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Reduction Assemblage Models in the Interpretation of Lithic Technology at the Tosawihi Quarries, North-Central Nevada

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PRELIMINARY results of the ongoing technological analysis of debitage recovered from the Tosawihi Chert Quarries illustrate how replication experiments are being used to model technologically variable lithic reduction assemblages. Three cases are presented to exemplify the use of reduction assemblage models in the technological interpretation of archaeological data.

The Tosawihi quarries are a source of white chert (technically known as opalite, a mixture of opal and chalcedony) located approximately sixty kilometers northeast of Battle Mountain, Nevada (Fig. 1), in an area occupied ethnographically by the "White Knife Shoshone" (Steward 1938). The initial step in tool stone procurement was to quarry the raw opalite by excavating pits to expose subsurface bedrock outcrops, or, less commonly by reducing surface cobbles. Tool stone procurement generally proceeded from the production of large flake blanks by core reduction or by direct removal from the bedrock, through a reduction continuum to produce large nonheat-treated Stage 3 bifaces for transport out of the quarry vicinity. To a lesser extent, heat-treated Stage 3 and Stage 4 bifaces were also produced near the quarries.

The central quarry area (formally recorded as 26EK3032), is an extensive complex of intensive quarrying and reduction loci covering approximately nine square kilometers of opalite deposit. Reduction stations and residential sites

occupied during tool stone procurement are mostly located around the periphery of the main quarries. Archaeological testing and data recovery projects conducted by Intermountain Research have focused on residential sites, reduction stations, and quarrying localities on the southern margin of the quarries (Fig. 2).¹

Research questions directing archaeological work at the Tosawihi quarries were designed to investigate the economics of opalite procurement and processing, with the overall goal of interpreting the place of the Tosawihi quarries in the regional economy. To that end, the technological analysis of the debitage assemblages has sought to *characterize the predominant biface reduction activities which produced the assemblages* and, hence, *interpret the organizational variability of biface production* within the vicinity of the Tosawihi quarries. The interpreted organizational relationships between variable biface production and residence patterns will eventually come together to form the basis for interpretations of the mobility strategies employed in the procurement of Tosawihi opalite.

The residential loci and reduction stations currently under study are the primary analytic universes for investigating the systemic nature of biface manufacture and the amount of time spent in the procurement of opalite. Most of the reduction stations are discrete loci that lend themselves as controlled sampling universes. Likewise, the residential areas are composed of isolated reduction loci and palimpsests of re-

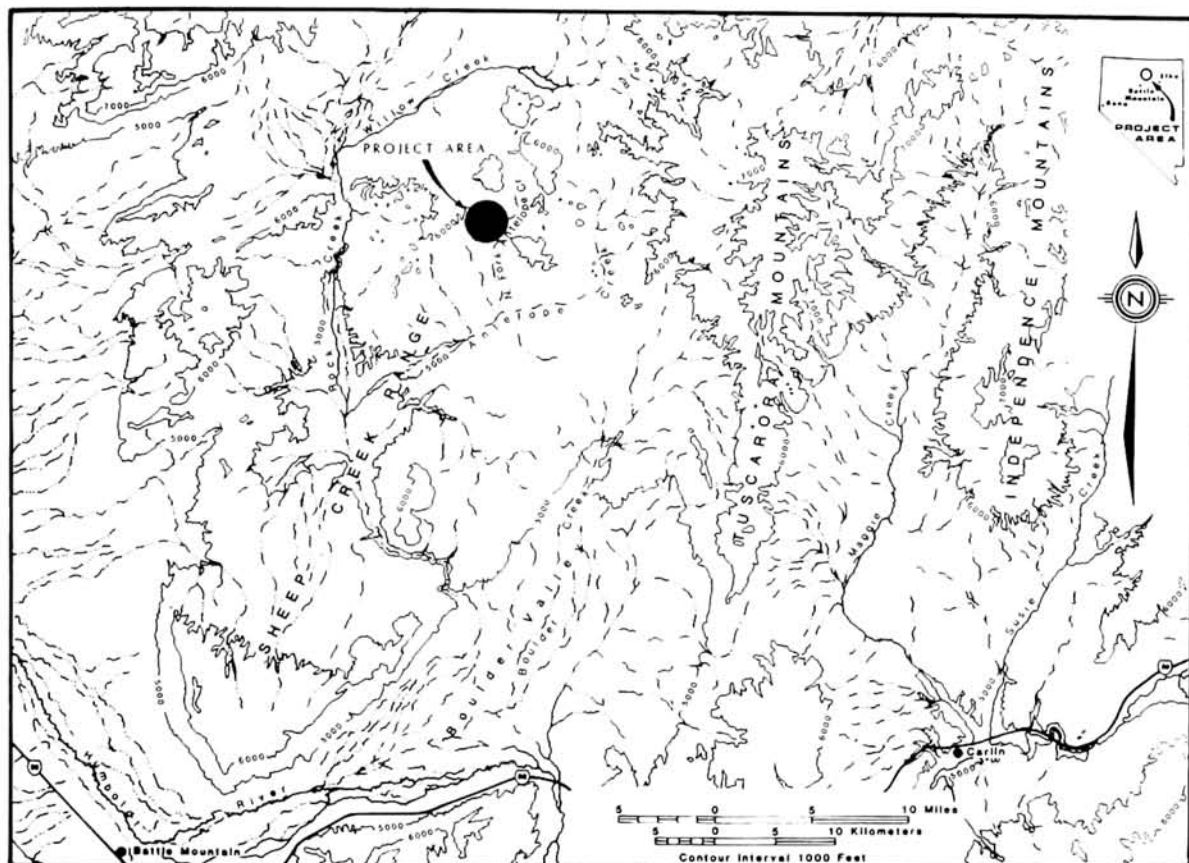


Fig. 1. Location of project area.

duction and residential activity that are isolated as discrete sets of activity remains.

TECHNOLOGICAL ANALYSIS

Methods

The technological analysis of debitage has focused on reduction loci as its main analytical universe. Attention was paid to sampling loci that would reflect the distribution and diversity of staged biface reduction relative to reduction stations and residential activities. Data generated through the analysis of bifaces collected from the same loci were used to supplement the results of the debitage analysis. Callahan's (1979) five stage scheme was used to classify

bifaces and served as the basis for replicating and modeling debitage assemblages produced during distinct stages of biface reduction. Collectively, the archaeological biface data have indicated the general Tosawihii reduction trajectory, but because most of the bifaces from any one locus are fragments broken during reduction, they comprise a data set limited in its reflection of the reduction activities which occurred at that locus. Biface data do not indicate the morphology of the bifaces at the initiation of reduction, which bears upon material transport and the amount of time spent at a locality. Biface data also do not indicate how many bifaces were actually reduced at a locality or the last stage to which they might ultimately

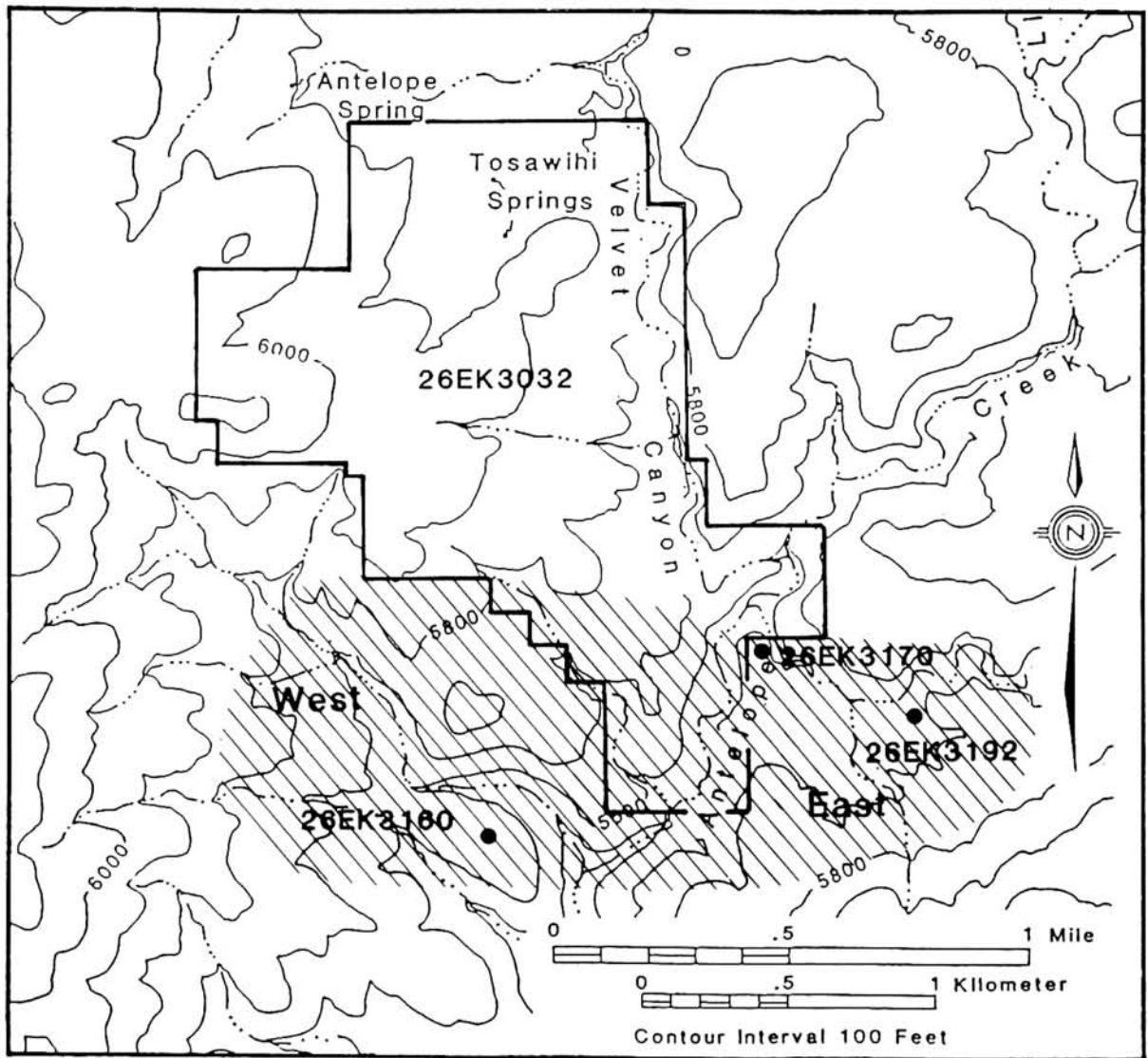


Fig. 2. General vicinity of the Tosawih quarries.

have been reduced. However, biface data, along with the debitage analysis, provide specific data concerning the general morphology of the manufactured product, and in light of biface breakage models, allow another avenue for estimations of manufactured quantities.

In contrast, debitage assemblages are the result of all reduction activities occurring at a given locus and, so, are viewed as a complete archaeological reflection of the numbers and

kinds of reduction activities. Debitage has been classified by four technologically diagnostic flake types and as nondiagnostic flake fragments and shatter. Diagnostic flakes include whole flakes classified as interior flakes, edge preparation flakes, early percussion biface-thinning flakes, and late percussion biface-thinning flakes (Flenniken 1987; Flenniken and Ozburn 1988).

Replication experiments, many of which were conducted during the 1989 Tosawih field

season, were technologically analyzed as control assemblages for the development of reduction models.² The analysis of replication data has shown that the relative proportions of debitage types vary with the stages of biface reduction (e.g., the ratio of edge-preparation flakes to early-stage biface-thinning flakes and the ratio of interior flakes to early-stage biface-thinning flakes). In addition, the proportions and ratios associated with core reduction are distinct from those of biface reduction. Therefore, proportional and ratio data can be used to distinguish core reduction and general stages of biface reduction.

To date, the analysis of replication data has allowed only the general distinction of early-stage biface reduction (Stage 1 to Stage 3.3) from late-stage biface-thinning (Stage 3.4 to Stage 5.0). This limitation is the result of analyzing replication debitage that was collected only at the end of each replicated reduction continuum. The replication debitage was not collected at the end of each stage of reduction, and therefore mixing of potentially distinctive data sets took place. Nevertheless, the distinction between early- and late-stage biface reduction is useful to the Tosawih analyses because most of the archaeological samples to which the replication-derived reduction models were applied also are the result of mixed reduction events. General conclusions satisfy the analytical goal to interpret the predominant reduction activities which occurred at any given locus.

Reduction Models

Technologically distinct reduction activities have produced technologically distinct debitage assemblages. The distinctions were measured by the variability of the proportions of diagnostic flake types. Importantly, the relative proportions of flake types vary somewhat ordinarily through the reduction continuum from the production of flake blanks (Stage 1 bifaces) by

core reduction to the final stages of secondary biface-thinning (Stage 4 reduction). The cumulative line graph in Figure 3 illustrates the variability of flake type proportions between different reduction activities. These cumulative curves can be thought of as profiles of the reduction character of each assemblage. Flake types are graphed left to right along the X-axis as interior flakes, edge preparation flakes, early-stage biface-thinning flakes, and late-stage biface-thinning flakes. The relative proportions of interior flakes and edge preparation flakes are greatest as a result of core reduction and the earliest stages of biface reduction. They decrease with a proportional increase in biface-thinning flakes as reduction proceeds through secondary thinning (Stage 4).

Replicating core reduction to produce large opalite flake blanks resulted in relative frequencies of diagnostic debitage illustrated by the uppermost cumulative line graph (profile) in Figure 3. The proportion of interior flakes and edge preparation flakes are high relative to the number of flakes with biface reduction attributes. That biface-thinning flakes were produced at all during core reduction illustrates the slight typological overlap between core- and biface-reduction debitage. The overlap is minimal, but draws attention to the necessity of emphasizing the analysis of proportional data sets. Ahler's criticism of the typological classification of debitage stems from his recognition of the same phenomena, but the fact that a small number of biface-thinning flakes are produced during core reduction does not outweigh the overwhelming predominance of flake types indicative of core reduction. The replication data from Ahler himself (1989:86-88; Table 1) support the assertion that flake type proportions vary distinctively between each reduction technology.

The middle profile represents the proportions of flake types resulting from replicating the early stages of biface reduction, in this case,

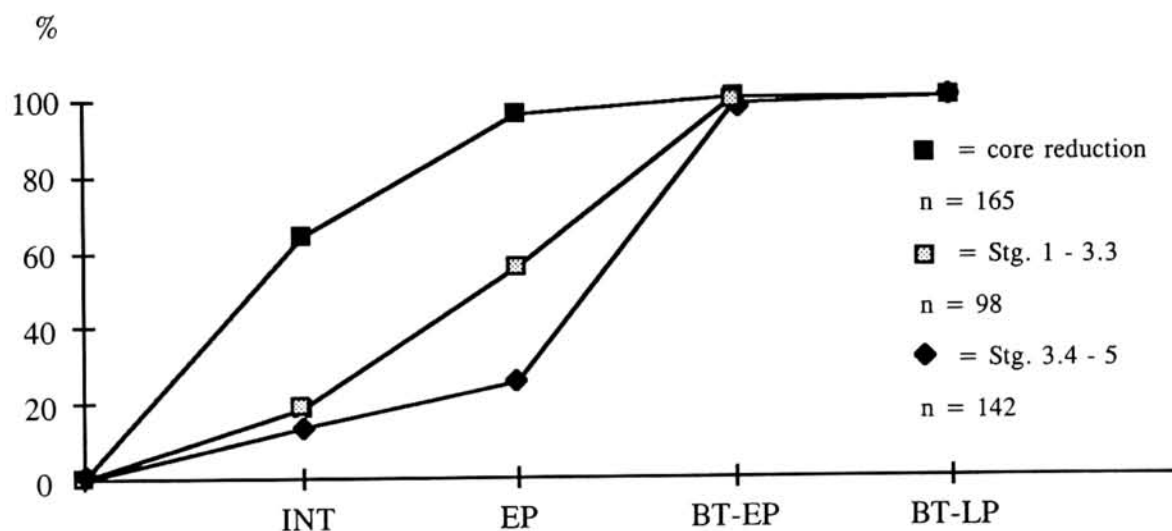


Fig. 3. Reduction assemblage profiles represented by cumulative debitage proportions. Debitage types: INT = interior; EP = edge preparation; BT-EP = biface-thinning, early percussion; BT-LP = biface-thinning, late percussion.

Table 1
KS* STATISTICS

Comparison between:	Maximum Difference	Probability of Normality
core reduction and stages 1 - 3.3	0.401	0.173
stages 1 - 3.3 and stages 3.4 - 5	0.232	0.179
core reduction and stages 3.4 - 5	0.632	0.156

* Kolomogorov-Smirnov tests

Stage 1 to Stage 3.3. The lower profile represents proportions from replicating the late stages of biface-thinning (Stage 3.4 to Stage 5.0). Comparing these three reduction profiles illustrates the significant diversity between the three technologically distinct reduction activities (Table 1). Kolomogorov-Smirnov tests (Table 1) show the observed differences between each pair of replicated reduction profiles to be significant ($p=0.05$).

In addition to the profiles of cumulative flake type proportions, ratios of flake type proportions discriminate between core reduction and early and late stages of biface reduction. The ratio of edge-preparation flakes to early biface-thinning flakes has proved to be the most discriminating. The analysis of flakes from 14 biface reduction replications indicated that ratios of edge preparation (ep) flakes to early biface-thinning (ebt) flakes greater than 0.35 to 1 (ep: ebt=0.35:1.00) are associated with early stages of biface reduction. Ratios less than 0.25:1.00 were associated with generally later stages of biface thinning. Intermediate ratios are interpreted as early/late reduction. Ratios of interior flakes (int) to early biface-thinning flakes (int: ebt) are not as discriminating, but can be used either to support or refine interpretations of the reduction character of an assemblage. The ep: ebt and int:ebt ratios for the three models profiled in Figure 3 are listed in Table 2.

The cumulative profiles and ratio models for core reduction, early-stage biface reduction and late-stage biface-thinning are used in the analy-

Table 2
RATIOS OF FLAKES IN SELECTED ASSEMBLAGES

Assemblage	Reduction	Number of Raw	Number of Heat-treated	Raw ep:ebt*	Heat-treated ep:ebt	Raw int:ebt	Heat-treated int:ebt
Replication	Core reduction	165	0	5.08:1.00	--	6.62:1.00	--
Replication	Biface stages 1-3.3	98	0	0.79:1.00	--	0.30:1.00	--
Replication	Biface stages 3.4-5	142	0	0.18:1.00	--	0.26:1.00	--
26EK3170 F8/LB	Early biface	851	46	0.55:1.00	0.88:1.00	0.42:1.00	0
26EK3192	Late biface	955	129	0.22:1.00	0.17:1.00	0.14:1.00	0.03:1.00
26EK3160 F1	Late biface	1,146	388	0.11:1.00	0.20:1.00	0.15:1.00	0.10:1.00

* ep:ebt = ratio of edge preparation flakes to early biface-thinning flakes;
int:ebt = ratio of interior flakes to early biface-thinning flakes.

sis of archaeological debitage assemblages as controls for the interpretation of the predominant reduction activities that produced those assemblages. At Tosawihi, many debitage assemblages are distinct reduction loci or residential/reduction loci. Sites at Tosawihi often are composed of numerous loci, and the geographically distinct project subareas encompass geographically associated sites. Therefore, interpreting the reduction character for each locus provides the basic data set for the analysis of the organization of biface manufacture, relative to various permutations of spatial contexts and reduction activities, throughout the vicinity of the Tosawihi quarries.

Analytical Results

The application of technological data collection methods and reduction assemblage models to the analysis of archaeological debitage has resulted in well-defined character distinctions for numerous intrasite and intersite reduction loci that reflect the diversity and intensity of reduction activities within variable residential contexts. Three cases were selected as examples of the methodological value of using assemblage models in the interpretation of reduction activities.

Case 1. Within the Tosawihi project's East Subarea, bordering the southeastern margin of the main quarry area (Fig. 2), sources of good quality opalite are limited and quarrying is sporadic with only 18% of the 155 reduction loci resulting from quarrying activity. Only 3% of the loci contain artifactual evidence of residential activities. However, discrete biface reduction stations are abundant (76.5% of the total). During the 1988 and 1989 field seasons, 1,301 complete and fragmentary bifaces were recovered from the East Subarea. Large Stage 2 bifaces comprised 19.6% of the collection while 69.5% were large Stage 3 bifaces, reflecting the early part of the reduction continuum. Feature 8/Locus B at site 26EK3170 is representative of the generally early reduction character of the East Subarea.

Feature 8/Locus B is a concentration of opalite reduction debitage within a sparsely diffuse lithic scatter, located approximately 300 m. from the edge of the main opalite source and within 160 to 200 m. of two isolated quarry pits. Locus B measured approximately 16 m.² on the surface with a depth of 20 cm., although the vast majority of the debitage was recovered within the upper two cm. of the surface sediments. The major part of Locus B was field

sampled with 16 1-m.² units surface scraped to a depth of two cm. The technological sample of the Locus B debitage assemblage consisted of a 25% random sample of the 16 field collection units.

Proportional typological debitage data indicate a generally early-stage biface reduction assemblage profile, resulting from the production of Stage 2 and early Stage 3 bifaces. The early character of biface reduction at Locus B is illustrated by the cumulative curve and histogram in Figure 4. Relatively high ep:ebt ratios and int:ebt ratios also indicate early biface reduction (Table 2). The possibility that biface production was initiated as core reduction to produce flake blanks is indicated by the low frequencies of whole flakes (Fig. 4) as compared to the much greater proportion of flake fragments. These results are comparable to the proportions of flake types from the replicated reduction of a large opalite core (Fig. 5). The relative proportions of nondiagnostic flake fragments (approximately 65%) reflected in both instances (Figs. 4 and 5) are greater than the 40% to 60% usually resulting from the reduction of opalite bifaces (Figs. 6 and 7).

The analyzed debitage proportions recovered from Locus B indicate that biface production was initiated on large flake blanks removed from opalite cores or on large irregular blanks probably produced at the quarry and transported to Locus B. Most reduction then proceeded through Stage 2, and in a number of cases, into the early phases of primary thinning (Stage 3 biface reduction). If late-stage biface thinning occurred at the locus it did not contribute significantly to the sample debitage assemblage.

Case 2. Within the West Subarea (Fig. 2) many of the sites are large diffuse lithic scatters with 15.1% of their total reduction loci exhibiting artifacts that indicate a residential function, a substantial increase over the East Subarea. Two seasons of fieldwork recovered 2,289 complete and fragmentary bifaces from the West

Subarea. Large Stage 2 bifaces comprise 11.1% of the collection, 75.1% were large Stage 3 bifaces, and 5.1% were Stage 4. Hence, in contrast to the biface data from the East Subarea, the West Subarea exhibits a relatively late-stage biface reduction character. The reduction of a much greater proportion of heat-treated bifaces is also evident in that 54% of the recovered bifaces were heat-treated as opposed to just 26.5% from the East Subarea.

The late character of biface reduction in the West Subarea is exemplified by the reduction profiles of the debitage recovered from Feature 1 at residential/reduction site 26EK3160 (Fig. 6). Site 26EK3160 is a large lithic scatter located approximately half a kilometer southwest of the quarries in an area where opalite does not occur at or near the surface (Fig. 2). A spatially bounded debitage concentration, designated as Feature 1, is the largest and most dense of the 23 featured reduction loci that comprise site 26EK3160. The site as a whole is classified as a residential/reduction site, but the Feature 1 scatter probably represents the most concentrated residential activity on the site.

Like most of the reduction loci in the Tosawih region, subsurface debitage throughout Feature 1 decreases drastically between 10 and 20 cm. below the surface, with more than 50% recovered in the upper 2 cm. The analysis of debitage recovered from 0 to 2 cm. below the surface of Feature 1 documents the reduction of bifaces to late Stage 3 and into Stage 4. The cumulative curves at the top of Figure 6 illustrate a predominantly late-stage reduction profile. The differential proportions between edge preparation flakes and early percussion biface-thinning flakes indicate reduction to probably late Stage 3 and into Stage 4. The same relationship is expressed as an ep:ebt ratio of 0.11:1.00 (Table 2). The occurrence of late-stage biface-thinning flakes is more direct evidence of Stage 4 biface production (secondary thinning).

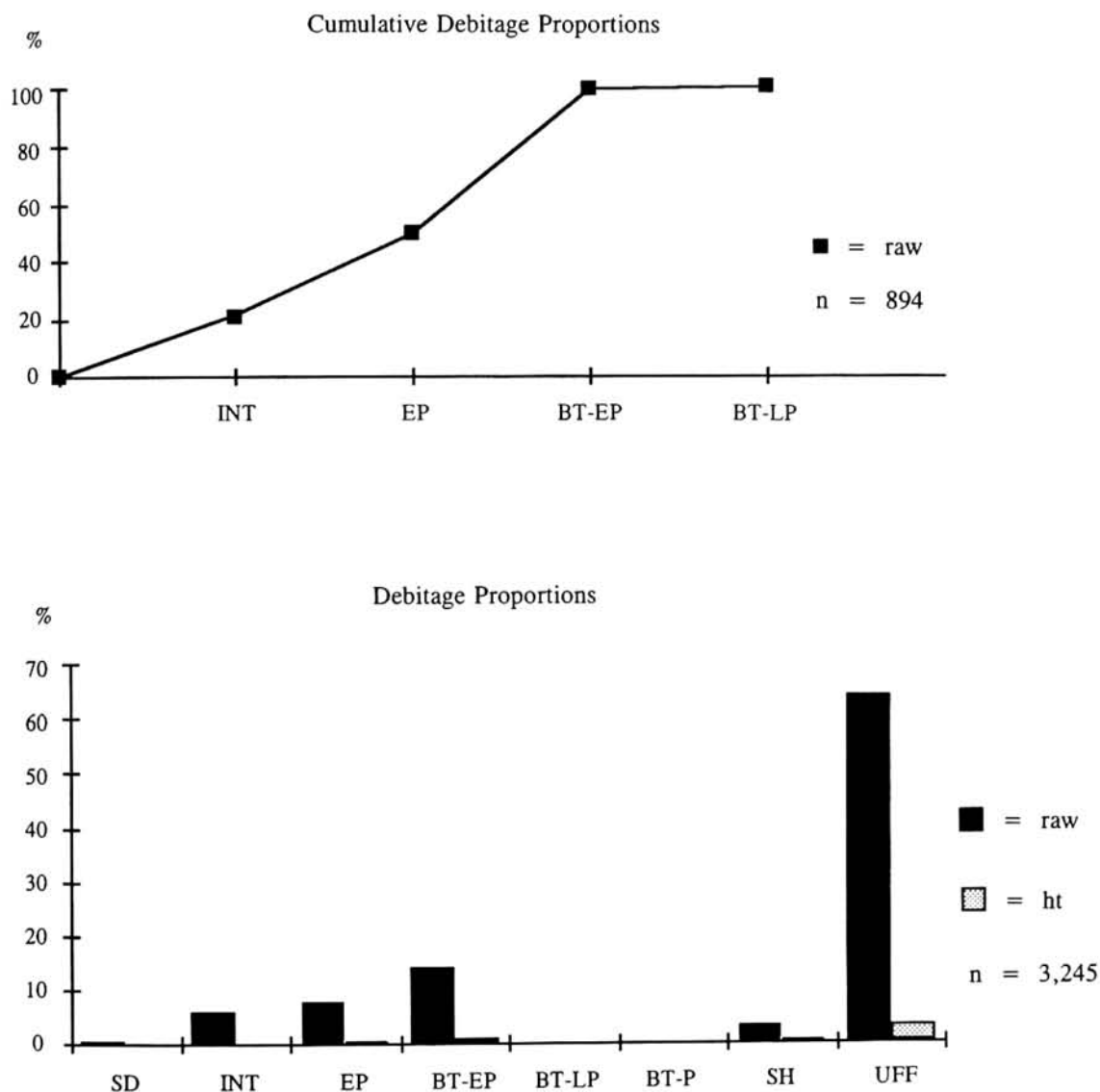


Fig. 4. Reduction assemblage profiles for debitage from site 26EK3170, Feature 8/Locus B. Debitage types: SD = secondary decortication; INT = interior; EP = edge preparation; BT-EP = biface-thinning, early percussion; BT-LP = biface-thinning, late percussion; BT-P = biface-thinning, pressure; SH = shatter; UFF = unidentified flake fragments.

Heat-treated debitage accounts for approximately 25% of the assemblage. The middle histogram (Fig. 6) shows the relative proportions of raw and heat-treated flake types calculated by

the total sample. The relative proportions of heat-treated debitage indicate that flake blanks, Stage 2 bifaces and Stage 3 bifaces were often heat treated prior to continued reduction. The

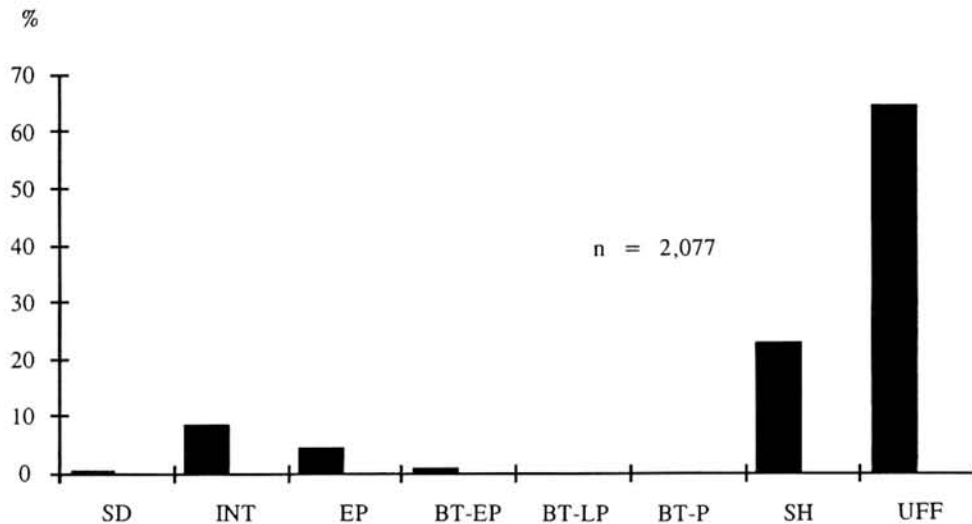


Fig. 5. Debitage proportions by type from replicated opalite core reduction. Debitage types: SD = secondary decortication; INT = interior; EP = edge preparation; BT-EP = biface-thinning, early percussion; BT-LP = biface-thinning, late percussion; BT-P = biface-thinning, pressure; SH = shatter; UFF = unidentified flake fragments.

bottom histogram (Fig. 6) shows raw and heat-treated opalite debitage proportions calculated by their separate totals. The reduction of heat-treated specimens was more often initiated slightly earlier in the continuum than for their nonheat-treated counterparts. The ep:ebt ratio data (Table 2) expresses the same relationship. The histogram also shows that a greater proportion of heat-treated bifaces were being reduced further through the continuum than was the case for raw specimens. Still, the relative proportions of raw to heat-treated debitage (Fig. 6, middle histogram) indicate that the majority of the biface reduction occurring at Feature 1 produced late Stage 3 bifaces without the benefit of heat treatment, with a probable ratio of 3 to 1 (raw:heat treated).

Case 3. This last case study is an analysis of the debitage associated with a large biface cache and serves as an example of the effect of flake blank morphology on the relative proportions of debitage that result through biface

reduction. The biface cache and its associated debitage also illustrate caching behavior, probably common within the Tosawihvi vicinity. The indicated pattern is that large flake blanks and probably early Stage 2 bifaces were often transported away from the main quarry, reduced further at camp sites, and cached for future transport out of the Tosawihvi quarries.

The cache locus is located approximately half a kilometer east of the main quarries at site 26EK3192 (Fig. 2). Poor to good quality opalite is available nearby, but the material of the biface cache and the associated debitage is good to excellent quality and probably comes from sources within the main quarry area. The cache of 41 large bifaces was recovered within a 0.5 m.² area between the surface and a depth of 20 cm. The bifaces were stacked and appear to have been placed in a pit.

Analysis of the surface debitage, systematically sampled over a 14 m.² area surrounding the cache, indicates that much of the debitage

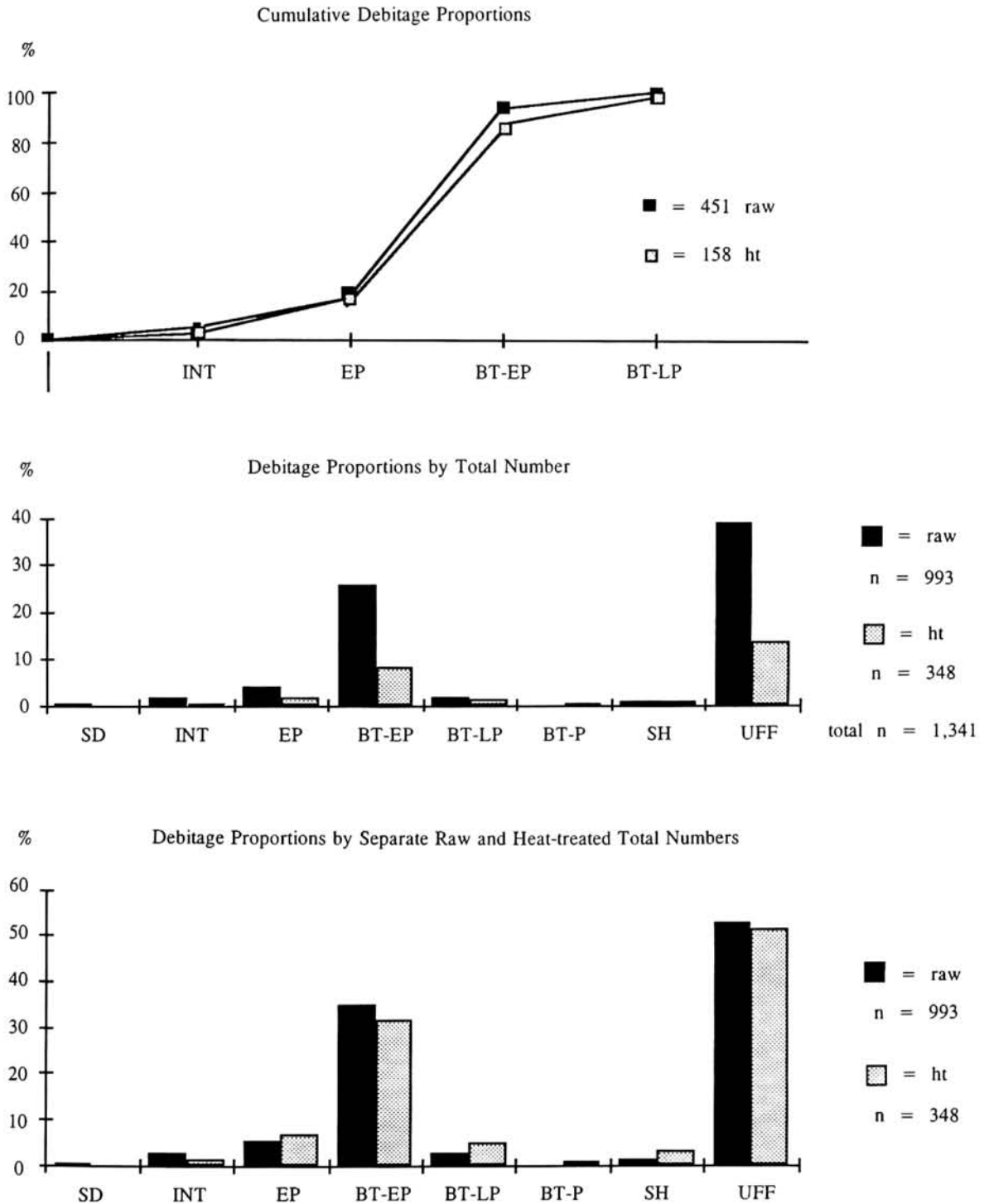


Fig. 6. Reduction assemblage profiles for raw and heat-treated debitage from site 26EK3160, Feature 1. Debitage types: SD = secondary decortication; INT = interior; EP = edge preparation; BT-EP = biface-thinning, early percussion; BT-LP = biface-thinning, late percussion; BT-P = biface-thinning, pressure; SH = shatter; UFF = unidentified flake fragments.

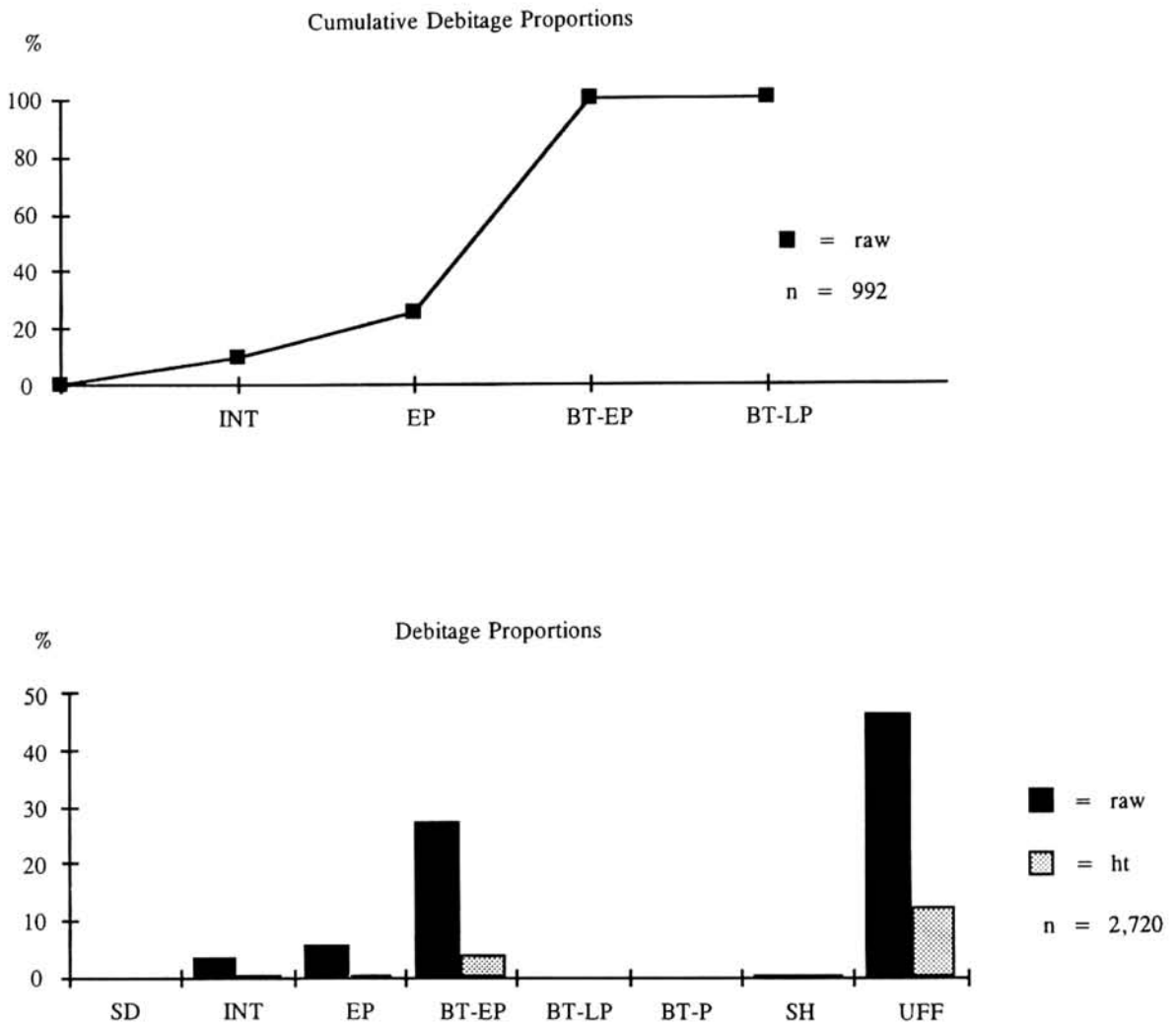


Fig. 7. Reduction assemblage profile for cache area debitage from site 26EK3192. Debitage types: SD = secondary decortication; INT = interior; EP = edge preparation; BT-EP = biface-thinning, early percussion; BT-LP = biface-thinning, late percussion; BT-P = biface-thinning, pressure; SH = shatter; UFF = unidentified flake fragments.

resulted from the reduction of the cached bifaces. The biface and debitage material are comparably similar varieties of opalite.³ The relative proportions of debitage types illustrated by both the cumulative curves and the histogram in Figure 7 indicate generally late-stage biface reduction. Figure 8 shows the relative proportions of the 55 cache area bifaces by stage (in-

cluding the 41 cached specimens and the 14 recovered from the surrounding 14 m.² area). The bar graph (Fig. 8) shows a greater percentage of Stage 3 bifaces, but also reflects a relatively high proportion of Stage 2 bifaces; more than indicated by the debitage proportions. At least two explanations for this are possible. First, when the bifaces were brought to the

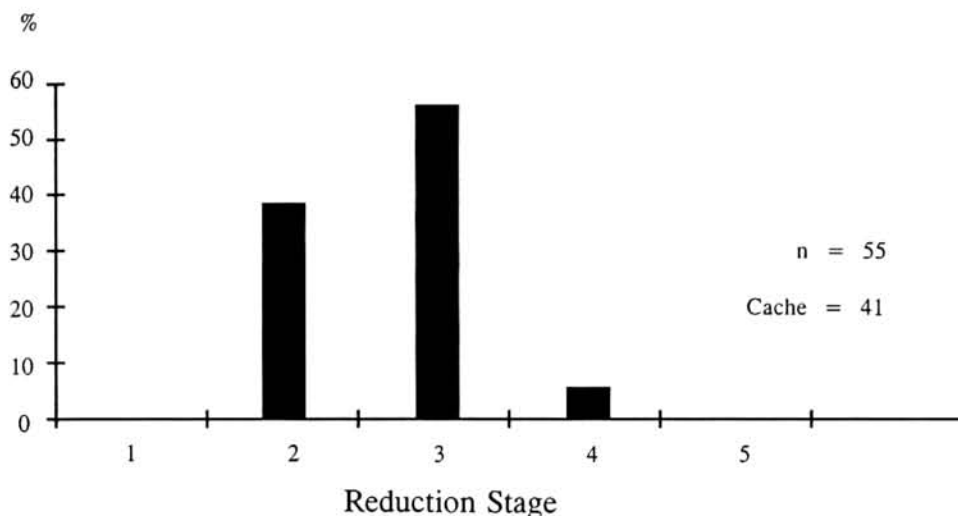


Fig. 8. Proportions of cache area bifaces by reduction stage from site 26EK3192.

cache area, a high proportion could have already been reduced to Stage 2 bifaces and possibly a somewhat lesser number to Stage 3. Continued reduction would have produced the recovered debitage and a majority of late Stage 3 bifaces. Many of the Stage 3 bifaces eventually would have been removed and a high proportion of the Stage 2 bifaces cached.

A second possibility illustrates the effect of flake blank morphology on debitage proportions. Analysis of the material of the cached bifaces indicates that the blanks were of fine quality opalite. Their symmetrical proportions would have required relatively little reduction before the initiation of primary thinning. Therefore, the relative proportions of interior flakes resulting from the removal of irregularities would have been minimal, and few edge-preparation flake removals would have been required to prepare a platform edge for primary thinning.

DISCUSSION

The technological analysis of debitage from discrete assemblages has resulted in the interpretation of biface production activities which occurred at specific loci within the vicinity of

the Tosawihii quarries. Reduction assemblage models developed from experimental replication data were successfully used as controls to interpret the reduction activities which produced the archaeological assemblages. The three cases presented to exemplify the theoretical and methodological basis for the ongoing technological analyses also illustrate the reduction variability evident in the Tosawihii archaeological record. The observed variability is being analyzed for linkages between residence patterning, mobility strategies, and tool stone procurement.

Case 1 has exemplified the frequent occurrence of early stages of biface reduction and probable core reduction within predominantly nonresidential contexts. Heat treatment and the reduction of previously heat-treated bifaces is evidently less common within nonresidential contexts. Case 2 investigated the nature of biface reduction within a residential context as a contrast to Case 1. Here the general profile of reduction activities indicated the continuation of biface production later through the continuum and included the heat treatment and continued reduction of probably 25% of the bifaces produced at the locus.

Case 3 was presented to illustrate the effect of flake blank morphology on the typological composition of a debitage assemblage. Replication data and archaeological assemblage data indicate that the morphology of the flake blank is a major nontechnological source of variability in the composition of a single event biface reduction assemblage. Recognition of its effect necessitates the future incorporation of morphological variability into the development of replication-derived assemblage models. This case also demonstrates the usefulness of incorporating biface data into debitage analyses as complementary evidence.

Characterizing the predominant lithic reduction patterns at loci across the quarries was the first step in what will eventually be a quantification of the effort, measured in time and reduced tool stone mass, expended to procure Tosawihi opalite. Since quarrying and biface production were the main foci of human activities at Tosawihi, the technological variability in tool stone procurement efforts was linked to settlement and mobility strategies, whether partially embedded or logistical.

Reduction assemblage models, based on multiple replications, will be the basis for additional analyses. Replications provide the control data sets for investigating the absolute frequencies and the relative proportions of diagnostic debitage resulting from technologically distinct reduction activities. The archaeological debitage comprises the essential representative data set for the interpretation of prehistoric reduction assemblages.

NOTES

1. Four years of archaeological investigations in the vicinity of the Tosawihi quarries were initiated in mitigation against proposed minerals exploration and extraction. The work was funded by Galactic Services, Inc.

2. During the 1989 field season, seven flintknappers, all lithic technologists (see acknowledgements), visited the Tosawihi field camp to participate in a knap-in. The purpose was to replicate the pro-

duction of large Tosawihi raw opalite bifaces, similar to those recovered from caches and other archaeological contexts. All replications have become part of a comparative collection housed at the offices of Intermountain Research.

3. Tosawihi opalite occurs in many distinct color and multicolor varieties.

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