Journal of California and Great Basin Anthropology
Vol. 13, No. 2, pp. 172-179 (1991).

Problems with the Use of Flake Size in Inferring Stages of Lithic Reduction

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THE analysis of lithic debitage has evolved both in sophistication and methodology over the last several decades (cf. Kalin 1981; Flenniken 1985; Sullivan and Rozen 1985; Ahler 1989). One method frequently used in debitage analysis is measuring and tabulating the size of individual flakes using calipers, size templates, or nested sieves. Once debitage is placed in pre-determined size categories, it has been used to identify stages of lithic reduction and to infer predominant stoneworking activities carried out at prehistoric sites (e.g., Minor and Toepel 1984; Scott 1985a; Minor et al. 1988; Ahler 1989). According to Ahler (1989), the examination of flake size in a systematic manner is essential for generating comparable, quantitative data.

This paper examines flake-size analyses and the type of information they produce. The prehistoric sites discussed are located in central Oregon, an area rich in obsidian sources and lithic scatter sites (Scott 1985a, 1985b; Davis and Scott 1986; Flenniken and Ozbun 1988). Although central Oregon data are the basis for this study, the information presented and the conclusions drawn are applicable to other regions where lithic scatters comprise a major portion of the prehistoric record.

PREVIOUS RESEARCH

From a historical perspective, lithic debitage analyses have only recently become a standard component of archaeological inquiry in the Great Basin. For example, during the 1961 excavation of the Lava Butte Site (Ice 1962), an important buried lithic scatter in central Oregon, most chipped stone flakes were discarded. Other early archaeological investigations in central Oregon also treated lithic debitage as having little or no interpretive value (e.g., Cressman 1948; Cole 1977). Prior to the advent of Cultural Resource Management (CRM), the focus of archaeological investigations in the northern Great Basin was largely on rockshelter and cave sites that contained a wide variety of artifact types (see Bedwell 1973; Aikens et al. 1977). Sites containing only debitage and stone tools received little attention. In many ways, CRM has been responsible for directing professional attention toward "small site archaeology," including the study of lithic scatters.

By the late 1970s, archaeologists began to realize the importance of lithic debitage through experimental replication studies conducted by Crabtree (1966, 1969, 1970), Callahan (1974, 1979), Muto (1971) and others. As a result, a new appreciation for the interpretive value of chipped stone emerged. However, debitage studies remained primarily descriptive in nature and involved counting, weighing, and measuring flakes as a means of determining lithic technology and stone tool function (see Henry et al. 1976). Archaeologists also used flake densities and their distribution to infer prehistoric occupational intensity and stone working activities. Comparatively few studies examined lithic debitage according to the technological categories developed by Crabtree (1972) and Callahan (1974, 1979). Only recently have the technological attributes of flake assemblages become a research focus in central and western Oregon (cf. Flenniken 1987; Flenniken and Ozbun 1988).

CASE STUDY

Size Grading Analysis

During the summer of 1982, test excavations were conducted at the Sand Spring lithic scatter site (25DS140) in central Oregon (Scott 1985a). The site is located on the southeastern edge of the Deschutes National Forest, near the Fort Rock Basin and lies within an area covered by a dense layer of Newberry tephra. The site contained large roughed-out bifaces, a few reworked dart and arrow points, and over 7,000 obsidian flakes.

Faced with the task of analyzing large numbers of chipped stone flakes, the traditional analytical approach used in this region was undertaken: focusing on flake size to determine lithic reduction stages and stoneworking practices. The analysis conducted was similar to flake studies reported in Minor and Toepel (1984) and Henry et al. (1976). Rather than measuring each individual flake with a template or calipers, the Sand Spring flake assemblage was sifted through six nested sieves ranging in size from 25.4 mm. to 6.35 mm. (Table 1). The analysis was based on the premise that flake size was correlated with discrete stages of lithic reduction.

Lithic replication studies were then undertaken to test the accuracy of the inferred reduction sequence at Sand Spring and to gather comparable, experimentally produced lithic debitage (see Table 1). Large biface blanks, morphologically similar to those found at Sand Spring, were produced by flintknapper John Fagan. Debitage created as each biface was produced was collected and then size graded through the nested sieves. The experimental study resulted in flake size percentages similar to those found at Sand Spring. A statistical analysis was conducted on both assemblages to see if some flake size categories occurred with significantly higher frequencies than others.

The statistical analysis, which involved the use of the F-ratio statistic, revealed that the size 6.35 mm. flake category occurred with a significantly higher frequency in both the replicated and prehistoric assemblages (Scott 1985a:6-7). Thus, based on statistical information and the results of the replication study, it was concluded that the debitage from Sand Spring resulted from the production of early and intermediate stage biface blanks and that this production process yielded significantly higher densities of size 6.35 mm. flakes. However, it should be noted that 1/4-in. mesh screen was used during the Sand Spring excavations, so the majority of flakes smaller than 6.35 mm. were not recovered.

In 1985, similar flake size analyses were conducted on six separate site assemblages from central Oregon (Scott 1985b). The six archaeological sites represent an interesting cross-section of site types, including a quarry, a lithic workshop, and open-air campsites. Like Sand Spring, these sites contained a small sample of stone tools, large numbers of chipped stone flakes, and few other artifacts. Because the size grading procedure used for Sand Spring was a seemingly effective method for analyzing flakes, it was also used to analyze debitage recovered from the six sites. Since the sites were of different functional types, it was assumed that this difference would be reflected in the size grading analysis. However, in all cases, as was observed at Sand Spring, significantly higher densities of the 6.35 mm. flake size occurred at the six sites.

Technological Analysis

After analyzing seven lithic assemblages and sorting over 25,000 individual flakes, it was troublesome that the flake size analysis showed that the same lithic reduction process occurred at all seven sites, despite obvious dif-

Table 1
SIZE GRADING AND EXPERIMENTAL REPLICATION WORK FROM SAND SPRING (35DS140)

Flake Size	Excavation Level														Experimental Data from Biface Production	
(mm.)	1	2[a]	6	7	8	9	10	11	12	13	14	15	16	17	Total	Biface 1	Biface 2
25.4	--	--	11	13	6	6	3	3	2	1	--	--	1	--	46	4	32
22.6	1	--	23	11	8	7	6	1	3	--	--	--	--	--	60	4	11
19	1	3	56	28	22	11	3	3	7	1	2	1	--	--	138	10	27
16	2	1	93	57	44	26	6	10	4	1	3	1	1	--	249	18	26
11.2	20	7	356	257	187	94	44	24	13	9	10	9	4	--	1,034	91	92
6.35	42	28	1,412	1,210	960	552	232	146	93	31	20	4	10	1	4,741	324	385
<6.35	19	6	362	354	268	202	112	80	52	22	15	1	6	1	1,500	--	--
Total Flakes	**85**	**45**	**2,313**	**1,930**	**1,495**	**898**	**406**	**267**	**174**	**65**	**50**	**16**	**22**	**2**	**7,768**	**451**	**573**

[a] Levels 3 to 5 consisted of sterile Newberry pumice.

ferences in site function. It appeared that the production of early and intermediate biface blanks was the primary flintknapping task undertaken at every site investigated.

The author's concern about the accuracy and reliability of flake size analysis led to a field course in flintknapping sponsored by Washington State University. Through the course, it became clear that for most types of lithic reduction, ranging from the production of blade cores to biface blanks, the manufacturing process results in more small flakes than it does big flakes. For example, in order to produce a biface core, large flakes are removed as the biface is roughed out into the desired shape. But a critical part of this early stage shaping process involves the removal of numerous small platform-preparation flakes.

In short, a lithic assemblage dominated by large flakes does not necessarily indicate that early stage tool manufacturing was the primary stone working task. Nor does an assemblage containing only small flakes indicate that only secondary lithic production or stone tool refurbishment was undertaken.

In order to determine if flake size was, in fact, correlated with various phases in a technological sequence, samples of debitage from three of the six sites were segregated into simple technological categories and were then size graded to see if flake size reflected specific reduction stages (Scott 1985b:87-95). The technological categories used in the analysis were developed on the basis of Crabtree's (1972) lithic handbook and on analyses conducted by Flenniken and Stanfill (1980). The technological categories used included biface-thinning flakes, alternate flakes, angular flakes, hinge flakes, outrepassé flakes, pressure flakes, bulb-removal flakes, decortication flakes, and flakes that exhibited original flake scars on their dorsal surface.

The results of this analysis are presented in tables 2 through 4. As the tables demonstrate, for most technological categories, flakes of all sizes are represented. For example, in the biface-thinning flake category, all flake sizes occurred, ranging from 25.4 to 6.35 mm. All of the pressure flakes analyzed were small, but not all small flakes examined were pressure flakes.

In several of the technological categories, as the flake size decreased the number of flakes increased. Overall, the largest number of flakes are found in the 6.35 mm. size category. But an important exception to this pattern are alternate flakes which are predominately large flakes. This exception is explained by the fact that the alternate thinning technique involves making a piece of stone sinuous along its edge so it can be thinned into a biface (Flenniken 1987). When large pieces of stone are worked, the reduction process results in few small alternate flakes.

At two of the sites examined from a technological perspective, the flake sizes were similar but subtle differences between the sites were indicated from the technological analysis. These differences reveal important information about prehistoric stone working tasks undertaken at the East Lake (35DS202) and Mahogany Cave (35DS1028) sites that would not have been discovered through flake size studies.

The East Lake site is located within Newberry Crater and lies approximately 600 m. from a major obsidian quarry where, based on XRF analysis, the chipped stone was quarried. In contrast, the Mahogany Cave site, which is actually an open-air site surrounding a lava blister, lies approximately 30 km. from its quarry source at Quartz Mountain. Despite the different distances of the two sites from their respective quarries, many of the prehistoric flintknapping tasks undertaken at the sites were the same. The large number of biface-thinning flakes demonstrates that bifaces were being produced; the bulb-removal flakes and the number of flakes that exhibited original flake

Table 2
TECHNOLOGICAL ANALYSIS OF THE EAST LAKE SITE (35DS202) ASSEMBLAGE (UNIT A, LEVELS 1-6)

	Size Grade (mm.)								
Attributes	**25.4**	**22.6**	**19**	**16**	**11.2**	**6.35**	**<6.35**	**Total**	**%**
Biface-Thinning Flakes	2	4	14	50	321	900	70	1,361	87.92
Alternate Flakes	4	3	9	5	15	6	--	42	2.71
Angular Flakes	--	3	1	5	4	2	--	15	0.97
Hinged Flakes	--	--	1	2	9	6	--	18	1.16
Outrepassé Flakes	--	--	--	3	9	7	--	19	1.23
Pressure Flakes	--	--	--	--	--	8	7	15	0.97
Flakes w/Pressure Flaking/Dorsal Surf.	--	--	--	--	1	6	--	7	0.45
Removal of Bulb Flakes	1	--	--	--	--	4	--	5	0.32
Dorsal Surf./Ventral Surf. Original Flake	1	--	2	4	13	28	1	49	3.17
Primary Decortication Flakes	--	--	1	3	1	12	--	17	1.10
Flake Totals	**8**	**10**	**28**	**72**	**373**	**979**	**78**	**1,548**	**100.00**

Table 3
TECHNOLOGICAL ANALYSIS OF THE MAHOGANY CAVE SITE (35DS1028) ASSEMBLAGE (UNIT 6, LEVEL 2)

	Size Grade (mm.)								
Attributes	**25.4**	**22.6**	**19**	**16**	**11.2**	**6.35**	**<6.35**	**Total**	**%**
Biface-Thinning Flakes	1	4	11	30	202	735	195	1,178	86.11
Alternate Flakes	1	1	2	3	8	8	--	23	1.68
Angular Flakes	3	7	6	4	7	7	2	36	2.63
Hinged Flakes	--	--	--	--	--	--	--	0	0.00
Outrepassé Flakes	--	--	2	--	2	13	--	17	1.24
Pressure Flakes	--	--	--	--	--	1	--	1	0.07
Flakes w/Pressure Flaking/Dorsal Surf.	--	--	--	--	2	3	--	5	0.37
Removal of Bulb Flakes	1	--	1	1	1	--	--	4	0.29
Dorsal Surf./Ventral Surf. Original Flake	--	--	8	2	13	39	4	66	4.82
Primary Decortication Flakes	1	2	3	3	7	21	1	38	2.78
Flake Totals	**7**	**14**	**33**	**43**	**242**	**827**	**202**	**1,368**	**100.00**

scars on their dorsal surface suggests that large flakes were being worked into blanks or biface cores; and the high number of outrepassé flakes suggests initial and intermediate bifacial reduction.

The primary difference between Mahogany Cave and the East Lake site is that debitage from Mahogany Cave included a higher percentage of primary decortication flakes and angular waste. These flake types were less evident at East Lake. The differences in the flake assemblages can be attributed to the nature of the two quarry sources.

At the East Lake Quarry, obsidian predominately occurs as large angular blocks in a massive obsidian flow. Outer cortex is infrequent or consists of a thin veneer of volcanic froth. The material is angular, brittle, and

Table 4
TECHNOLOGICAL ANALYSIS OF THE EAST LAKE QUARRY SITE (35DS213) ASSEMBLAGE (UNIT 5, LEVEL 4)

	Size Grade (mm.)								
Attributes	**25.4**	**22.6**	**19**	**16**	**11.2**	**6.35**	**<6.35**	**Total**	**%**
Biface-Thinning Flakes	3	4	6	23	83	409	72	600	83.00
Alternate Flakes	9	3	2	3	8	5	--	30	4.15
Angular Flakes	2	--	1	--	5	3	--	11	1.52
Hinged Flakes	--	--	--	1	4	3	--	8	1.10
Outrepassé Flakes	--	--	1	--	4	3	--	8	1.10
Pressure Flakes	--	--	--	--	--	10	1	11	1.52
Flakes w/Pressure Flaking/Dorsal Surf.	--	--	--	--	--	--	--	0	0.00
Removal of Bulb Flakes	--	--	--	--	2	2	--	4	0.55
Dorsal Surf./Ventral Surf. Original Flake	--	1	6	5	8	15	--	35	4.84
Primary Decortication Flakes	7	--	--	--	1	5	3	16	2.21
Flake Totals	**21**	**8**	**16**	**32**	**115**	**455**	**76**	**723**	**100.00**

exceptionally sharp to carry or handle. Personal observations and experience at flaking East Lake obsidian indicate that it hinges into comparatively thin, rectangular-shaped flakes. The attributes of the glass suggest that flakes were easily worked into bifaces at the quarry which facilitated transport and handling. In contrast, the obsidian from Quartz Mountain occurs as small cobbles. The nodules are dense, are completely covered with cortex, and require sectioning before workable flakes can be produced. Thus, the differences in the debitage assemblages indicate that at Mahogany Cave, slightly modified obsidian cobbles were transported to the site where they were reduced into biface cores and blanks. Evidence from the East Lake site suggests that primary reduction tasks required considerably less effort and that much of this work took place at the quarry instead of at the site.

SUMMARY AND CONCLUSIONS

In summary, based on the comparison of the type of information obtained from size grading flakes versus that gained through technological analysis, it appears that flake size provides only general morphological information that may or may not be a reliable indication of lithic reduction sequences and stoneworking tasks. In contrast, technological flake classes provide specific information regarding the types of reduction processes that occurred and the character of stone that was being worked. Flake size analyses appear to mask potentially relevant differences in lithic reduction as illustrated by the East Lake and Mahogany Cave site data.

As the current volume of articles attests, many archaeologists have become specialists in lithic analysis and stone tool manufacturing techniques out of research necessity. Field investigations, whether they are sponsored for academic or CRM reasons, have become increasingly focused on prehistoric flaked stone scatters. Traditional approaches to debitage analysis, particularly flake size studies and morphological descriptions have produced largely generic results. Technological studies may ultimately provide more meaningful information about prehistoric stone working tasks and practices.

Specialization in lithic technological analysis seems appropriate in light of the specialized analyses that characterize most other aspects of archaeological research. Few zooarchaeologists for example, would only size grade faunal assemblages as a means of inferring genus and species—though this effort might provide a general indication of animal size. Likewise, potsherd size data might provide a general idea of site-use patterns, but it would tell us little about prehistoric pottery manufacturing techniques and cultural origins.

Lithic debitage analysis is analogous to studying bone, ceramics, and other artifact assemblages. Though flake size analysis does provide morphological data, its ability to reveal precise technological patterns is limited. Obviously, many problems still exist with technological debitage analysis. As Sullivan and Rozen (1985) pointed out, the apparent subjectivity of technological classification schemes remains a stumbling block. But this issue simply requires further investigation and clarification. Ultimately, technological flake classes will be defined to allow for replicable results. Certainly, as we attempt to standardize our analytical methods and classification schemes, we should move beyond basic analytical categories such as flake size and lean toward more specific analyses that provide precise and meaningful information about prehistoric stoneworking technology.

ACKNOWLEDGEMENTS

I thank Jeff Flenniken for organizing the symposium that ultimately resulting in the writing of this article. Carl Davis reviewed several drafts of the paper and offered many helpful comments. Jeff Flenniken, Terry Ozbun, Phil Wilke, and Mark Q. Sutton provided editorial assistance, and the article is much improved as a result.

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