Investigating Flake Attributes from an Experimentally Produced Multidirectional Core

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Abstract

Several debitage attributes were monitored on an assemblage produced from the controlled reduction of a multidirectional core. It was found that several aspects of flake size tend to decrease as the core is progressively reduced. It was also found that dorsal cortex amount on flakes decreases as the core is reduced but that this is probably related to the kind of reduction technology used and the amount of cortex on the original core.

Introduction

Debitage has long been a subject or the study of lithic technological organization. It has been used by lithic analysts to infer several aspects of stone tool technology such as reduction stage (Magne and Pokotylo 1981; Morrow 1984; Tomka 1989), patterns and characteristics of reduction strategy (Mauldin and Amick 1989; Patterson 1982, 1990), and relationship between debitage and settlement patterns (Raab *et al.* 1979; Sullivan and Rozen 1985). Analysis of debitage is usually based on a wide variety of attributes. Among the metric and nominal attributes commonly used for the analysis of debitage are length, width, thickness, weight, cortex amount, platform type, termination type, maximum linear , and raw material type.

It is widely believed that the differences or similarities in production technology essentially affect the characteristics of debitage assemblages. For example, Patterson (1990) found that biface reduction produces more predictable flake-size distribution patterns than do other reduction technologies. Type of load application, such as hard hammer percussion versus soft hammer percussion versus soft hammer percussion, also affect the type of flake produced (Crabtree 1972; Whittaker 1994). In this paper we investigate a debitage assemblage derived from a controlled replication experiment. Our purpose is to identify trends in debitage resulting from the reduction of a multidirectional core.

Methods

The debitage data for this analysis were collected from a controlled replication experiment. A broken chert cobble weighing 1044.7 gram and having 100% cortical surface was selected for reduction. All the stages of reduction were carried out using hammer percussion technique. The core was reduced in a multidirectional manner, that is, the core was periodically rotated as it has

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opposing striking platforms suitable for percussion. The end product weighed 290.3 gram and had 10% of total cortex amount left on its surface.

This experiment collected detached pieces after every blow or impact. Some blows produced only one flake and some made more than one flake. However, most of the blows produced only one flake. This is opposed to Mauldin and Amick's (1989) experiments where most blows produced multiple flakes. Each flake was given an ordered sequence number. Resulting small shatter and powder-like debris were also collected, labeled as "S-fraction", and weighed as a group. Four sequences of reduction labeled as S 1-10, S 11-21, S 23-34, and S 35-38 were recorded during knapping. Measurable flakes were morphologically classified into three types: proximal flake, flake shatter, and angular shatter (Andrefsky 1998). Proximal flake simply refers to flake that exhibits principal features of typical flake such as platform or point of percussion, bulb of percussion, ripples, and termination type on its ventral surface. Put another way, proximal flake is a complete flake in Sullivan and Rozen's (1985) category. Flake shatter or distal flake refers to a flake whose its striking platform is missing. Its dorsal and ventral surfaces are still identifiable. Angular shatter is the term applied to flake fragment exhibiting none of the features described; it normally is difficult to tell ventral and distal surfaces apart from an angular shatter flake.

Eleven attributes were recorded, including sequence number, raw material, weight, maximum linear dimension, type of flake, cortex amount, termination type, platform type, maximum length, maximum width, and maximum thickness. However, only seven attributes were selected (sequence number, weight, maximum linear dimension, flake type, cortex amount, maximum length, and maximum thickness) for this analysis because they are replicable and they meet the requirements for this analysis. To complete the metric and nominal measurements, we followed Andrefsky's (1998) measurement techniques. For example, in measuring the dorsal cortex amount, four nominal scales were used to determine cortex percentage: 0% (numbered as 0), less than 50% or equal (numbered as 1), more than 50% (numbered as 2), and 100% (numbered as 3). For angular shatters which do not have ventral or dorsal surfaces, cortex amount was measured on the same basis as other flake types.

We first sorted the population into 5 size grades but later decided to stratify them into eight size grades following Patterson's (1990) suggestion. We used maximum linear dimension as a basis for size determination. Since there was only one flake measuring less than 10 mm, this size grade was not used for size grade distribution analysis, but was used for the calculation of means of flake types. The eight size grades have 10 mm interval. They were called G1 (10-20 mm), G2 (21-30 mm), G3 (31.40 mm), G4 (41-50 mm), G5 (51-60 mm), G6 (61-70 mm), G7 (71-80 mm), G8 (81-90 mm), and G9 (>90 mm). It should be noted that "s-fraction" samples were not included in the size grade stratification simply because they are immeasurable or too small to gain measurement values.

We then looked at size grades across different sequences or stages to se how different size grades vary according to different sequences, The procedures were conducted on the basis of percentage of weight, raw count, and cortex amount.

Results and Discussions

Flake Types and Total Population

The experiment produced a total population of 160 flakes greater than ¼ inch in minimum size. Flake shatters (44.9%) and proximal flakes (41.0%) made up the first two major components of the total population, while angular shatters (14.1%) composed the remaining assemblage (see Figure 1).

Looking closely at proximal flake, we found that mean maximum thickness (mth), mean maximum length (ml), and mean weight (w) decrease as the core was progressively reduced. In other words, mean values of the three attributes (mth, ml, and w) at the earlier sequences are greater than those of late stages (Table 1, Figure 2). This is the pattern everyone should expect because it is well recognized that lithic technology is a reductive process. As the objective piece become progressively smaller, we may anticipate that the detached pieces removed from the objective piece would also become smaller as the reduction stages progress. However, when we measured the mass (weight) of all flake types to see the distribution across the four sequences, we were surprised to see the trend slightly oscillated over the sequences (see Table 2 and Figure 3). This probably suggests that using one flake type (proximal flakes) out of other types in the total population alone can be problematic because only one type may not be a totally reliable indicator of overall trend.

Size Grade Distribution

As noted earlier, the population was sorted into different size grades and we hypothesized that greater number of size grades probably would exhibits a more detailed distribution pattern. Although the same trends were produced by five size grades and by nine size grades (see Figure 4 and Figure 5), the nine size grades provide a more precise resolution.

Table 3 and Figure 5 show a trend of greater percentage by count for progressively smaller by size grades. Put another word, there is a sharp distinction in number of large flakes and number of small flakes-small number of large flakes and large number of small flakes. Percentage by count shows an inverse correlation with percentage by weight. Although there are a relatively large number of flakes (n=62) designated for G1, the percentage by weight is very low comparing to number of G9 flake (n=1) which produced greater percentage of weight. Nevertheless, this is not a surprise because it is unequivocal that large flakes usually weigh more than smaller ones. Figure 5 shows that there are two clear modes related to percentage by weight and percentage by count. One exhibits high percentage of total count and low percentage of total weight within the same size grade. This group consists of G1, G2, and G3, indicating small flakes. Another group includes G5, G6, G7, G8, and G9 that illustrate low percentage of total count but high percentage of total weight, suggesting large flakes. It should be also noted that size grade 4 (G4) does not present a drastic contrast between the percentage of total count and percentage of total weight. However, if we only look at mean flake weight, we will find that mean values by size grade progressively increase regardless of high or low percentage of total count and total weight. The data for mean flake weight by size grade is shown in Figure 6.

Size Grade Distribution in Different Sequences

With regard to size grade distribution within each of 4 sequences, Table 5 and Figure 7 present the percentage by count of each of size grades. The result shows that size grades 1 and 2 clearly dominate all other size grades in all reduction sequences. Table 6 and Figure 8 give the percentage by weight of each of size grades in different sequences. It demonstrates that percentage of total weight of most size grades increases as the reduction progresses. The patterns of size grade distribution within each sequence are not uniform except those in sequence 4 that percentage of total weight progressively increased. However, the increase in total weight percentage does not indicate the increase in total count percentage. Rather, it represents the fact that weight is related to size of flakes, not number of flakes. To be more explicit, within sequence 4, 10.2% of total weight of size grade 1 represents 9 flakes, while 40.9% of total weight of size grade 4 was derived from only one flake.

Table 4 and Figure 9 present relative percentage of cortex amount categories in 4 different sequences. The distribution pattern fits with expectations. For example, percentage of 0% cortex amount on flakes removed from early stages of reduction is less than those of late stages. Conversely, percentage of flakes holding >50% cortex amount is greater in the early stages than those of later stages. Put another word, high frequency of flakes with 0% cortex appears in later sequences, while flakes with greater amount of cortex concentrate on earlier stages.

Distribution patterns are not uniformly presented when size grades were incorporated. Figures 10 and 11 clearly illustrate this point. The fluctuation of patterns shown in Figures 10 and 11 may be a sample problem. For example, the sudden drop of percentage of flakes with 0% cortex of G6 and G9 flakes is because of the lack of flakes assigned to such size grades (see Figure 11). As one may notice, the occurrence of these distribution patterns is from one replication. It would be interesting to see whether or not the oscillation of distribution patterns occurs with more than one replication. Perhaps if greater numbers of G6 and G9 flakes were produced there would have been a different trend in the cortex data. The results do not support an argument made by Mauldin and Amick (1989:73) that a combination of flake size and cortex cover may provide a more accurate representation of the stage of reduction. However, more replications are needed before this issue is settled.

Conclusion and Discussion

This study included the debitage from a single core reduction in a multidirectional manner. Multiple replications would probably change some of the findings and reinforce others. One of the results of this study found that flake size tends to get smaller as the multidirectional core is progressively reduced. This is intuitively reasonable since lithic tool production is a reductive process. However, this pattern does not always hold with other kinds of core reduction such as unidirectional cores or parallel sided cores with a single striking platform. Nor does this pattern hold in all cases with bifacial core reduction (Patterson 1990). Our results show that with multidirectional core reduction, debitage size gets progressively smaller during reduction whether size is measured by maximum thickness, maximum length, or weight on debitage with intact striking platforms.

Another result of the study is that debitage counts get progressively smaller as debitage size gets progressively larger. Using size grades as a way to understand the population we found that smaller debitage tend to dominate the assemblage when multidirectional core technology was used. This is interesting because some studies have implied that small debitage is produced in high relative proportion to large debitage when using hard hammer percussion.

Our results also confirmed the notion of cortex amount on debitage will decrease as core reduction increases. This pattern is directly associated with the nature of the core being reduced and the kind of reduction technology. Our core began as a chert nodule with 100% cortex cover and it was reduced in an opportunistic manner using a multidirectional reduction strategy. If this nodule were reduced using a unidirectional technique of flake removal there is a good chance that consistent cortex amounts would have been found in all stages of reduction. Similarly, as shown by Tomka's research (1989), if the core had little or no cortex to begin with, then the pattern of cortical debitage would have been greatly different regardless of the kind of reduction technology used.

Finally, we have to say that these results are preliminary since only a single core was reduced and only a single technology was used. Variability in the kind of raw material being worked as well as type of hammer used, application load, shape and size of core, and the desired end product (s) may influence the size, shape, and composition of the debitage produced.

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Table 1. Three Attributes of Proximal Flakes by Sequences.

Sequence	Mean Maximum Thickness	Mean Maximum Length	Mean Weight
1	9.4	47.3	19.8
2	5.5	27.8	9.5
3	4.6	22.9	5.1
4	5.0	5.1	2.6

Increments are in millimeter.

Table 2. Mass (Weight) Distribution by Sequence for Proximal Flakes (gram).

Sequence 1	Sequence 2	Sequence 3	Sequence 4	Total
282.7	286.0	150.1	26.4	745.2

Table 3. Size Grade Distribution Percentage by Count and by Weight.

Size Grade	Percentage by Count	Percentage by Weight
G1	40.0 (62)	2.7
G2	25.8 (40)	3.9
G3	14.8 (23)	8.6
G4	7.1 (11)	8.1
G5	3.2 (5)	10.8
G6	4.5 (7)	19.4
G7	2.6 (4)	22.3
G8	1.3 (2)	14.4
G9	0.6 (1)	9.8

Note: Number in parenthesis refers to raw count.

Table 4. Percentage of Cortex Amount by Sequence.

Sequence	0%	<=50%	>50%	100%
1	28.2	38.5	25.6	7.7
2	58.0	24.0	8.0	0.0
3	70.0	20.8	6.2	0.0
4	94.7	5.3	0.0	0.0

Table 5. Percentage by Count by Size Grade by Sequence.

Sequence	G1	G2	G3	G4	G5	G6	G7	G8	G9
1	38.4	23.1	10.2	7.7	7.7	5.1	2.6	2.6	2.6
2	40.8	20.4	20.4	4.1	2.0	8.2	2.0	2.0	0.0
3	37.5	31.2	12.5	10.4	2.1	2.1	4.2	0.0	0.0
4	47.4	31.6	15.8	5.2	0.0	0.0	0.0	0.0	0.0

Table 6. Percentage by Weight by Size Grade by Sequence

Sequence	G1	G2	G3	G4	G5	G6	G7	G8	G9
1	1.4	2.4	2.7	6.4	12.4	10.6	9.5	19.9	25.6
2	2.5	2.5	10.7	5.3	4.2	33.1	24.3	17.3	0.0
3	4.4	7.6	12.1	11.7	4.8	12.4	46.9	0.0	0.4
4	10.2	13.9	34.9	40.9	0.0	0.0	0.0	0.0	0.0

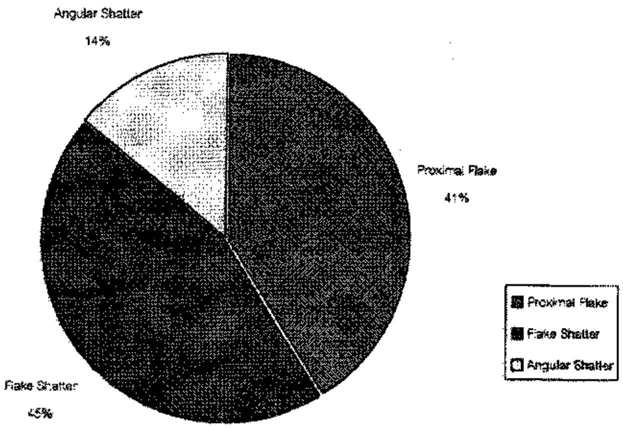

Figure 1. Relative percentage by flake type in total debitage.

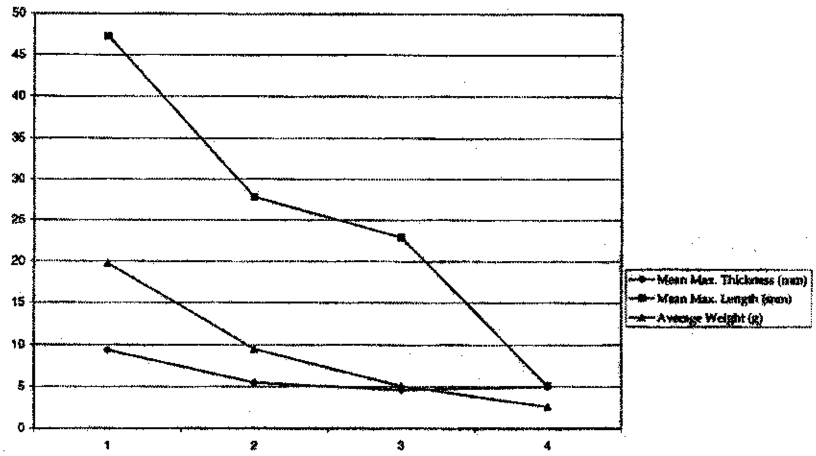

Figure 2. Mean max thickness, mean max length, mean weight by sequence for proximal flakes.

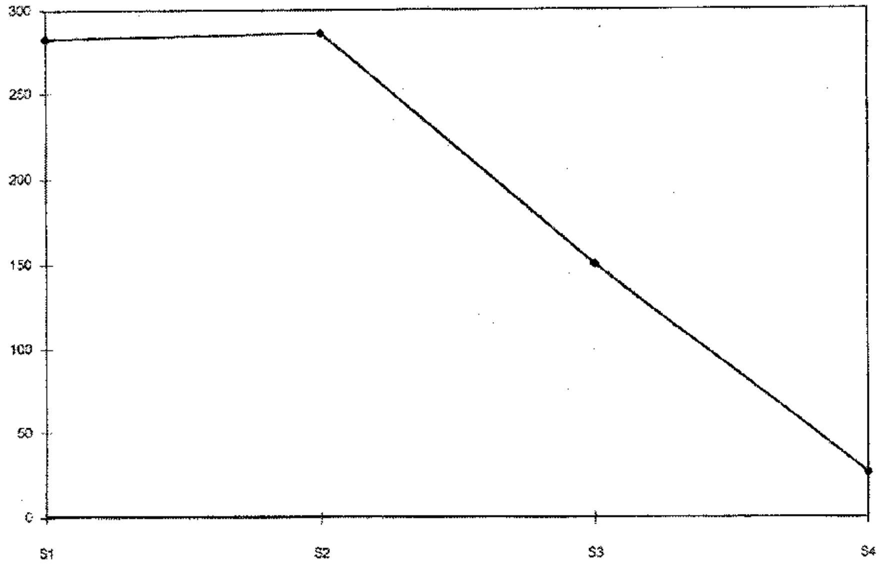

Figure 3. Mass (weight) distribution by sequence.

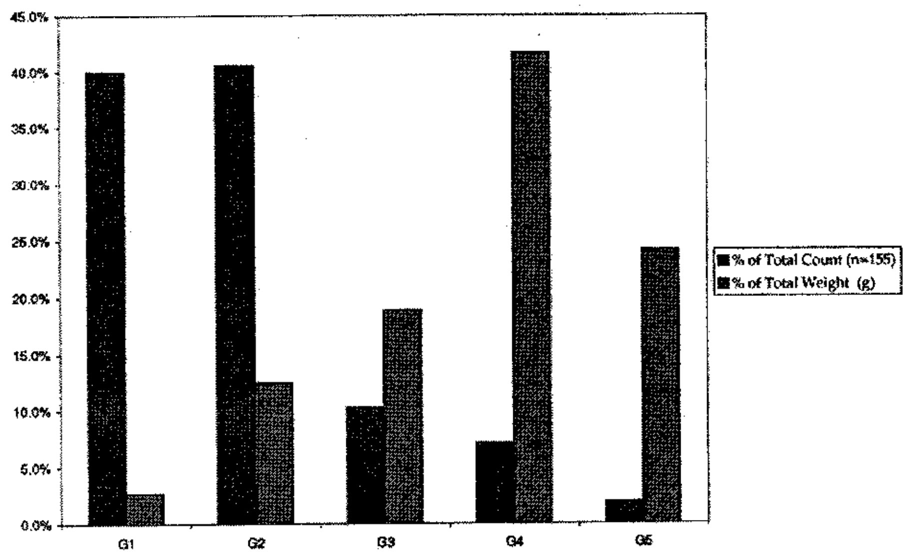

Figure 4. Comparative percentage of 5 size grades by count and weight.

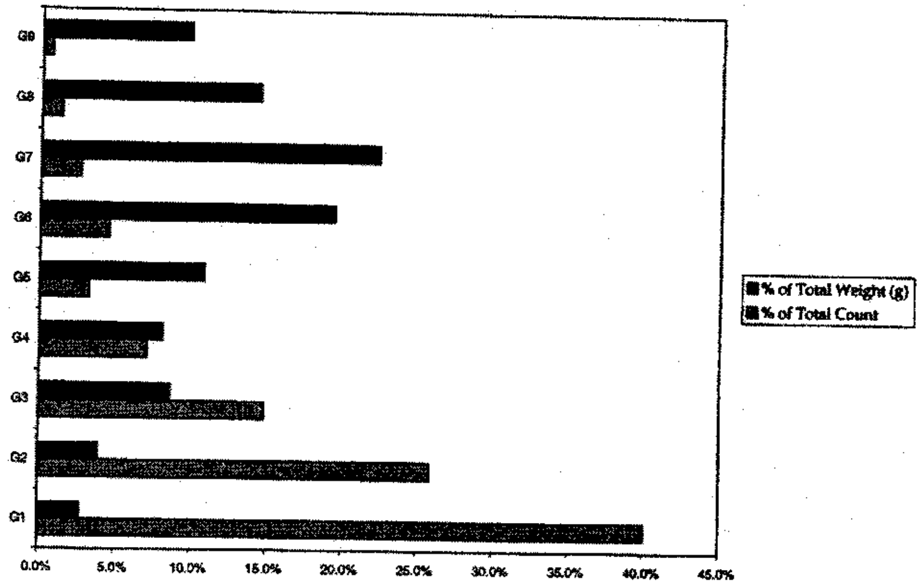

Figure 5. Percentage by count and by weight by 9 size grades.

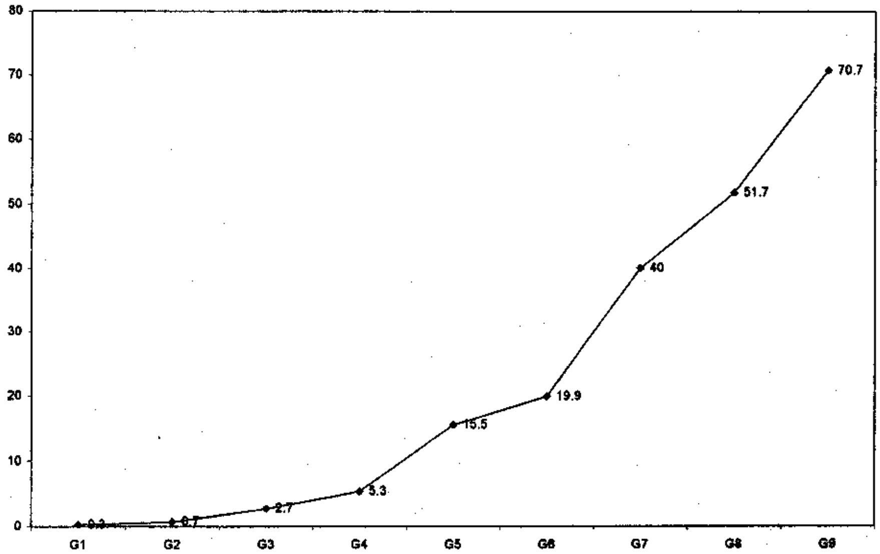

Figure 6. Mean flake weight (g) by size grade.

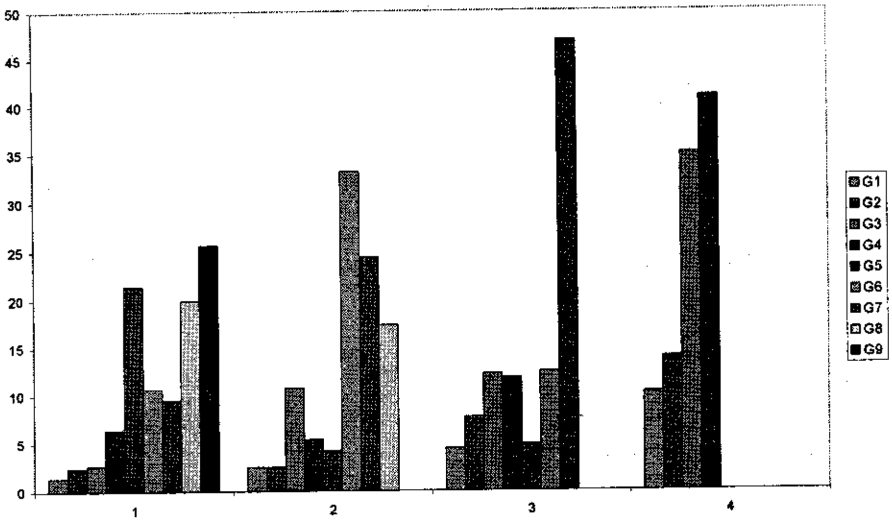

Figure 7. Percentage by weight by size grade by sequence

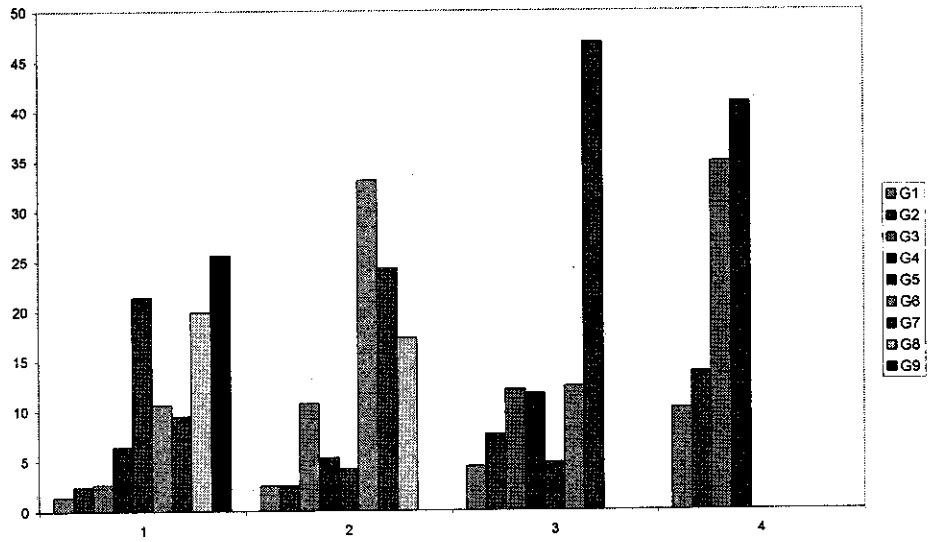

Figure 8. Percentage by weight by size grade by sequence.

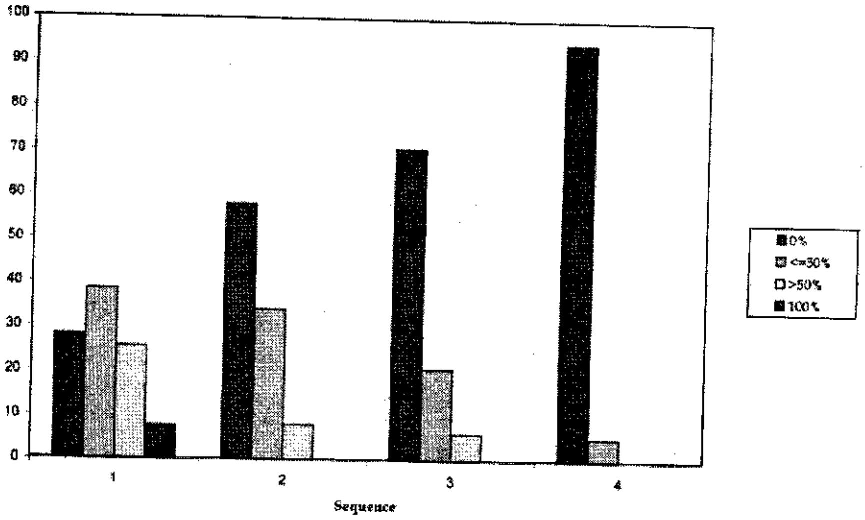

Figure Percentage of cortex amount by sequence

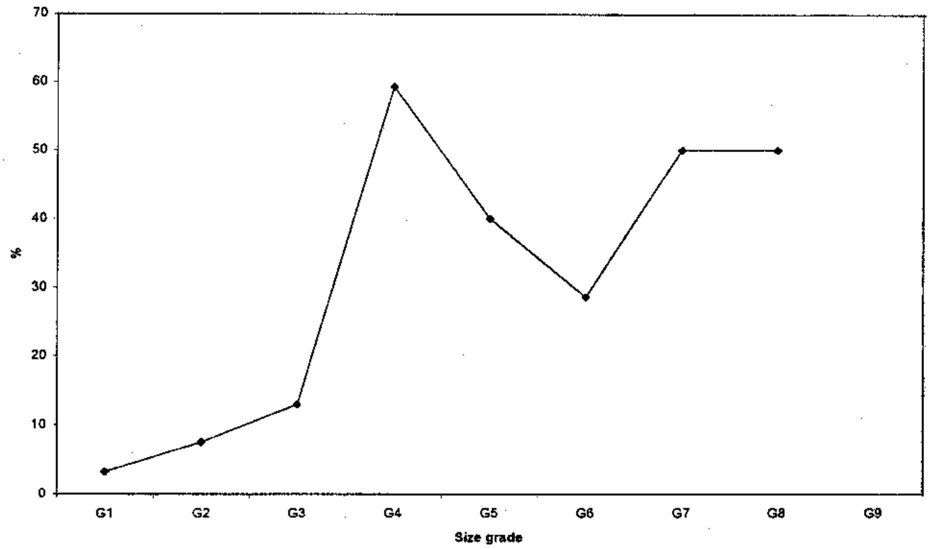

Figure 10. Percentage of flakes with >50% cortex by size grade.

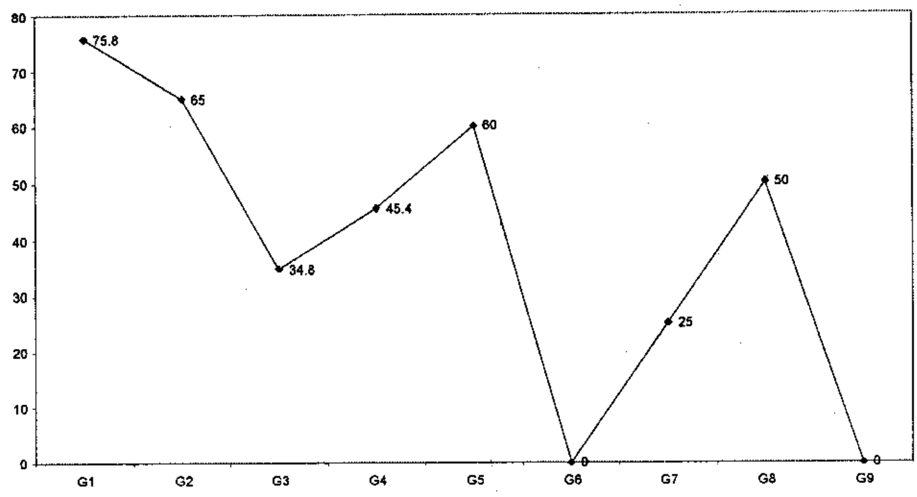

Figure 11. Percentage of flakes with 0% cortex by size