# Deciphering the behavioural heritage of knapped flakes

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**Abstract:**

The major dimensions of a flake are shown to accurately capture how a knapper's actions manage the impact dynamics responsible for flake formation. When weight and density are also known, those same dimensions convey essential information about the volumetric geometry of a flake, including basic flake shapes typically valued for tools or to control core morphology. Combining the complementary modes of information allows the culturally imbedded heritage of a removed flake to be sufficiently represented that lithic analysts can reliably evaluate the mechanisms of flake formation without needing to be skilled flintknappers themselves. Presuming that habits of making flakes are culturally determined, it should be feasible to distinguish signature traits between lithic traditions.

**Keywords:** flake morphology; knapping behaviour; impact dynamics; fracture mechanics

## 1. Introduction

Flakes are the residue from one of humanities earliest technological advances and certainly its most persistent; in fact, the vast majority of archaeological evidence consists of flakes. Archaeologists routinely associate flakes and their scars with knapped tools presumed to be responsible for their creation but, unfortunately, there is no universal guide for interpreting the information available from flakes. Identifying for certain how a stone tool was made is complicated by the equifinality problem, referring to the difficulty in discerning the distinction between separate means of achieving the same result. There are three basic modes of archaeological flake manufacture: direct percussion, indirect percussion, and pressure. Each mode can be accomplished by myriad knapping tools and their capabilities are known to overlap considerably. A practical approach for examining the relationship of flake formation processes to cultural behaviour and decision making would be of significant value for resolving the manner in which early people formed their lithic tools.

Since few present-day practitioners create stone tools in a traditional context, analysts typically must rely on comparing attributes of recovered flakes with those whose knapping tools and manner of use are documented. Optimally, this requires an exhaustive survey of all possible knapping tools and knapping processes, a daunting task for anyone and not practical for the typical lithic analyst. Practicality often dictates that analysts rely on their limited personal experience. Furthermore, most professional archaeologists lack the time to become

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sufficiently proficient in diverse flintknapping techniques. Controlled experiments that make flakes by dropping steel balls on the edges of plate glass may seem to emphasize the difficulty with comparing mechanically produced flakes to archaeological examples. However, Pelcin (1996) succeeded in isolating particular variables that were responsible for producing the important attributes of flakes. This paper resolves the few variables deemed important by Pelcin into quantifiable indices that can be easily applied to general archaeological investigation by representing specific attributes of knapping behaviour, core morphology, and reduction strategy without requiring input from a practitioner of lithic technology. The goal is to demonstrate how ingrained habits of knappers produce unique, quantifiable characteristics in flakes that allow assessment of how knapping tools and cores were physically manipulated within specific lithic traditions.

### 1.1. Limitations of fracture mechanics

Fracture mechanics, as exemplified by Cotterell and Kamminga (1987), provides essential insight into the tripartite phases of initiation, propagation, and termination of flakes, each with their separate mechanisms that contribute to flake formation. However, Cotterell and Kamminga are careful to point out that they have described only the most basic mechanisms. Although fracture mechanics allows prediction for fracture paths within geometrically simple objects like thin rectangular plates, real-world cores and bifaces are currently beyond our computational reach. The kind of information necessary for deducing culturally relevant information may be found in empirical extrapolations of artefacts and experimental replications of their important features. Rather than attempt to isolate individual attributes, my approach is to capture the cumulative effect of knapping gestures and decisions. Each flake should contain observable evidence of the culturally transmitted knapping behaviour of the craftsman.

Pelcin (1996) noted that "variation in core morphology may be the most important independent variable for the production of dimensional flake attributes." For computational simplicity, many researchers remove flakes from the edge of plate glass, simulating the longitudinal centre plane of a wider and more complex-shaped core. Extrapolation from plate-like cores to complex-shaped cores may be dubious. Typically, the test core is immobilized in a holding devise that does not represent a hand-supported core and seems more representative of pressure flaking than percussion. Aspects of impact dynamics that will be discussed later bring the relationship to practical knapping behaviour into question.

## 2. Methods

The study in this paper draws heavily on experiments conducted by Andrew Pelcin, who determined from exhaustive controlled experiments that indenter type and core surface morphology are the primary independent variables responsible for the linear flake attributes of length, width, and thickness (1996:318). The remaining independent variables (indenter mass, indenter velocity, indenter diameter, platform bevelling and width) were found to determine the mass of the flake. Mechanisms responsible for the flake dimensions were not within the scope of Pelcin's study, but impact location was shown to determine how deep beneath the core surface a fracture will travel and the remaining factors relate to the kinetic energy available to promote fracture.

Later, when Tony Baker (2002) decided to simulate fracture paths by computer, he used Pelcin's data as a control to calibrate his modelling. Observed differences between Baker's model of Folsom fluting and archaeological data prompted replication trials conducted by Patten (2005) in order to bring modelling into agreement with actual knapping practice. Even after Baker simulated dynamic loading through finite-element analysis to describe and validate variables controlling the path of fracture, practical application of the results for interpretation of archaeological material was limited. Baker subsequently used a "dynamic loading model" (2004) to explain discard of hand axes, raising the prospect of applying the same concept to describe individual flakes in terms of the conditions responsible for their creation. Although data from Pelcin's early study provides an unbiased test of the dynamic loading model, he produced flakes under mechanical conditions not obviously relevant to archaeological material. Therefore, a new set of data was developed by collecting flakes made by deliberately contrasted methods of manufacture considered relevant to actual practice.

The data used for this study reflect measurements of ninety six reference flakes that were knapped with antler billets and hard hammer stones, using direct and indirect percussion, with both unyielding and minimal core support in a conscious effort to provide a comprehensive data set representative of diverse knapping methods and tools. Flakes were selected from all stages of reduction, whether the flake satisfied the knapper's intended morphology or not, because the goal was to identify characteristics that reveal underlying culturally-influenced knapping behaviour. To avoid potential bias and ambiguity, dimensions gathered for this study are standardized as maximum measurements. Correlating the major dimensions of flakes with the behaviour responsible for their proportion allows the knapping action to be expressed as an index representing a metric property that may provide distinctions between lithic traditions. Relative conformance of that property should be useful for determining how uniformly a tradition adhered to culturally standardized processes.

In his exhaustive study of the relationship between flake attributes, Pelcin (1996:320) concluded that "flake mass is an ideal attribute through which to examine the changes produced on different core types, with different indenter types, and/or bevelled platforms without concern for the effects of these independent variables." Since mass is a function of volume it seems appropriate to find a way to relate the major dimensions of a flake to its volume. Shapes of flakes are too complex and variable to be exactly modelled, but Patten (2007:71) found that flake volume could be represented by a percentage of a box volume represented by the flake's maximum dimensions of length, width and thickness. Since flakes that fill their boxed volume are relatively stiffer than those which do not (Patten 2005:190) the boxed representation of a flake's geometry will be used as a proxy while describing the mechanical properties of a flake. Comparing the boxed volume of a flake to volume derived from weight provides information about how the mass of a flake is distributed.

## 2.1. Causes of dimensional flake attributes

Rather than depend on arbitrary landmarks or flake typologies, the dimensional flake attributes suggested by Pelcin (1996) are reviewed in order to appreciate how knapping decisions and behaviour contribute to each of those critical dimensions.

Length of a flake reveals how impact at the platform transmits sufficient stress some distance from the impact site in order to detach the flake from its parent core. For a fracture to extend the full length of the core or biface, the core had to be subjected to critical bending stress throughout that distance. If only inertia counters the force of impact, then the fracture is not likely to reach further than the centre of mass. For the flake to travel further than that, the core must be supported by the knapper's hand-hold or an anvil. However the knapper thinks about the support, the path of the flake is automatically directed to the strongest point of resistance to the blow. Fixing the preform to a support serves to direct the flake toward that point of support. Therefore, consistently directed full-length flakes indicate that support was deliberately applied to the location on the edge where the flake was expected to travel. Flake length is obviously related to biface width, particularly when full-length flakes are utilized. Angle of blow, amplitude of impact, and choice of knapping tool all contribute to determining the direction and force that had to be countered by the support. Rotating the support against the direction of blow can cause flakes to arc dramatically from edge-to-edge. The arc of fracture flattens in proportion to the opposing counter-rotation to the blow. Regardless of all other factors, the fracture will progress only as long as load is applied to the platform. It is therefore desirable to introduce a flexible support for the core, in order to maintain tool contact until the fracture can be completed.

Thickness of flakes is primarily controlled by how far the impact is offset from the face of the core or biface (Patten 2005:76). Maximum flake thickness is often in the bulb of force, which Cotterell and Kamminga attribute to Hertzian initiation during hard hammer percussion (1987). Blows directed perpendicular to a platform surface typically cause the most severe swelling of the bulb of force. Support of the core and magnitude of blow also have much to do with how far the fracture travels below the surface morphology. Flexible support can allow fractures to travel in an arc near the exterior surface while nearly plane fractures, promoted by very stiff support conditions and inertial mass of the knapping tool, may remove a flake of considerable thickness.

Width of flakes is primarily controlled by surface morphology because prominences, such as arrises, stiffen and guide developing flakes. Thicker flakes generally appear to be less affected by surface morphology, but are necessarily wider than if the fracture were shallow. Knappers familiar with how surface morphology guides flake shape can intuitively draw a predicted flake outline with considerable confidence. The most common source of error is simply that the actual depth of the fracture is greater or less than anticipated, meaning that flake width is usually dependent on thickness. A knapper controls the intended outline and thickness of the flake through a combination of conscious decision and cultural influence.

### 2.2. Dynamic loading effects

Fundamental tools and techniques have long been understood to generally involve using hammer-stones to break apart large rocks, soft hammers to thin bifaces or smaller cores, and pressure tools to refine edges. Each basic tool set overlaps greatly in capability because they conform to the same physical properties. As such, hammer-stones can be used to make projectile tips rivalling those made by soft hammer or pressure. Knapping tool kits are distinguished primarily by their size, density, and stiffness; properties that influence how tools transmit force to an object. Each component of a knapping system, including the craftsman, can be described as springs each having characteristic rates of compression and rebound. Stiffness of a spring is described mathematically as dividing the load by the amount of deflection. Since the interaction is dynamic, the rate at which the load is exchanged between components of the complete knapping system is critical. Too stiff a spring action, (i.e. hammer-stone) can shock the impacted object and cause shatter or irregular fracture paths when there is not enough time for the parent rock to distribute the stress. A weaker spring action (i.e. soft hammer) allows the incipient flake time to bend away along a smoothly arced path of fracture. Not only does the spring principle explain the effects of impact, it can help us understand many of the common defects that plague flintknappers.

If the core is too stiff or the blow too fast, the crack will not have time to run its full course before contact is lost as the hammer bounces, allowing hinges to occur as they use up energy stored in the core. Step terminations are different than hinges and occur when energy is insufficient to propagate the crack. Increasing support, whether by grounding the object against an anvil or gripping with the hand more tightly, can add stiffness that increases fracture speed, while freehand support reduces stiffness and lengthens the time available for a fracture to complete because the object takes longer to compress and rebound.

The shock of impact during percussion is a transient phenomenon expressed by the duration and amplitude of energy. Because the hammer and the core each have a characteristic rate of compression and rebound, their impacting frequencies may not correspond to each other. However, to obtain the longest flakes requires matching the duration of a complete impact cycle between hammer and core because a fracture can progress for only as long as the hammer and core remain in active contact. As the frequencies of the hammer and the core approach each other, their energy amplitudes combine and produce the maximum level of energy when the impact frequencies match exactly.

Any hammer can be easily mishandled, causing damping of impact to yield a poorly-formed flake indicating an undesirable interaction between the core and hammer, typically resulting in exaggerated conchoidal-shaped fracture, hinge termination, and a generally short flake. However, impact that appears to be matched with the support frequency produces the flakes with the shallowest ventral features, like undulations, that are capable of travelling the furthest.

A knapper must manage energy amplitude by actively avoiding energy damping effects. Clamping a core in a holding devise effectively binds the core to a larger mass and increases the energy necessary to initiate fracture. Even holding a preform in one’s hand dampens the energy available for fracture, so the lightest possible support is recommended. Inertial mass sets a practical minimum support. Wielding of the hammer follows the same prescription - lighter is better - as long as sufficient energy is available. Tension in the muscles of either arm can be equally detrimental to effective flake formation. Stone hammers are generally spherical because the vector of impact automatically passes through the centre of mass of the hammer. Since antler batons are not spherical, any impact other than longitudinal can cause vibration that may interfere with frequency matching. The effect may be negligible for light flaking but is crucial for driving full-face flakes from a core or biface.

Baker (2004; see also Bradley, et al 2010:45) provided plots of length vs. SQRT(width × thickness) for various core configurations to illustrate how resistance of the core to dynamic bending load apparently imposes limits on the proportions of hand axes at abandonment. The prospect of using basic dimensions to objectively quantify the resultant behaviour of unique knapping traditions is intriguing. Rather than having to deal with a primary product, it seems advantageous to study the removed flake. Not only is the stage of production not critical, flakes are far more numerous and less subject to subsequent modification through use than the functional tools or cores they were derived from. Baker’s “dynamic loading model” can be thought of as illustrating how support of the impacted object counters deflection introduced by impact.

$$\text{Dynamic Loading Model number (DLM\#)} = (\text{Width} \times \text{Thickness})^{1/2} / \text{Length}$$

Although the expression was empirically derived, it explained 97 percent of the variation in Levallois core dimensions. The DLM# allows characterization of impact via a number derived from the dimensions of a flake. The expression is independent of scale and thus should be equally applicable for any size of flake.

## 3. Results

The DLM# roughly characterizes how the impact frequencies of hammer and core interact. The higher the DLM#, the greater will be the mismatch in impact frequency between hammer and core. Since the history of a flake’s formation is condensed into a single value by the DLM#, it can be treated as an index value that describes a fundamental numeric property of a flake. Maximum measurements of flakes were divided by thickness to make them non-dimensional in order to avoid distortions that would have been introduced by scale. Flake thickness is more readily controlled by a knapper than any other dimension and actual measurements could be easily compared to the proportional data set.

The proportional major dimensions were then plotted against the computed DLM# to see what correspondence might be evident (Figure 1). Because the major dimensions describe a box volume that is not equal to the volume determined by weight, a separate volumetric index was plotted against DLM# to assess the influence of how flake mass was distributed. As detailed in the following sections, graphic depiction of the data led to important implications for improving lithic analysis.

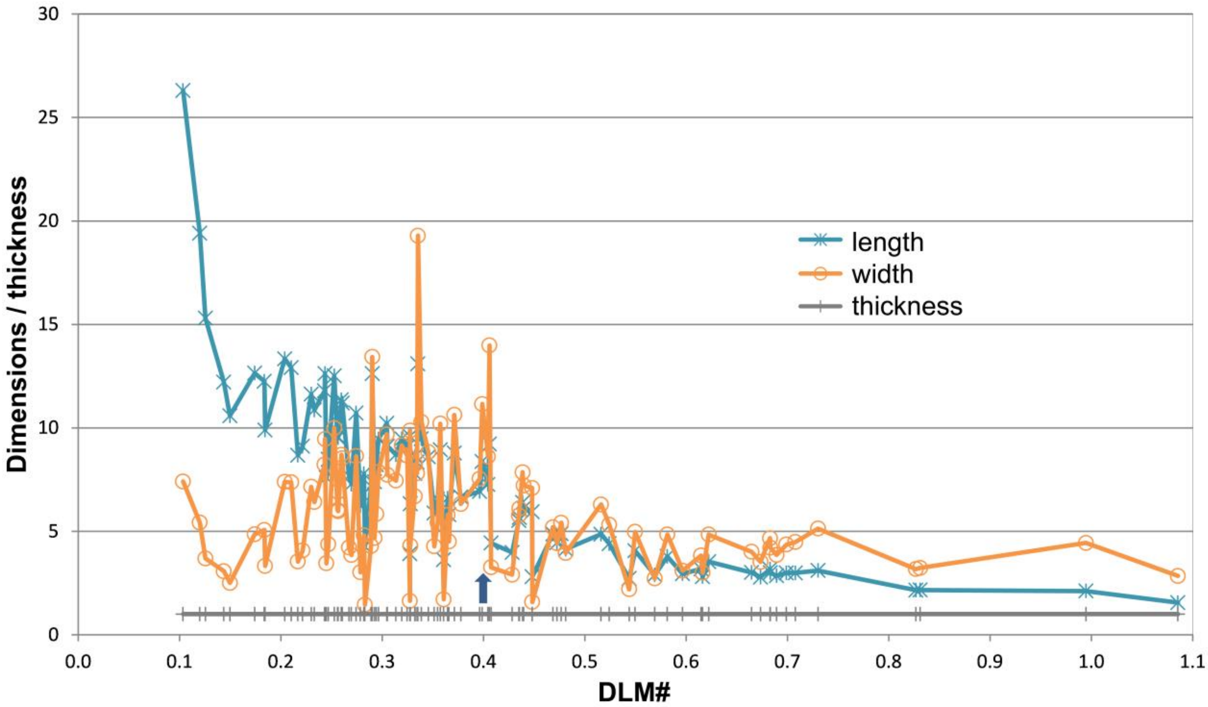


Figure 1: Co-variation of flake dimensions is shown by plotting the behavioural (DLM#) index in relation to major flake dimensions (divided by thickness to illustrate proportionality). An arrow indicates a discontinuity separating marginal flakes on the left from off-margin flakes on the right.

### 3.1. Indexing by behaviour

When the DLM# was plotted against proportional maximum dimensions (Figure 1), an apparent discontinuity was revealed between major regimes at a DLM# = 0.4, most visibly represented as reversals in flake length to width proportions. Fortunately, data were available as to whether each flake was removed by impact on the margin (edge), or off-margin (away from the edge). Ninety percent of the margin and non-margin flake assignments agree comfortably with the division by DLM#. The importance of where a blow lands may be understood by realizing that experience with knapping trains the craftsman's body to automatically increase muscle involvement when preparing to strike a point on the platform offset from the flaking face in anticipation of the additional fracture strength of the stone that must be overcome in order to remove a thicker flake from the core. The distinction corresponds to the difference between a striking an object supported only by inertial mass and one braced against impact, allowing DLM# to be characterized as an index that captures the cumulative expression of knapping behaviour based on stiffness. Off-margin flakes are initiated either by Hertzian fracture that is accompanied by a bulb of force, or as a wedge (Cotterell and Kamminga 1987:698). Furthermore, the flakes can be so thick that they demand more energy than is delivered by the blow, which leads to step and hinge terminations. High DLM#’s (> 0.4) represent increasingly stiff flakes from cores that need to be well stabilized against movement. Marginal flakes are routinely made by soft hammers, while hard hammers are seldom used to strike an edge. Flake initiation from an edge occurs by a bending initiation that leads to a stiffness-controlled propagation and compression-controlled feathered termination (Cotterell and Kamminga 1987:697-698). Low DLM#’s (< 0.4) represent flexible flakes that are most readily produced with yielding preform support.

The effect of knapping behaviour on DLM# values is supported by subjective observations (Table 1), where the manner of blow delivery is seen to sometimes favour one regime of fracture mechanism over another. There is a strong correlation between muscular reinforcement of a blow and where it lands for DLM# values < 0.4. However, the association is less clear for DLM# values > 0.4.

Table 1: Subjective data regarding the manner of blow delivery for each flake show that the mechanisms of fracture are greatly affected by how a knapper delivers a blow.

| # of flakes with DLM# < 0.4 | # of flakes with DLM# > 0.4 | Manner of blow delivery |
|---|---|---|
| 11 | 32 | indirect rocker punch |
| 25 | 28 | direct percussion |
| | | |
| 6 | 41 | relaxed blow |
| 30 | 19 | forced blow |
| | | |
| 6 | 54 | margin impact |
| 30 | 6 | off-margin impact |

That a dimensional expression can characterize flake formation under dynamic loading without introducing properties of materials may seem unlikely, but when we recognize that the regimes defined by the DLM# operate with distinctly different mechanisms of fracture, it is less mysterious that linear dimensions can be used to pick them out. After all, each mechanism distributes stress differently through the impacted object.

A knapper uses biofeedback to intuitively manage the relation of impact and support in a manner that strives to optimize the effective extension of a flake. In turn, the dimensions of the flake quantify how effectively the knapper achieves his goal. It thus seems appropriate to use the DLM# as a meaningful measure of knapper skill in that it reveals how well the craftsman uses biofeedback to manage a mechanical collision between two objects of variable size and material composition. Skilful manipulation of less than optimal tools can lead to low DLM#'s, meaning that the index reflects the resultant action instead of a contributing component.

### 3.2. Indexing by flake volume

The boxed volume of a flake was found to approach double that of the actual volume for a long prism shape or six times that of the flake when it resembled a slender wedge. Long, flattened flakes are inherently flexible while more compact shapes are relatively resistant to bending. Specific conditions can be shown to affect one dimension significantly more than another but the geometric properties may still retain a degree of interdependence.

Comparing volume ($V$), determined by dividing the weight of a flake by its density, with box volume ($V_B$), based on major dimensions characterizes the extent to which the flake fills the box volume. Lower values can be seen to indicate flakes where edges parallel the box frame, while flakes with high ratio values generally have complex shapes. Those distinctions can be roughly correlated to stages of manufacture and specialized flake shape requirements as diverse as blades or expanding flakes. Although many knappable materials have essentially the same density because they are commonly composed of silica, care should be exercised to confirm density when determining volumes from weight. Substituting other than maximum dimensions would also distort the volumetric ratio.

The volumetric index has the potential for identifying the use of deliberate strategies designed to provide specific flakes for use as tools or to control core morphology. Although we cannot expect all knapping to resolve into tidy categories, there is reason to continue with this line of investigation because of the prevailing human tendency to conform to actions of those around us. The range of variation displayed will bear witness to how tightly (or not) people adhered to process controls. Low variability may be interpreted to mean that rigid controls were utilized (Patten 2012).

### 3.3. Combining the behavioural index with the volumetric index

The DLM# identifies whether a flake is formed by a stiffness-controlled fracture in the case of marginal impact, or a compression-controlled mechanism in the case of off-margin impact. On the other hand, $V_B$:V describes how the volume of a flake is distributed, with low values representing narrow, thick flakes and high values representing wide, thin flakes. Mapping the two indices in a matrix (Figure 2) therefore conveyed an extraordinary amount of specific information about individual flakes.

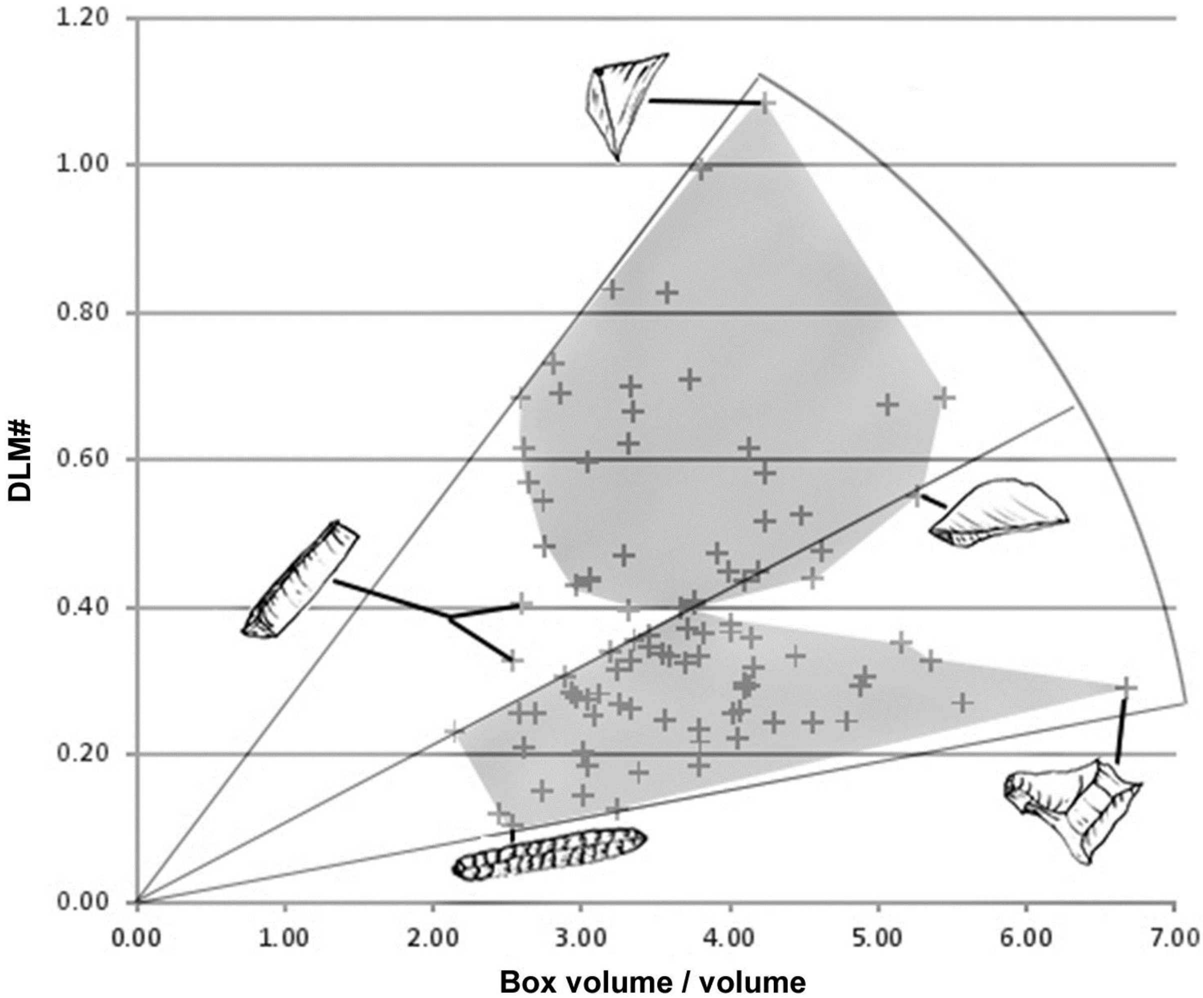


Figure 2: Data mapped as a matrix with the behavioural index (DLM#) on the vertical axis and the volumetric index (box volume divided by volume) on the horizontal axis. Shaded areas of the matrix emphasize how data is separated into two regimes of flake mechanics. The role of flake geometry is illustrated by the morphology represented at selected specific data points.

Despite an earlier suggestion that the volume of a flake may be a set percentage of the box volume (Patten 2007:71), the matrix shows that that only applies to flakes from a particular stage of reduction or from a similarly shaped core. Otherwise, using the boxed dimensions of a flake to derive the DLM# seems to remain valid since the matrix highlights the appropriate volumetric relationship.

Radial trends in the matrix plot are associated with gross morphological trends. The central portion of each radial sector is generally represented by flakes that are thickest in the centre and have nearly equal length and width. As DLM#'s decrease, relative thickness decreases. Increasing VB:V ratios lead to progressively more acutely feathered distal flake terminations as the DLM# decreases. Flakes with low VB:V ratios tend to follow a central prominence or arrise while those with increasing ratios indicate a transition to feathered terminations with fan-shaped outlines, following branching arrises. Not only are arrises responsible for gross morphological trends in the distribution of a flake's volume, they play a substantial role in the behavioural index. Flakes characterized by DLM# values greater than 0.4 generally have arrises that are twice as thick as those on flakes having DLM#'s less than 0.4.

## 4. Conclusions

Having commented on the limitations of fracture mechanics at the beginning of this paper, the proposed indices appear to place flakes along a continuum that spans the blended tripartite phases of flake formation described by Cotterell and Kamminga (1987). The ability to characterize mechanisms controlling flake formation using a discrete, quantifiable index numbers derived from maximum dimensions of complete flakes associated with a specific lithic tradition provides the means to objectively assess differences in knapping behaviour and decision-making that are impossible to observe directly. With knowledge of likely characteristics of knapping implement and preform support, additional parameters, such as platform structure or damage, can be used to enhance the analysis. Meaningful correlation between a flake's DLM# regime and subjective observations of how the blow was delivered (Table 1) indicate that it may be possible to design future experiments that will better quantify the contributions of a knapper's action to the DLM# of a flake.

Replicative experiments demonstrate that tightly controlled conditions are capable of producing flakes of various size and shape with highly correlated index values. A lithic tradition is unlikely to adhere to any single knapping behaviour over all others, but it is not unreasonable to expect that a consistent pattern would be detectable from a large, culturally representative assemblage of flakes. Non-conforming flakes from early-stage regularization of cores, or isolated problem-solving are not likely numerous enough to distort a cultural trend. The first step toward such a comparison would consist of controlled studies of deduced knapping techniques and core strategies. With those studies in place as benchmarks, sufficient data should already exist to quantify index values for various sites and complexes. If archaeological data shows index values to be generally highly variable for a given lithic tradition, it may be assumed that the processes used were not highly controlled. Assuming that lithic traditions grew out of pre-existing behavioural patterns, it is reasonable to expect that indices will provide useful signals to help trace their developmental lineage.

Lithic traditions bear the imprint of habitual practice learned through generations, although we have little assurance that ancient processes were as highly controlled as is generally necessary for experimental data. In fact, as core size decreases, the prospect of variation rises. Using an anvil or holding devise to increase support has the effect of making a core act as if it were much larger than it is on its own, while freehand support can be unpredictable. The linkage between flake morphology and knapping tool suggests that habitual use of certain knapping tools may constrain the resulting indices in ways unique to a cultural tradition. Consequently, it is advisable to compare each range of flake size to learn whether the physics of flaking remain constant for a tradition or vary as reduction progresses. Reducing flake geometry to four easily quantified variables establishes a meaningful baseline for addressing myriad independent variables including: platform structure, impact offset, flake curvature, fracture strength, and external support. Once pertinent associations can be established on complete flakes, it may be feasible to estimate dimensions of incomplete flakes by comparison to complete but otherwise identical examples.

Individuals who have demonstrated competence in replication of artefacts related to the lithic tradition being studied, will continue to assess knapping behaviour, but the use of unambiguous measurements to characterize behaviour sidesteps many objections related to potential bias, whether justified or not. Since experimental data has now shown that highly specific techniques may produce equally specific and unique products, experts may now be expected to quantify their claims in ways that assure analysts unskilled in replication that the conclusions are relevant to the lithic tradition under investigation. In combination, the quantitative indices discussed in this study avoid the equifinality problem because all components of the contributing behaviour need not be known. Cultural lithic indices developed from reference studies eventually should be compared to see if they can resolve questions of lineage. Flakes may ultimately allow cultural associations to be determined even when there are no traditionally diagnostic lithics at a site.

Future studies can be expected to provide a clearer view of distributions that may be representative of debitage resulting from quarrying, base camp, and transient occupations. Most studies would examine behaviour on a population level, but special circumstances of isolated flake depositions should allow occasional investigation of behaviour by individuals. Although the proposed indices are non-dimensional, it is possible to screen data on box volume or flake thickness in order to detect possible differences in approach between early and late stages of reduction. Flakes that serve an apparent technological purpose, whether it is to further a stage of reduction or to use as a tool, may be found to exhibit signature indices. Even the difficult task of separating cultural from non-cultural flakes may be aided by the indices. As existing metric data is reprocessed and new experimental correlations are identified, we can learn how consistent the actions of populations were, whether those actions arose to achieve the morphology of a desired tool form, or if ingrained behaviour persisted even when a new form had to be adopted.

Confirming that metric properties of flakes can be used to decipher knapping behaviour in the context of fracture mechanics opens a new line of inquiry into the origins and transmission of lithic traditions. Instead of treating flakes as inconvenient artefacts of questionable worth, they may now provide fresh new insights.

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