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The Introduction of the Bow and Arrow and Lithic Resource Use at Rose Spring (CA-INY-372)

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One objective of the most recent re-excavation of the Rose Spring site in eastern California was to evaluate the impact of the introduction of the bow and arrow on local obsidian exploitation. Part of the strategy of the study involved the collection and analysis of a large sample of lithic reduction/production waste produced over the 5,500-year occupation of the site. A change was anticipated in the use of bifacial cores with the adaptation of a new hunting technology requiring less lithic material. A model of change was posited and then tested by using the data generated from the study. The results of the analysis indicate the possibility that certain changes in the reduction strategies practiced by the inhabitants of Rose Spring did not become manifest until nearly 1,000 years after the appearance of the bow, suggesting persistence of the use of the dart and atlatl until about A.D. 1500. An alternative interpretation based on obsidian hydration data is also discussed. Depositional mixing late in time coupled with change in site tool production activities late in time could account for the apparent appearance of continuity of earlier dart point reduction strategies during the long-term use of the site.

THE introduction of the bow and arrow to the North American continent surely had a profound impact on hunting and gathering populations who adopted its use late in the occupation of the New World. With this new hunting technology, the hunter could remain visually undetected while releasing deadly projectiles from a considerable distance, with greater accuracy (in most cases) than could be afforded by the atlatl. Inherent to this change in technology was a second advantage—the projectile tips, if made of stone, required less material than that necessary to construct dart points. In the absence of large quantities of readily available raw lithic material, this new technology could have been a particular boon. It also could have made scavenging of lithic materials from earlier encampments more profitable than at any time before the bow.

From an archaeological perspective, however, the above scenario begs the following question: Exactly what was the impact of the introduction of the bow and arrow on the way early Native Americans processed lithic resources? Although the answer to this question undoubtedly varies from region to region, taking into account a wide range of variables (level of dependence on stone for tool material, availability of certain types of stone, size of raw materials, etc.), the one consistent theme should be that related to size; ethnographic arrow points are smaller than dart points (Thomas 1981). Therefore, we can assume that projectile tips generally became smaller with the appearance of the bow. Smaller size means less stone, so how did this affect reduction/production trajectories? Presumably, this information should be manifest in lithic assemblages recovered from archaeological sites. Special emphasis must be placed on the lithic waste flakes from tool production, since the story they tell may be as robust as that of the formed artifacts.

The purpose of this article is to explore one test case involving a multiphase lithic analysis from the southwestern Great Basin. The site chosen, Rose Spring (CA-INY-372), formed the basis of a portion of the author's dissertation research (Yohe 1992). This site is well known for extensive prehistoric activity and a large number of projectile points (Lanning 1963). Rose Spring is the type site for the Rose Spring projectile point common in the American West.

THE INTRODUCTION OF THE BOW AND ARROW TO THE GREAT BASIN

Although it is difficult to say definitively that the bow was *not* independently developed in the New World, the present evidence indicates a diffusion of this technology from the Old World within the last few thousand years. The chronological occurrence of small projectile points and occasional bow fragments recorded in the archaeological record worldwide suggests early development of this technology in Europe and subsequent dispersal east and southward (Rausing 1967; Clark 1970). The first archaeological incidence of the bow ranges from 22,000 to 12,000 B.P. (Rausing 1967; Henry and Odell 1989), but it was clearly commonplace during the Mesolithic (Rausing 1967). The introduction of the bow to North America by way of the Arctic appears to have occurred by 5,000 years ago, but its progress south was impeded until approximately 2,000 years ago (Blitz 1988; Yohe 1992).

With the exception of small points from the Brewerton Phase of the Laurentian Tradition in New York thought to date to about 2,500 B.C. (Ritchie 1965), the oldest dates for the bow and arrow south of Canada are reported from the Great Basin. Estimated dates for the arrival of the bow and arrow in the Great Basin have ranged from 4,500 B.P. to 1,300 B.P. (Grosscup 1960; Davis 1966; Grant et al. 1968; Aikens 1970; Heizer and Hester 1978; Webster 1980; Laurent and Newton 1983; Holmer 1986). The evidence consists of the occasional preservation of actual bows and arrows in dry caves, in addition to the "sudden" stratigraphic appearance of smaller projectile points. Bow fragments have been preserved in a number of Great Basin cave sites, such as Lovelock Cave (Loud and Harrington 1929), Roaring Springs Cave (Cressman 1942), and Danger Cave (Jennings 1957). Arrow fragments have also been found in these and other caves (Aikens 1970; Jennings 1980). None of the bows or arrows has been subjected to radiocarbon analysis directly, but many occur in dated strata. The most ambiguous arrow shafts are present in Levels I through III at Lovelock Cave, the ages of which range from 500 B.C. to A.D. 900 (2,500 to 1,100 B.P.) (Grosscup 1960). Bow fragments from Danger Cave were recovered from Stratum V, which has three radiocarbon assessments on twigs from its base dating between 2,850 B.C. and A.D. 20 (Jennings 1957). Arrow shafts from Cowboy Cave are confined to Unit V, Strata A and B, dated at 1,890 ± 65 RCYBP and 1,580 ± 60 RCYBP, respectively. At Hogup Cave, arrows first appear in significant numbers in Unit II (3,250 to 1,600 B.P.) (Aikens 1970). If the artifacts in question have been correctly identified and the context is undisturbed, then these data alone suggest the presence of the bow in the Great Basin by at least 1,800 years ago.

The advent of small, predominately corner-notched points in the Great Basin is largely consistent with the above data. These points, frequently recovered in the central intermountain west, are commonly referred to as the Rose Spring and/or Eastgate types (or Rosegate [see Thomas 1981]). They are believed to represent the first arrow points in this area (Heizer and Hester 1978; Jennings 1978; Holmer 1986) and were first completely described in published form by Heizer and Baumhoff (1961) and Lanning (1963). Potentially early dates for these points include specimens from Connley Caves (3,000 B.P.; Bedwell 1973), Swallow Shelter (2,630 ± 110 RCYBP; Dalley 1976), Dirty

Shame Rockshelter (2,740 ± 80 RCYBP to 1,140 ± 95 RCYBP; Aikens et al. 1977; Hanes 1977), and Dry Creek Rockshelter (3,270 ± 110 to 1710 ±75 RCYBP; Webster 1980). Interestingly, all of these sites are located in the northern end of the Great Basin. While some conservative scholars contend that the bow first appeared after A.D. 1500 (Lanning 1963; Clewlow 1967; Madsen and Berry 1975), most archaeologists recognize an earlier (2,000 B.P.) presence of this weapon in the northern and eastern Great Basin (Aikens and Madsen 1986; Holmer 1986) and a later appearance (1,500 B.P.) in the west (Elston 1986). The overall evidence suggests that the bow and arrow was present in the Great Basin, at least at its northeastern end, perhaps as early as 2,000 years ago, and that it was well established by 1,500 years ago.

THE ROSE SPRING PROJECT

The Rose Spring site has long been recognized as one of the more important sites in the southwestern Great Basin because of its cultural stratification, high density of complete flaked stone artifacts (especially projectile points), and stratigraphically controlled radiocarbon assessments. It is located at the northern extreme of the Mojave Desert, just east of the Sierra Nevada and south of Owens Valley, California (Fig. 1). Original investigations of the site began in 1951 with the work of an avocational archaeologist (Riddell MS), followed by a more concentrated effort in 1956 by members the Archaeological Research Facility from the University of California, Berkeley (Lanning 1963). Additional excavations undertaken by Berkeley anthropology students in 1961 produced more than 300 projectile points from a stratified deposit more than three meters in depth (Lanning 1963).

In 1987, as a graduate student from the University of California, Riverside (UCR), the author returned to the Rose Spring site for three field seasons to conduct further excavations in an effort to obtain additional materials from features for radiometric analysis and to collect a representative debitage sample. Rose Spring is a large site complex, approximately 75,000 $m.^2$ and comprised of six separate loci. Locus 1, the focus of this study, was also the location of all previous work conducted at the site (Fig. 2). Radiocarbon dates from this site prior to the 1987 study had been limited to below 1.5 meters, and charcoal samples were not designated as coming from specific features (e.g., hearths). Based on the 1956 excavations, the oldest previously known date from the site was 3,900 ± 100 RCYBP. The 1987 field season resulted in the discovery of a hearth resting on sterile soil at 3 m., dating to 5,460 ± 80 RCYBP. Seventeen radiocarbon assessments are now available from Locus 1 (see Table 1).

Two questions served as part of the impetus to return to Rose Spring for further investigations: When was the bow and arrow first introduced to the southwestern Great Basin, and what impact did this new technology have on the use of locally obtained obsidian? Although the exact time frame is unknown, based on changes in projectile point size, the appearance of the bow was clearly later than the latest radiocarbon assessment obtained from the deposit prior to the 1987 field work (2,260 ± 100 B.P. [Lanning 1963]). An additional important factor in this study was the proximity of the immense Coso Volcanic Field obsidian quarries less than eight miles southeast of the site; obsidian comprises 99% of the lithic material types for flaked stone at Rose Spring.

RESULTS

In order to appropriately evaluate the two issues introduced above, it was necessary to discriminate between arrow and dart points in the archaeological deposit at Rose Spring and then firmly establish when each appears in the record. Rose Spring points have long been assumed to be the first arrow points, and thus have served as a marker for the inception of the bow

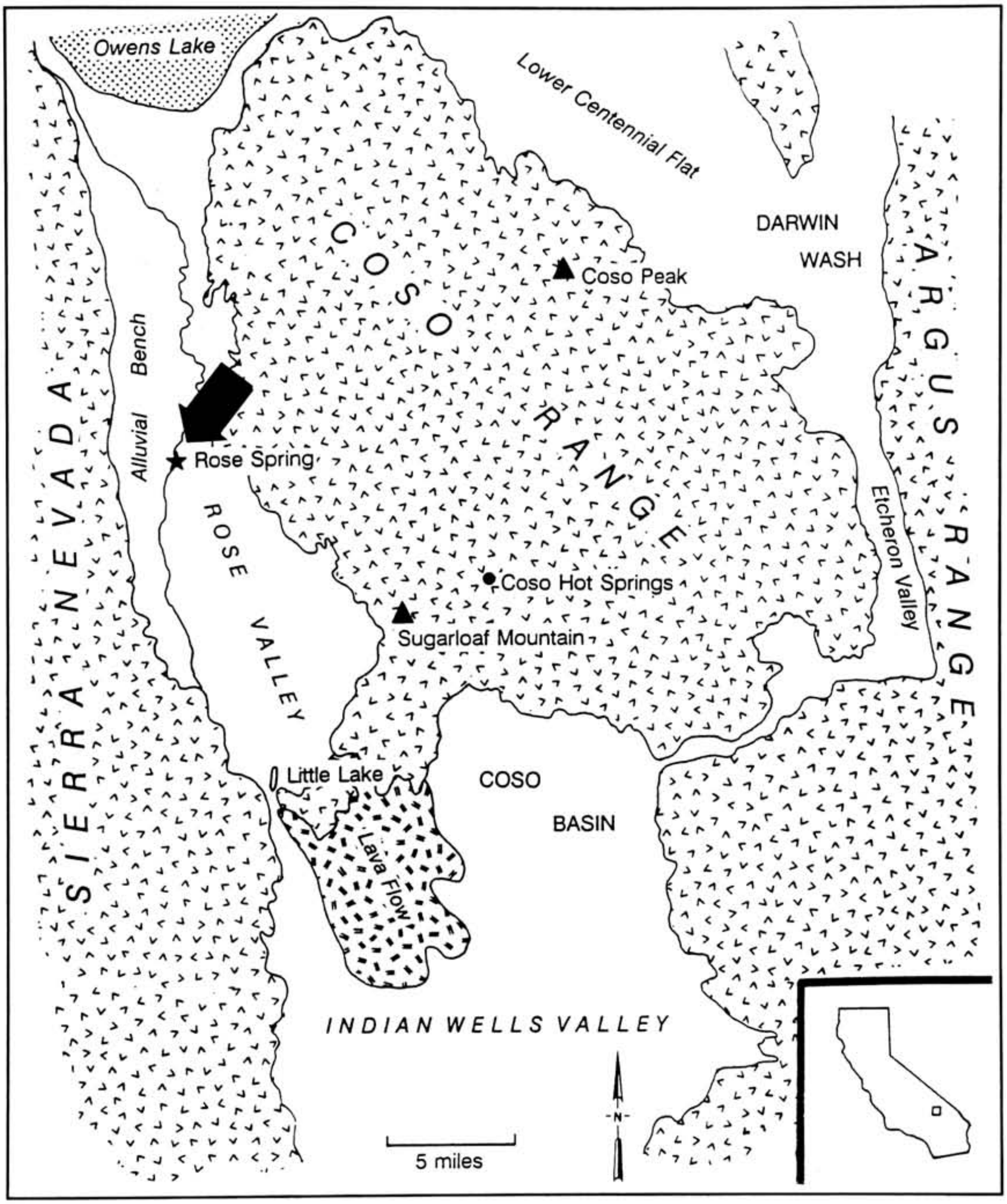

Fig. 1. Location of the Rose Spring site (CA-INY-372).

in this region. A reanalysis of the flaked stone materials collected between 1951 and 1961 seemed to reaffirm this contention. This distinction was further supported by the analysis of projectile points collected during the 1987-1989 field work at the site. A simple analysis of the length and width of complete projectile points from Rose Spring clearly demonstrates the existence of two separate populations (Fig. 3). It is important to note that these two populations are

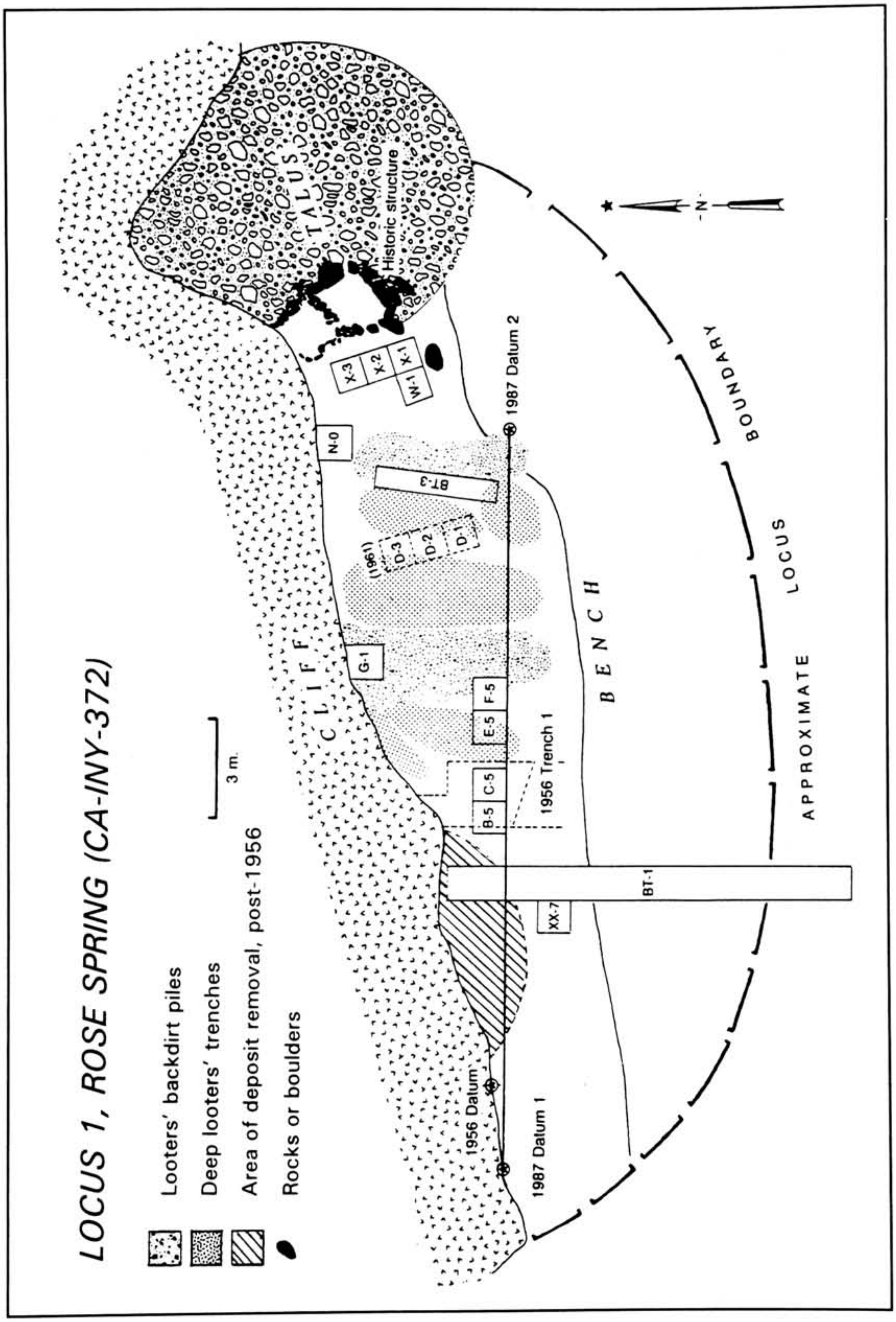

Fig. 2. Map of Locus 1, Rose Spring (CA-INY-372).

Table 1
RADIOCARBON ASSESSMENTS FROM 1987-1989 EXCAVATIONS, LOCUS 1, CA-INY-372

Lab. No.	Age (RCYBP)	$^{12}C/^{13}C$	Unit	Depth (cm.)
UCR-2323	110 ± 50	--	X-3	50
UCR-2327	280 ± 50	-27.02	W-1	70
UCR-2388	330 ± 50	--	X-1	42 to 48
UCR-2537	330 ± 60	--	W-1	100
UCR-2333	590 ± 60	--	W-1	65
UCR-2535	1,360 ± 70	--	X-1	80 to 90
UCR-2324	1,400 ± 50	-11.66	X-2	140
UCR-2513	2,070 ± 90	--	X-2	200 to 210
UCLA-1093A	2,240 ± 145	--	Trench 1	152 to 164
UCLA-1093B	2,900 ± 80	--	Trench 1	182 to 213
UCR-2328	3,240 ± 60	-19.77	BT. 1	230
UCLA-1093C	3,520 ± 80	--	Trench 1	213 to 225
UCLA-1093D	3,580 ± 80	--	Trench 1	244 to 255
UCLA-1093E	3,900 ± 180	--	Trench 1	274 to 305
UCR-2341	4,030 ± 100	--	E-5	270 to 280
UCR-2536	4,460 ± 110	--	E-5	260 to 270
UCR-2325	5,460 ± 80	-18.84	BT. 1	300

also separated stratigraphically (Yohe 1992). Based on these data, and the enriched suite of radiocarbon dates, the first significant occurrence of Rose Spring points in the deposit corresponds with a date of approximately 1,600 B.P.[1] (Yohe 1992).

If the appearance of Rose Spring points chronologically marks the introduction of the bow and arrow in eastern California and the western Great Basin, then it is clear that this technology was firmly established by 1,600 B.P. If such a technological innovation had a significant impact on obsidian resource utilization at Rose Spring, then a stratigraphic examination of obsidian core reduction/tool production refuse from the Rose Spring site could provide a model test case.

Prior to commencing this study, it was necessary to develop hypotheses about what one might expect to observe with the change from large dart points to small arrow points. A simplistic, yet functional, model based on the use of bifacial cores was proposed. Because large points require more obsidian, there should be a reduction in overall flake size, as well as biface size, following the appearance of the bow and arrow. In addition, larger biface thinning flakes, suitable for use as preforms for arrow points but too small for dart or large knife production, should be recovered in small numbers after the shift from darts to arrows. Flakes left at the site in dart point times could have been recycled during arrow point times, which would account for this reduction. Such scavenging and reuse of archaeological materials has been suggested elsewhere (Moratto 1987; Skinner 1988; Bettinger 1989). Also, overall biface size should be reduced with the appearance of the bow since aborted preforms should become smaller through time, reflecting the production of smaller points.

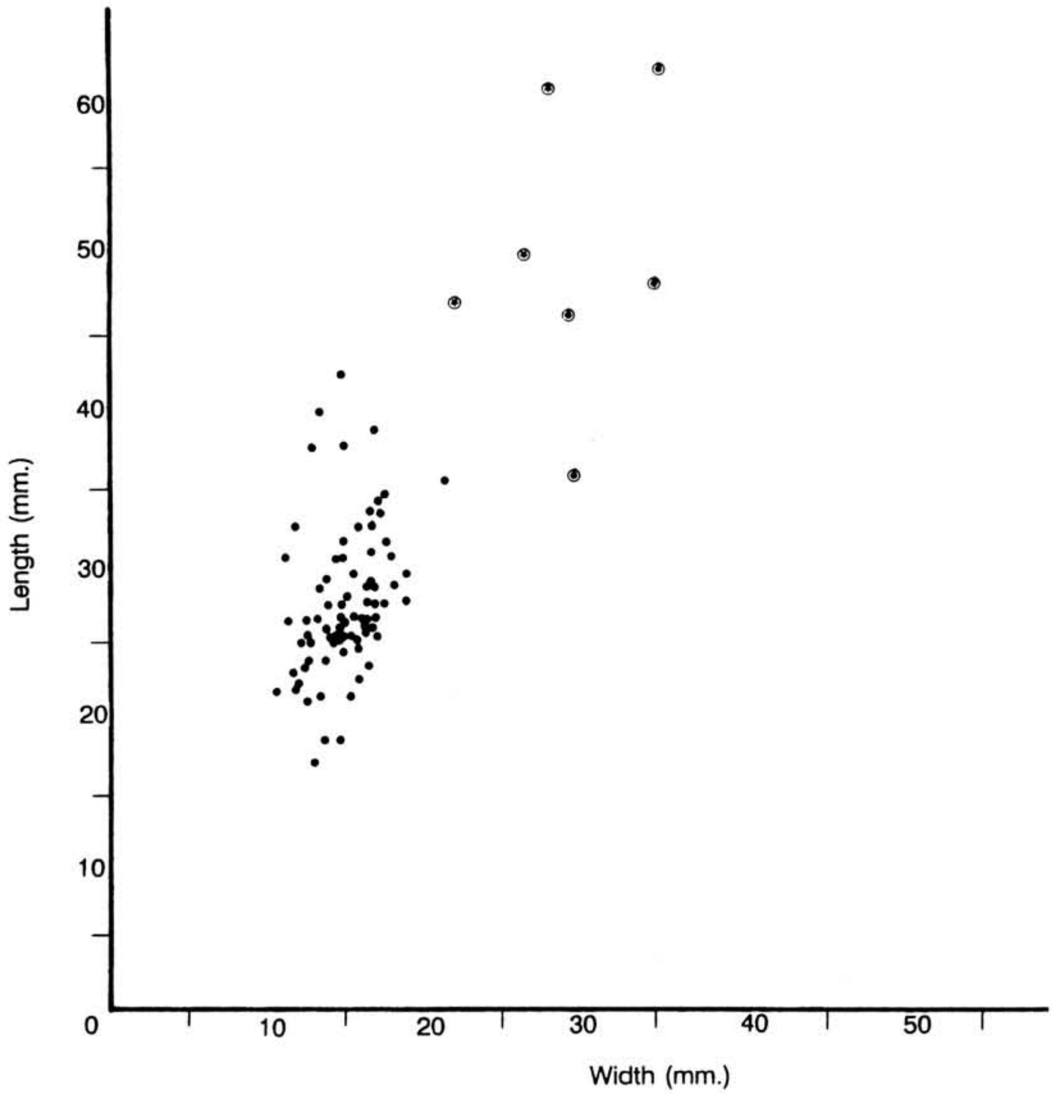

Fig. 3. Scattergram of complete length/width values for corner-notched/contracting stem points from Rose Spring. Note that two distinct populations emerge; all those forming the left group were "intuitively" classified as Rose Spring points. The other population is comprised of Elko/Gypsum points.

To test the model, bifaces and debitage taken from clear stratigraphic contexts were analyzed. The assumption critical to this study was the relative integrity of the cultural stratigraphy at Locus 1, which was supported in large part by the vertical distribution of temporally sensitive projectile point types throughout the deposit (but obsidian hydration studies may provide a different interpretation [see below]). Three distinct lithic analyses were undertaken: (1) the analysis of change in biface size through time; (2) a technological analysis of obsidian debitage; and (3) an analysis of the change in biface thinning flake size through time. The sampling universe for bifaces included those from the 1951-1961 excavations and those from the 1987-1989 excavations, the latter group taken from six 1.5 $m.^2$ excavation units at Locus 1 (G-1, N-0, XX-7, X-1, X-2, and X-3). Owing to the small, incomplete sample of debitage collected during the 1951-1961 excavations, only debitage from selected levels of the above units from the more recent excavations was included in the analysis.

A general assumption made prior to the analysis of these materials was that the primary form of obsidian core technology used at Rose Spring was the bifacial flake core. Single or multidirectional flake cores of obsidian occur at the site in very small numbers, and the majority of complete flakes from the deposit bear attributes diagnostic of biface thinning.

Biface Analysis

In an effort to account for possible change in reduction strategies and trajectories at Rose Spring, 523 bifaces and biface fragments were analyzed. Surface material and material from known disturbed contexts were not included in this study.

Methods. Technological analyses of bifaces focusing on reduction stage have only recently been applied to specific assemblages (Muto 1971; Callahan 1979) and addressed experimentally (Wilke and Flenniken 1988). The bifaces from Rose Spring were sorted into two main categories: late-stage and early-stage bifaces. These distinctions are largely qualitative rather than quantitative, but rely on the complexity of the surface topography and margin configuration of the specimen. Specimens with sinuous margins and simple surface topography were classified as early-stage bifaces; those with relatively regular margins, complex surface topography, and evidence of pressure flaking were classified as late-stage bifaces. Types of breakage (bending or perverse fractures) were also noted, since most of the specimens were broken during manufacture. Obvious preforms were also sorted out whenever possible, indicating dart/knife versus arrow point preforms.

Due to the incompleteness of most specimens, comparisons of size presented a problem. The decision was made to use thickness as the unit of comparison between all bifaces since it was the one attribute most frequently preserved in broken specimens. Admittedly, various production stages were represented by the sample, but it was believed that the sample size was sufficient to show any general trends in size change that might occur as the result of a shift in reduction/production strategies.

Results. The 1951-1961 and 1987-1989 collections were analyzed separately and then compared. Table 2 shows the frequency of bifaces and their various attributes by 12-in. levels from the 1951-1961 excavations. Attribute values are expressed as means with standard deviations being presented in the far right column. The same format is used in Table 3 for the analysis of the 1987-1989 bifaces.

Initial comparisons of the two data sets revealed several differences. The first difference is with respect to the number of early-stage versus late-stage bifaces in both collections. In the 1951-1961 collection, 41.7% of the bifaces are early stage, while in the most recent sample (1987-1989), early-stage bifaces make up the majority in reverse frequency (59.0%) (Tables 2 and 3). This may be an artifact of the difference between the two sampling strategies; the latest sample was collected from the extreme edges of the site, while the earlier sample comes largely from the interior. Secondly, standard deviations for size in the 1951-1961 sample are low, showing little variability in thickness, whereas the most recent collection shows a much higher rate of variability. In spite of these differences, the overall change in biface thickness through time seems similar (see Fig. 4). Contrary to the predicted model, the greatest reduction in biface

Table 2
MEAN BIFACE THICKNESS BY DEPTH, CA-INY-372 (1951-1961)

Depth (in.)	N	Early Stage	Late Stage	Thickness (mm.)	Std. Dev.
0-12	53	10	43	63	0.79
12-24	49	17	32	58	0.76
24-36	54	24	30	80	0.89
36-48	61	22	39	73	0.86
48-60	56	29	27	84	0.92
60-72	46	27	19	90	0.95
72-84	14	10	4	102	1.01
Totals	333	139	194		

size occurs within the last 600 years rather than the predicted 1,600 years.

Statistical Analysis of Biface Data. Although simple statistics for change in biface size (as defined by thickness) through time indicate an observable trend towards reduction, a more solid means of defining this change was warranted. The important questions to ask are: (1) to what degree is the variation in size a function of depth?; and (2) is there a statistically significant difference in size after the appearance of Rose Spring projectile points in the cultural deposit?

These questions were thought to be best addressed through further statistical analysis. This analysis was accomplished with the use of the SAS system on the VAX mainframe at UCR. Three separate data sets were analyzed: the 1951-1961 biface collection (n = 333); the 1987-1989 biface sample (n = 183); and the combined sample (n = 516) (Table 4). Analysis of correlation was used in an effort to answer the first question concerning size as a function of depth. For this analysis, biface thickness was correlated with level using Pearson's *r*, Kendall's *tau*-B, and Hoeffding's *D*. For the 1987-1989 sample, Pearson's *r* was selected since levels were uniform. For the other two samples, Kendall's *tau*-B was selected since levels were ranked, but unequal. The formula for Kendall's *tau*-B is:

$$\tau = \frac{\sum_{i<j} \operatorname{sgn}(x_i - x_j) \operatorname{sgn}(y_i - y_j)}{\sqrt{(T_0 - T_1)(T_0 - T_2)}}$$

Additional t-tests were performed to compare biface size between the samples, one above one meter (the point at which the bow and arrow seem to be in common use [Class 1]) and one below one meter (pre-arrow time [Class 2]) (see Table 4). The first group analyzed was the 1951-1961 collection; the second group was the 1987-1989 collection; and the third was the combined sample. A second combined sample (Combined 2), comparing materials from 0 to 60 cm. with those found from 60 to 260 cm., was also analyzed because it is between 0 and 60 cm. that flake size begins to decline.

The results of the correlation and dependence analyses are presented in Table 5. Correlation of thickness with depth is significant for all three groups analyzed. The t-test shows a statistically significant difference between all classes, with the exception of the 1987-1989 sample (Table 6). The greatest difference appears to be in the comparison of the Combined 2 group, which is interesting in that this is further corroborated by a reduction in biface thinning flake size late in the occupation of the site (see below).

In sum, based on the measurement of biface thickness, statistical data do indicate a slight,

Table 3
MEAN BIFACE THICKNESS BY DEPTH, CA-INY-372 (1987-1989)

Depth (cm.)	N	Early Stage	Late Stage	Thickness (mm.)	Variance	Std. Dev.
0-10	5	2	3	4.63	2.37	1.54
10-20	12	4	8	4.80	5.10	2.25
20-30	12	7	5	6.72	10.60	3.26
30-40	12	6	6	7.14	13.51	3.68
40-50	7	4	3	6.61	12.03	3.47
50-60	15	13	2	9.23	7.20	2.68
60-70	8	4	4	9.54	22.69	4.76
70-80	9	6	3	8.20	9.83	3.13
80-90	15	8	7	9.11	28.8	5.37
90-100	7	3	4	7.69	9.04	3.00
100-110	12	8	4	9.54	9.54	3.09
110-120	10	7	3	6.82	10.66	3.26
120-130	12	5	7	7.63	4.30	2.07
130-140	6	4	2	11.93	31.97	5.65
140-150	8	5	3	7.35	4.44	2.11
150-160	8	5	3	8.20	8.14	2.85
160-170	10	8	2	7.67	7.36	2.71
170-180	2	1	1	10.78	13.88	3.73
180-190	3	1	2	8.17	2.35	1.53
190-200	4	2	2	8.83	13.26	3.64
200-210	2	2	--	11.60	0.09	0.30
210-220	--	--	--	--	--	--
220-230	2	1	1	3.74	--[a]	--[a]
230-240	2	2	--	7.7	7.29	2.70
Totals	183	108	75			

[a] Measurement is the same for both specimens.

though statistically significant, reduction in overall biface size post-1,600 B.P. However, the noted reduction is perhaps not as much as one might expect with a major shift in hunting technology.

Discussion. A possible explanation for this apparent yet unexpected temporal extension of pre-bow reduction strategies may be the continued production of Humboldt Basal-notched bifaces/knives (which are markedly larger than arrow points), into the beginning of early Cottonwood times (approximately 100 to 600 B.P. [Lanning 1963; Yohe 1992]). Based on microwear studies, Bettinger (1978) suggested that these bifaces may have been used as knives rather than projectile points. There is also the possibility that because this form of biface lacks barbs, it may have been used as a thrusting or "dispatching spear" (P. Wilke, personal communication 1987). This was a variable not accounted for in the model of bifacial flake core usage described above. Humboldt Basal-notched

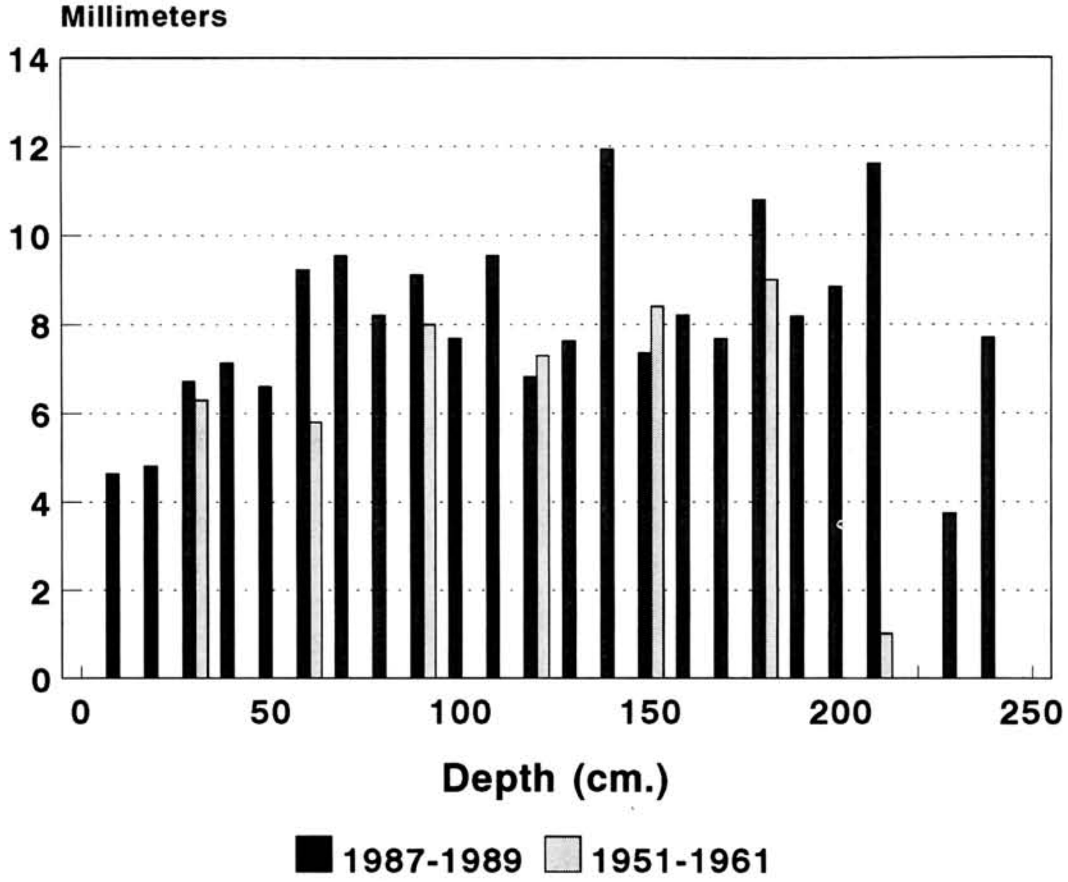

Fig. 4. Biface thickness through time based on the analysis of all bifaces collected from Locus 1, 1951 through 1989. The greatest decrease in size appears to have occurred within the last 500 years.

bifaces continued to be produced until approximately 600 years ago, just around the time when biface size in general decreased to a much greater degree. Bifaces large enough to serve as blanks for Humboldt tools would be approximately the same size as those necessary for the production of large dart points.

In other words, the bifacial core reduction trajectory apparently remained largely the same throughout the most intensive period of use at the site, with exhausted bifacial cores or large, trimmed flake blanks serving as the source of preforms for Humboldt Basal-notched bifaces, just as they would have earlier in time for dart points. Biface size decreases only when Humboldt "knives" were replaced by some other, possibly smaller, knife type (presumably ca. 600 to 700 B.P.). This interpretation is further corroborated by the debitage analysis (see below). The number of bifaces by depth also indicates the intensity of biface production at the site over time. Figure 5 shows the vertical frequency of bifaces from both major excavations (1951-1961 and 1987-1989), which in both instances show

Table 4
VALUES RESULTING FROM STATISTICAL ANALYSIS OF BIFACES, CA-INY-372

Class	N	Mean	Std. Dev.	Std. Error	Minimum	Maximum
1951-1961						
1	156	0.675	0.311	0.025	0.19	2.57
2	177	0.846	0.313	0.023	0.21	1.83
1987-1989						
1	102	0.759	0.397	0.040	0.19	2.55
2	81	0.836	0.346	0.039	0.26	2.35
Combined						
1	258	0.707	0.349	0.022	0.19	2.57
2	258	0.839	0.322	0.020	0.21	2.35
Combined 2						
1	165	0.639	0.288	0.023	0.19	1.45
2	351	0.836	0.347	0.018	0.21	2.57

Table 5
CORRELATION AND DEPENDENCE VALUES OF BIFACES, CA-INY-372

1951-1961 Sample (n = 333)	Class	Level
Pearson's *r*	0.25724	0.34813
probability	0.0001	0.0001
Kendall's *tau*-B	0.23838	0.26430
probability	0.0001	0.0001
Hoeffding's *D*	0.01299	0.03702
probability	0.0001	0.0001
1987-1989 Sample (n = 183)		
Pearson's *r*	0.10203	0.17718
probability	0.1741	0.0177
Kendall's *tau*-B	0.10625	0.14064
probability	0.0847	0.0066
Hoeffding's *D*	-0.00152	0.01014
probability	0.6901	0.0094
Combined Samples (n = 516)		
Pearson's *r*	0.19328	0.27856
probability	0.0001	0.0001
Kendall's *tau*-B	0.18784	0.21637
probability	0.0001	0.0001
Hoeffding's *D*	0.00820	0.02394
probability	0.0001	0.0001

that biface production was most intensive at Rose Spring during the last 3,000 years, with a zenith of activity about 1,500 to 2,000 years ago (also the time when site activity in general was at its greatest).

Another possible explanation for the presence of larger bifaces later in time is the persistence of the use of the atlatl following the introduction of the bow and arrow. It is not likely that such a long-term, deeply ingrained hunting technology would be instantaneously abandoned once the bow appeared on the scene. Clear examples of continued use of the atlatl until historical and even more recent times in the Americas are seen with the Aztec and with the peoples of the Arctic Circle. There was likely a technological overlap that may be difficult to discern archaeologically since atlatl use may have persisted for less than a few centuries. The total number of dart points from Rose Spring is fairly low; however, based on the vertical distribution of points from this site (Table 7), the numbers of dart points do appear to persist until 600 B.P.

This analysis seems to suggest that biface size does decrease with time, but not immediately following the introduction of the bow and arrow

Table 6
T-TEST RESULTS OF STATISTICAL ANALYSIS OF BIFACES, CA-INY-372

Sample	T	DF	Prob > |T|	Interpretation
1951-1956	-4.9230	342.0	0.0001	significant
1987-1989	-1.3645	177.0	0.1741	not significant
Combined	-4.4945	516.0	0.0001	significant
Combined 2	-6.8424	382.5	0.0001	significant

as originally hypothesized. The persistence of the manufacture of Humboldt Basal-notched bifaces late into the use of the site, or perhaps the persistence of the use of the dart and atlatl for several hundred years after the appearance of the bow, may account for this phenomenon.

Debitage Analysis

As an adjunct to the analysis of the bifaces presented above, a *technological* debitage analysis was undertaken on a selected sample of debitage collected during the 1987 field season from excavation units X-1 and XX-7. This analysis involved more than 12,000 flakes taken from selected levels spanning 0 to 260 cm. in depth. All of the debitage analyzed in this study was obsidian, which is the dominant material type (as noted above). More than 200,000 flakes of obsidian were collected during the 1987-1989 fieldwork, all of which were collected using 1/8-in. hardware mesh.

Although debitage analysis has become increasingly popular in the last several years as a means of quantifying and describing flake types as compared with experimental assemblages (Sullivan and Rozen 1985; Amick and Mauldin 1989; Ingbar et al. 1989; Prentiss and Romanski 1989; Rozen and Sullivan 1989; Paterson 1990), few analyses have attempted to fully evaluate assemblages using more refined technological categories. This is, in part, a result of the infancy of this avenue of inquiry. Beyond categorizing flakes as primary, secondary, and tertiary, or describing them as possessing or not possessing a platform, Lithic Analysts of Pullman, Washington (e.g., Flenniken et al. 1990), have increased levels of analysis to include the identification of types of biface thinning flakes (early-stage, late-stage), platform type (single-faceted, multifaceted), aberrant flake termination (i.e., *outre passé*), and other technological categories that allow for the examination of levels of *process* in lithic reduction/production. A similar approach for this study was adopted using terminology defined by Crabtree (1982) and Lithic Analysts (MS).

Technological categorization of debitage may allow for the identification of specific trends in reduction behavior in archaeological contexts. For example, lithic reduction strategies focusing on single directional and multidirectional cores would include nonbiface type flakes with minimal dorsal surface complexity, predominantly single-facet platforms, and exhausted single directional or multidirectional cores and/or core fragments. Cores prepared somewhere other than at the site should show little or no cortical material visible on the debitage; a preponderance of cortex in the archaeological flake assemblage would indicate that raw lithic materials were being imported to the site with little preparation. Strategies focusing on bifacial cores should be dominated by large biface thinning flakes, multifaceted platforms or platforms with remnant margins, few single-facet platforms, and an absence of multidirectional or single directional cores and/or core fragments.

Given the preponderance of bifaces over multidirectional/single directional cores at Rose Spring (Lanning 1963; Yohe 1992) and the

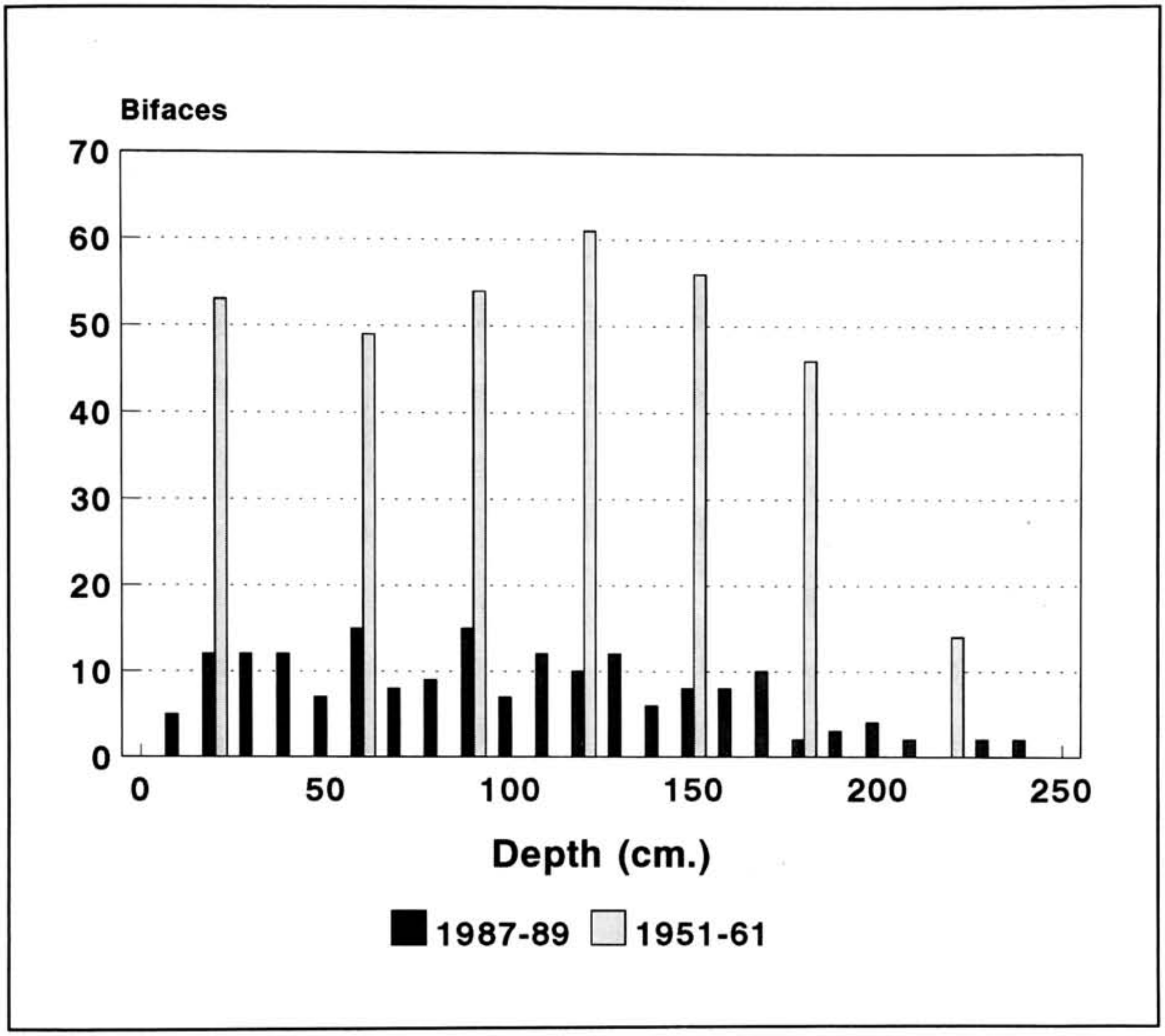

Fig. 5. Biface numbers by depth, Locus 1, Rose Spring (CA-INY-372).

abundance of diagnostic biface thinning flakes noted during the 1987-1989 excavations, an assumption was made (as noted above) that bifacial cores were the most commonly used type of core during the occupation of the site. Similar conclusions have been reached by other investigators in the Coso area (Elston and Zeier 1984; Allen 1986; Hildebrandt and Gilreath 1988). Elston and Zeier (1984) proposed a quarry obsidian-nodule-reduction strategy revolving around the "Coso core," a type of core that is keel-shaped and largely unidirectional. They reconstructed a reduction system that involved splitting nodules lengthwise and, by using the best half as the core, maximized the use of the stone. They likened the technology to the Old World Levallois technique. However, it is more likely that these cores represent the end pieces of larger cobbles that were sectioned for use as bifacial cores rather than being specific ends in themselves.

A debitage analysis conducted by Allen (1986) at the Coso Junction Ranch site (CA-INY-2284, approximately five miles south of Rose Spring) was used to test Ericson's (1984) hypothesis that the introduction of the bow and

Table 7
VERTICAL DISTRIBUTION OF PROJECTILE POINTS[a], CA-INY-372 (1951-1989)

Depth (cm.)	Age	CT[b]	DSN	RS	ELK	HUM	GYP	PIN
0-30		11	5	33	--	3	--	--
30-60	600 B.P.	10	4	48	2	2	--	--
60-90		3	--	32	4	2	--	--
90-120	1,500 B.P.	1	--	12	2	3	--	--
120-150		--	--	3	3	6	2	--
150-180	2,200 B.P.	--	--	3	10	1	--	--
180-220	2,500 to 4,000 B.P.	--	--	--	6	--	2	2
Totals		25	9	131	27	17	4	2

[a] Does not include surface artifacts.
[b] CT = Cottonwood Triangular (arrow); DSN = Desert Side-notched (arrow); RS = Rose Spring (arrow); ELK = Elko series (dart); HUM = Humboldt Basal-notched (dart/knife/thrusting spear); GYP = Gypsum Cave (dart); PIN = Pinto/Little Lake (dart).

arrow had a significant impact on trade and distribution of obsidian in eastern California during the Middle-Late Horizon transition. Using a modification of Elston and Zeier's (1984) debitage classification, Allen (1986) demonstrated through his analysis that the appearance of the bow did not seem to have a profound impact on the production or exchange of obsidian bifaces.

Methods. The analysis of the Rose Spring debitage was conducted using the technical categories adapted from those proposed by Wilke (MS). Flakes were examined for: (1) presence/absence of cortex; (2) attributes of biface thinning (flake morphology, including platform configuration); (3) attributes of nonbiface thinning; and (4) stage of biface thinning (early versus late). Based on a cursory examination of the debitage during the cataloguing process, a hypothesis was formulated concerning the obsidian reduction strategy most likely employed by the inhabitants of the site. The low density of cortical flakes and the high density of biface thinning flakes suggested the importation of well-trimmed, bifacial core blanks from the obsidian quarry areas less than 10 miles southwest of Rose Spring. By using the technological debitage categories in Table 8, it was felt that the proposed hypothesis could be confirmed or rejected. It could also serve to monitor any specific changes in flake type frequencies that might occur over time, specifically with regard to changes caused by the introduction of the bow and arrow. The original hypothesis described in detail above also states that flake size should diminish with the introduction of the bow, since it is suspected that recycling of large biface thinning flakes for arrow point blanks would be commonplace. Again, this was based on the premise that flakes that would have been usable for arrow points would not have been large enough for dart point blanks; therefore, if recycling was common after the introduction of the bow and arrow, then the premium biface thinning flakes should disappear or occur in small numbers *after* the arrival of the bow.

With this hypothesis in mind, a selected vertical sample of debitage was analyzed using the technical flake categories noted above. Since the sheer number of flakes from the two sample units was so great (n = 42,116), a staggered 31% vertical sample (n = 12,850) was analyzed. Sample levels were chosen at 30 to 50

Table 8
FLAKE TYPES AND DESCRIPTIONS FOR ROSE SPRING DEBITAGE ANALYSIS

Code	Flake Type	Significance
CC	completely cortical	earliest phase of reduction
PC/SFP	partially cortical, single-facet platform	early reduction phase, both for biface and all others
PC/MFP	partially cortical, multifaceted platform	early reduction, biface production
PC/PA	partially cortical, platform absent	early reduction
NC/SFP	noncortical, single-facet platform	later core reduction or early biface production
NC/MFP	noncortical, multifaceted platform	later reduction for bifaces and multidirectional cores
NC/PA	noncortical, platform absent	later core reduction
BT/ALT	biface thinning, alternate flake	early biface production on tabular cobbles
BT/BULB	biface thinning, bulb removal (with multifaceted platform)	bulb of percussion removed from large flake serving as a blank for a biface
BT/EP	biface thinning, early percussion	early stage of biface thinning
BT/LP	biface thinning, late percussion	late stage of biface thinning
BT/PRESS	biface thinning, pressure flaking	final stage of tool production

cm. intervals to insure a full representation of the deposit. Since excavations terminated at 210 cm. in Unit X-1, the remainder of the sample was chosen from two levels (220 to 230 and 240 to 250 cm.) of Unit XX-7. All flakes were categorized, counted, and bagged separately with labels bearing the category name.

Results. Probably the most striking finding about the debitage analysis is the apparent variability in most categories through time (Table 9).[2] As found in other special studies in archaeological materials (such as faunal analysis), the number of unidentifiable/unclassifiable items greatly exceeds that of the diagnostic categories. Many of the special categories of flakes (e.g., bulb removal, *outre passé*) were found to occur in very small numbers, and no significant shifts in patterns or percentages of flake types through time are obvious. However, other patterns with greater behavioral implications are clearly apparent.

The extremely low incidence of single-facet platforms and the ubiquity of biface thinning flakes throughout the deposit appear to support the original contention that bifacial cores were the most commonly used core type at the site. Platform abrasion prior to flake detachment seems to have been an uncommon practice. The small incidence of bulb removal flakes (flakes with a ventral aspect consisting of a detached bulb of percussion from a large flake/core) suggests that the incipient bifacial cores were completely prepared prior to arrival on the site, a contention that also is supported by the small numbers of alternate flakes and flakes bearing traces of cortex. In an experimental study performed by the author involving the sectioning of an obsidian cobble and trimming of three resulting flake blanks, all cortical flakes were sorted from interior, noncortical flakes. With 100% recovery of the experimental waste flakes, of the 683 flakes produced, 143 (26.5%) were either partially or fully cortical, suggesting that an increase in cortical flakes would be an indication

Table 9
RESULTS OF DEBITAGE ANALYSIS FROM SELECTED LEVELS, LOCUS 1, ROSE SPRING (CA-INY-372)

Level (cm.)	CC[a]	PC/ SFP	PC/ MFP	PC/PA	NC/ SFP	NC/ MFP	NC/PA	BT/ ALT	BT/ BULB	BT/EP	BT/LP	BT/ PRESS	All Others	Totals
0-10	1	--	--	--	14	25	91	--	1	6	20	6	205	369
10-20	--	1	2	2	23	112	95	--	1	4	23	38	989	1,290
40-50	--	2	--	1	19	59	40	--	--	9	12	10	837	989
60-70	--	2	4	1	9	110	124	--	--	7	23	55	1,591	1,926
90-100	--	1	--	--	38	326	233	--	--	20	72	66	1,606	2,362
120-130	--	--	--	14	14	140	164	--	--	12	43	38	1,873	2,298
150-160	1	9	16	4	--	71	84	--	--	13	19	14	469	700
180-190	1	2	3	5	13	70	62	--	--	13	5	20	887	1,081
200-210	1	--	1	1	9	30	25	--	--	--	--	7	245	319
220-230	--	13	10	6	29	93	102	5	--	18	9	30	677	992
240-250	--	11	1	16	29	35	76	--	--	5	6	9	336	524
Totals	4	41	37	50	197	1,071	1,096	5	2	107	232	293	9,715	12,850

[a] Refer to Table 8 for column code definitions.

of the importation of unaltered or only slightly altered raw materials. There is an apparent increase in partially cortical flakes below 130 cm.; however, the highest incidence of cortical flakes from *any* of the levels analyzed from Unit X-1 was 1.02%.

One trend that was apparent from the study of the debitage is the change in the production of late- versus early-stage bifaces just after the introduction of the bow at Rose Spring. Although the number of pressure flakes appears to be fairly consistent through time, early-stage biface thinning flakes outnumber those of late-stage biface thinning *prior* to the appearance of arrow points in the cultural deposit. Between 2,000 and 1,500 B.P., the number of late-stage biface thinning flakes increases markedly (Table 9). This is also the period of time during which all activities at the site increase dramatically, including the initial occupation of five of the six loci of CA-INY-372. This may suggest an expansion of local population, and perhaps a new emphasis on the production of bifaces for trans-Sierran and Mojave Desert trade (Coso obsidian is the most common obsidian source recovered from archaeological contexts in southern California [Ericson 1984]).

Interestingly, these data are not completely consistent with the study undertaken by Allen (1986). Using a different approach to his debitage analysis, he concluded that the arrival of the bow did not seem to result in a dramatic change of the obsidian reduction/production system at Coso Junction. Although he noted an expansion of "generalized lithic production" at about the time of the appearance of the bow, he did not detect an increase in late-stage biface reduction. He further concluded, as had Moratto (1984), that the bow was a simple technological addition and its impact on production systems was minimal, especially compared to more profound factors, such as population increase and environmental change. In this regard, both may be correct; the change in hunting technology locally may have completely independent roots from those of the increased production of late-stage bifaces.

Flake Size Through Time. It is logical to assume that one should see a decrease in overall flake size with the introduction of the bow and arrow, since the sheer volume of material needed to produce arrow points would be greatly reduced. Others have suggested this trend, and it has manifested itself in other archaeological assemblages (Singer and Ericson 1977; Jackson 1984; Skinner 1988).

In an attempt to further identify the approximate size of the bifacial cores that were being imported into Rose Spring, and to see if larger flake sizes decreased with the introduction of the bow and arrow, all *complete* biface thinning flakes from the same levels analyzed in Unit X-1 and two levels (220 to 230 cm. and 240 to 250 cm.) from Unit XX-7 were isolated and measured with sliding digital calipers from platform (representing margin) to termination (representing in most cases the approximate midpoint of the biface being manufactured). All measurements were made parallel against the margin to the termination to insure maximum accuracy in biface width estimation (Fig. 6). The logic behind this approach was that the width of these flakes would usually approximate one-half the width of the biface being produced, which was especially clear in those cases where a portion of the opposing terminating flake scar was included on the distal end of the flake being examined. In all cases, biface thinning flakes were also the *largest* complete flakes from the sample. Therefore, this sample also served to test the hypothesis concerning the reduction of the number of biface thinning flakes that would be anticipated if recycling of debitage for arrow point blanks became common after the appearance of the bow.

Again, the hypothesis as originally proposed was not supported by the data. The number of complete, large flakes actually *increases* slightly at approximately 1,600 B.P. (along with overall

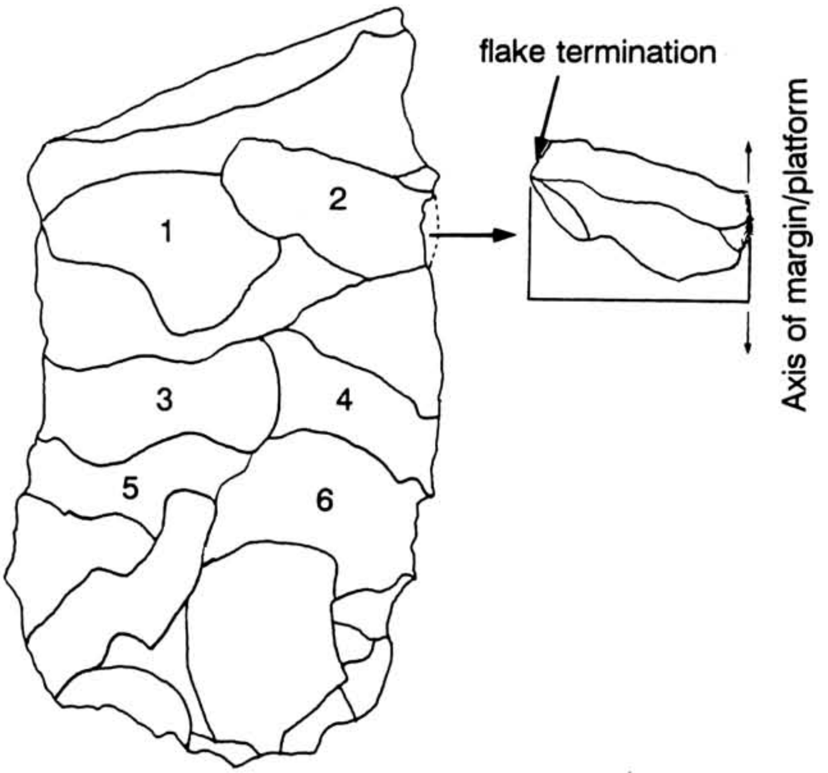

Fig. 6. Measurement of maximum biface thinning flake length as a means of reconstructing biface width. Note that most biface thinning flake scars on the biface illustrated (a drawing of an acutal specimen from CA-INY-1534) are approximately one-half the width of the biface. A fairly accurate estimate of maximum biface width can be obtained by measuring the maximum length of a complete biface thinning flake from a line parallel to the axis of the platform. By measuring the six most complete flake scars on this biface alone, the estimate for the maximum biface width (based on the mean value of scar length [2.85 x 2 = 5.7]) was within two millimeters of the actual value (5.5 cm.).

site activity) and then slowly declines until very late in time (Fig. 7). The implication is that basic stoneworking technology and bifacial core trajectory remain fairly constant throughout the use of the site, at least until the last few hundred years. Based on these data alone, it would be hard to argue for a reduction in the use of bifacial cores in favor of debitage recycling. This does not mean that debitage was *not* recycled for various uses at the site (since recent obsidian hydration studies have demonstrated recycling at this site); it simply suggests that the continued use of quarried material persisted after the introduction of the bow and arrow.

In terms of size, complete bifacial thinning flakes were found to vary little over the last 4,000 years of site use. Figure 7 shows the mean values for flake size plotted stratigraphically. There is a slight trend for reduction in size of early-stage biface thinning flakes later in

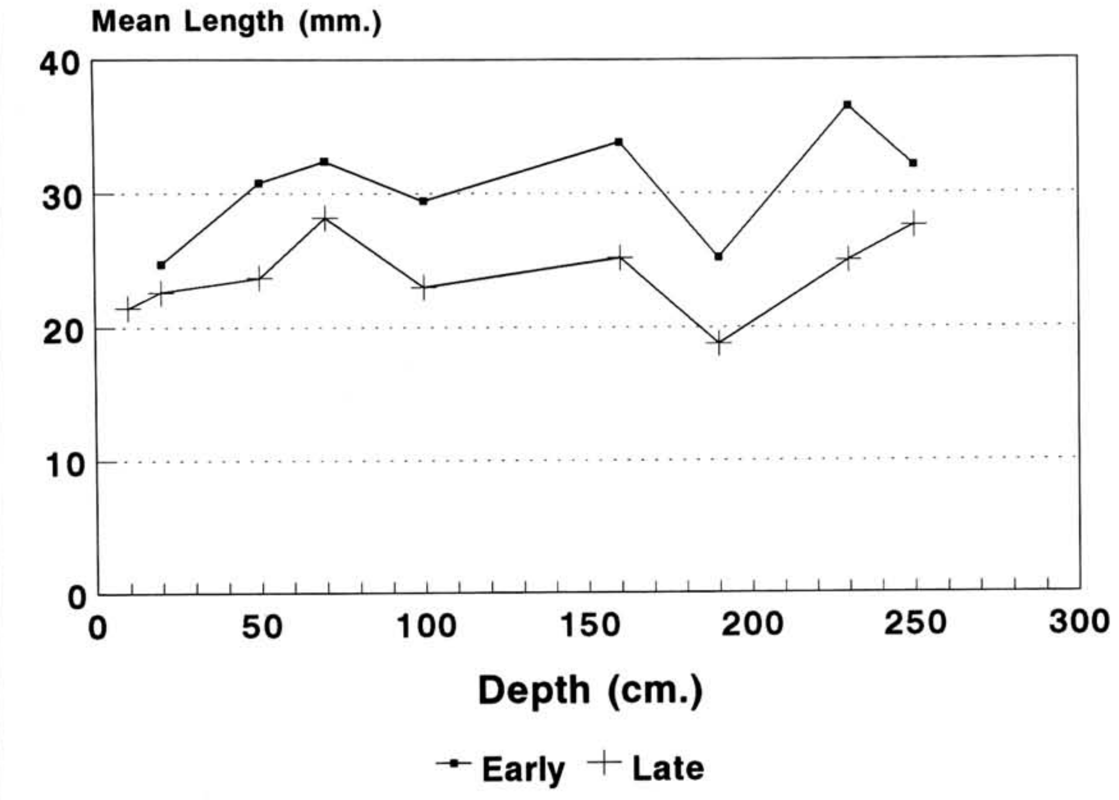

Fig. 7. Mean length of complete biface thinning flakes by depth, Locus 1 (CA-INY-372).

time, which mirrors that of the biface thickness data presented above. The largest early-stage biface thinning flakes (52 mm.) from the sample came from the deeper part of the deposit (220 to 230 cm.), but the average values in general are in the 25 to 40 mm. range. This suggests that most of the rough bifacial cores coming into the site were slightly less than 10 cm. in width. When this information is compared with experimental data from the reduction of three rough bifaces approximately 10 cm. in width, the results are quite similar. The point plots in Figure 7 show a similar size range for both early-stage and late-stage biface thinning flakes.

Late-stage biface thinning flakes are only slightly smaller, which may suggest the size of bifacial cores at the exhaustion point or the stage where pressure flaking was used to produce knives from the depleted cores. This trend parallels that of the early-stage flakes, which are consistently slightly larger.

The above data indicate a slight, overall reduction in biface size through time, which probably also accounts for the perceived diminution noted in biface thickness described earlier. This analysis also intimates that the small but apparent reduction in flake size may be due to a decrease in bifacial core size through time, espe-

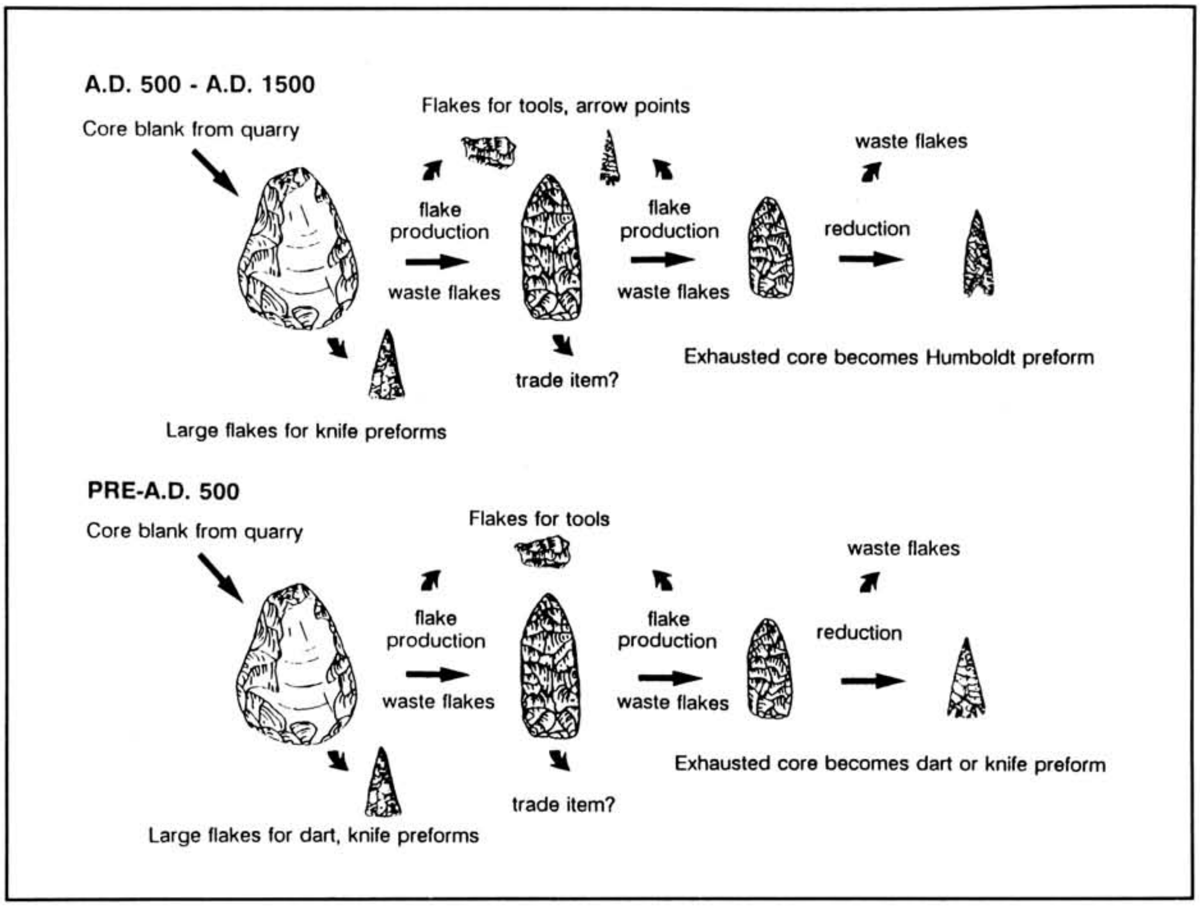

Fig. 8. Proposed reconstruction of generalized obsidian reduction strategies before and after the introduction of the bow and arrow.

cially apparent in the last 500 years. The hypothesis concerning the abandonment of earlier reduction strategies focusing on the production of large projectile points with the appearance of the bow and arrow was not supported by these preliminary studies. It is likely that the lithic resource utilization strategy that was in use when the site was first habitually visited in prehistory remained largely intact until very late in prehistory.

Based on the analysis of projectile points, bifaces, various flaked stone tools, and debitage, a new hypothetical reduction strategy is proposed for Rose Spring. An idealized view of this new system is illustrated in Figure 8. The various lines of evidence suggest that even though a remarkably different technology (the bow) was introduced to this region approximately 1,500 years ago, the general reduction system remained similar until very late in time. It is proposed that one reason for this continuity may have been the persistence of the production of large bifacial knives/thrusting spears, or perhaps the persistence of the use of the atlatl and dart, until the end of A.D. 600. Exhausted bifacial cores may have been used as preforms for dart points and knives, but eventually were used as knife preforms alone once the atlatl was abandoned entirely. Materials brought from the nearby quarries in pre-arrow times may have included rough core blanks as well as dart point flake blanks.

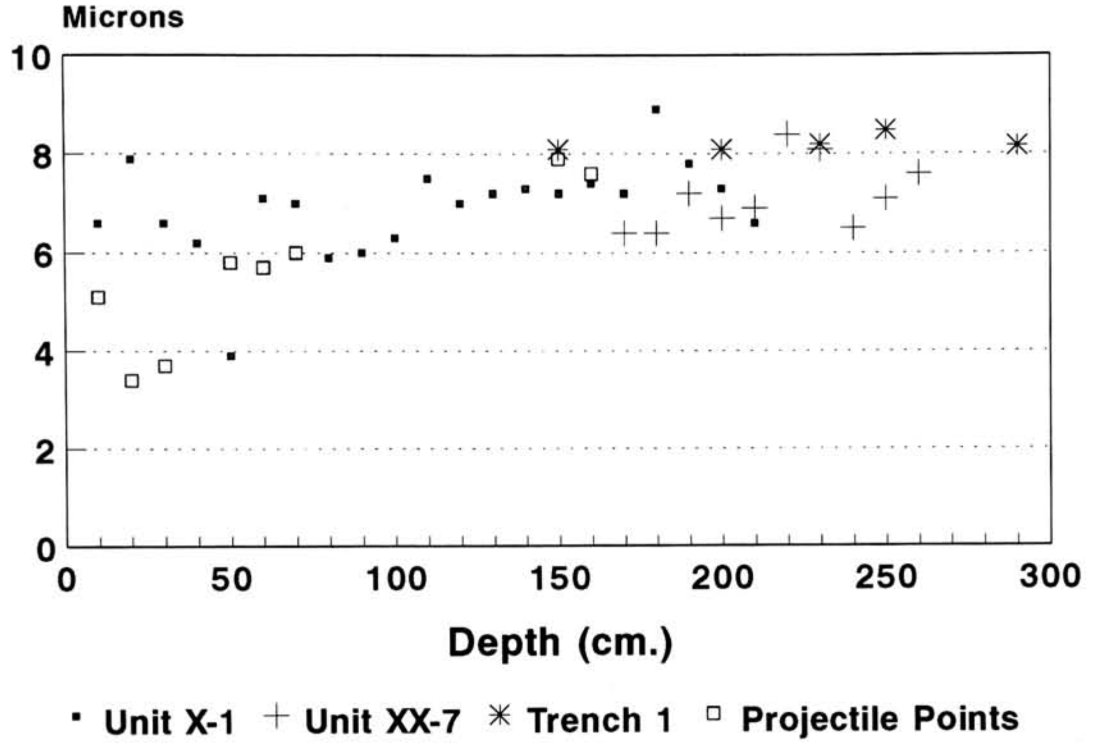

Fig. 9. Mean obsidian hydration readings from debitage and individual selected projectile points by level, Locus 1, CA-INY-372. Projectile points occurring at or below 150 cm. are Elko points; those above 150 cm. are Rose Spring or Desert series points.

However, this model may be compromised if the assumption that the archaeological deposit at Rose Spring is relatively intact is found to be in error. As noted previously, the above scenario/interpretation is predicated on the belief that the cultural strata at the site are largely undisturbed by natural agencies. Evidence of rodent activity in the form of krotovina was commonly noted during excavation, and at least a few temporally sensitive projectile points were vertically displaced, but at the time of the original study these observations were believed to be the result of fairly minimal bioturbation. The radiocarbon samples, as we have seen, suggest integrity of at least the features from which they were derived, if not the strata themselves.

Nevertheless, a slightly different picture is presented by the obsidian hydration analysis of the debitage and a selected number of traditionally time-sensitive dart/arrow points. A vertical sample of obsidian debitage (n = 95) was subjected to hydration analysis, as were 18 projectile points, all recovered from the 1987-1989 excavations. All obsidian was sourced to the Coso Volcanic Field. Figure 9 shows the vertical distribution of hydration values for Locus 1. The majority of the values fall into the 7μ to 8μ range, even in the upper levels of the deposit. This takes on greater significance when the mean values for the time-sensitive projectile points are examined (Table 10); most of the values fall into the "Elko" range (mean =

Table 10
OBSIDIAN HYDRATION VALUES FOR PROJECTILE POINTS, LOCUS 1, CA-INY-372

Cat. No.	Depth (cm.)	Type[a]	Band 1 (μ)	Band 2 (μ)[b]
131-G1-121	disturbed[c]	DSN	2.3	--
131-B5-160	disturbed	CLS	5.0	7.6
131-F5-21	10-20	CT	NVH[d]	--
131-G1-84	40-50	CT	3.6	--
131-N0-19a	0-10	RSCN	5.1	7.2
131-N0-19b	0-10	RSCN	5.2	7.0
131-W1-65	40-50	RSCN	3.7	--
131-W1-80	50-60	RSCN	5.8	18.3
131-X2-74	30-40	RS	3.4	--
131-XX7-72	60-70	RSCN	5.7	--
131-F5-36a	disturbed	HBN	6.7	--
131-F5-36b	disturbed	HBN	6.6	--
131-W1-98a	60-70	HBN	6.0	--
131-W1-98b	60-70	HBN	6.0	--
131-E5-59	150-160	ELK	7.9	--
131-E5-100a	160-170	ELK	7.6	--
131-E5-100b	160-170	ELK	7.7	--

[a] DSN = Desert Side-notched; CLS = Cottonwood Leaf-shaped; CT = Cottonwood Triangular; RSCN = Rose Spring Corner-notched; RS = Rose Spring; HBN = Humboldt Basal-notched; ELK = Elko series.
[b] Readings were taken from a remnant detachment scar from the original flake removal.
[c] All projectile points designated as "disturbed" were recovered from clearly disturbed contexts whose actual stratigraphic positioning within the site is unknown.
[d] No visible hydration.

7.7μ), which corresponds with the general increase in obsidian quarrying activity and biface production noted by other investigators in the Coso area between 3,500 and 1,000 B.P. (Hildebrandt and Gilreath 1988).

Based on the hydration data, the reconstructed series of events is as follows: early site occupants, presumably makers of Elko projectile points, made few points at the site but produced large numbers of bifaces for use as cores off site or for trading purposes, or both. Later occupants, during Rose Spring projectile point times (i.e., after the introduction of the bow and arrow), made fewer large bifaces, but more projectile points, presumably using flakes they found on the surface of the site (or perhaps they even dug into the ground to "mine" flakes) produced during the earlier Elko biface production frenzy (this is supported to some degree by the second band readings on remnant flake detachment scars on two Rose Spring points and a Cottonwood Leaf-shaped point [Table 10]). Presumably, if this is indeed the case, then the analysis of bifaces and debitage would exhibit no significant technological change through time when examined stratigraphically. According to this model, biface production could disappear altogether late in time but would be difficult, if not impossible, to clearly discern. The slight though apparent shift in biface production late in time noted above may have been the result of bow and arrow adoption in a significantly mixed upper, late component. However, in order to support this model further, it will be necessary to conduct obsidian hydration analysis on several bifaces from the upper levels of the deposit. Also, the original hydration sample (5 flakes/10 cm. level from two separate units, X-1 and XX-7) may be insufficient to accurately assess change through time. Additionally, the presence of a yellow clay layer between 45 to 60 cm. in depth across Locus 1 appears to represent a ponding event that occurred approximately 600 years ago, affectively sealing the deposit below. If this is true, then the upper 60 cm. should be mostly separate from the previously deposited occupational materials, which complicates the second model somewhat since it relies heavily on the profound mixing assumption, especially late in time.

SUMMARY AND CONCLUSIONS

The introduction of the bow and arrow, assumed to correspond with the appearance of Rose Spring points in the midden at CA-INY-372, appears to have occurred approximately 1,500 years ago. This is consistent with previous estimates in the past, but new data have now been verified radiometrically in a stratified context. The lithic exploitation pattern of materials from the local quarries near Rose Spring appears to remain fairly stable through time, as indicated through the analysis of flaked stone implements and reduction/production detritus. The introduction of the bow and arrow to the region may have had minimal impact on the general reduction/production strategy used by the inhabitants of Rose Spring, which is consistent with at least one other study within the region (Allen 1986). Based on the latest excavations at the Stahl Site (CA-INY-182), a far more drastic shift in the nature of the obsidian reduction strategy is apparent in Rose Valley at about 5,000 B.P. which is a topic of continuing research (Schroth and Yohe n.d.). The continued use the atlatl and/or thrusting spears and large knives after the introduction of the bow and arrow may account for the patterns observed in the CA-INY-372 lithic assemblage. If so, then the atlatl may have persisted until approximately A.D. 1500.

An alternative interpretation of these data based on limited obsidian hydration studies at the site suggests greater mixing and/or depositional compression during the last 1,000 years of occupation at the site, incorporating debitage and bifaces from earlier periods of site use into the more recent cultural deposit. This suggests that later occupants engaged in little biface production, concentrating on the use of flakes deposited at the site during earlier episodes of biface manufacture to produce arrow points. Obsidian hydration analyses of bifaces recovered from the upper levels of the deposit will be necessary to add further credence to this interpretation. Further work to address the issues raised by both interpretations is obviously warranted.

NOTES

1. Although the two radiocarbon dates from the feature at the levels where Rose Spring points start to become appreciable are 1,360 ± 70 and 1,400 ± 50 RCYBP, respectively, when adjusted for their ^{13}C values wrt PDB, the samples become approximately 200 years older (see Taylor 1987:Fig. 5.7).

2. In 1995, three of the levels used in the author's analysis (60 to 70 cm., 150 to 160 cm., and 220 to 230 cm.) were reanalyzed using a slightly different set of technological debitage categories to allow comparisons with flakes from the Stahl site (CA-INY-182) (Schroth and Yohe n.d.). The results of the reanalysis have not markedly altered the interpretations presented in this paper.

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