999). After all, the notion that prehistoric artisans often received ideas about the techniques and range of products they intended to use through some form of social transmission is surely not difficult to accept. As Bleed (2001:122) states:

> it is inconceivable that patterned actions of technology – even those that seem essentially ad hoc and responsive to immediate conditions – can proceed without some kind of "plan" even if that plan is nothing more than a vocabulary of known alternatives.

Despite its potential for investigating social and ecological questions, however, it should be emphasized that a reduction approach to stone implement morphology need make no assumptions regarding the cognitive or social aspects of technology that may underlie perceived patterns, and indeed, nor is it possible for sequence modeling, or any other approach to stone artefact analysis for that matter (including typology), to empirically investigate issues pertaining to the 'intentions' of prehistoric knappers. Moreover, understanding why people used certain techniques and made certain implements and not others also requires that we first develop a thorough understanding of the various constraints placed on technology by the availability and quality of raw materials and the various provisioning systems people employed to cope with different environments, before we may progress to comparisons of variation and central tendency in regional reduction sequences.

Conclusion

The purpose of this paper has been to illustrate that a reduction sequence approach to describing the transformative nature of flake morphology is effective, and that much of the variation in scraper forms seen, at least in northern Australia, can probably be explained by differing degrees of retouch intensity. By drawing attention to the problems that exist with typology as a means of understanding the reduction process, or as measures of reduction intensity, it is hoped that archaeologists will begin exploring techniques that emphasize materialist/technological approaches to the description of assemblage variation over essentialist/typological ones.

In conclusion, it can be argued that reduction approaches offer archaeologists a chance to begin exploring what assemblage-level variation in reduction intensity might mean in terms of mobility patterns, uncertainty in the scheduling and location of activities, and its effects on settlement and subsistence systems, and perhaps even the nature of inter-regional contacts and connections. Such an approach offers a chance to significantly advance Australian lithic studies, and allows exploration of the implications of technological and typological changes free from the stylistic and functional straightjacket of traditional archaeological thought.

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