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Obsidian Acquisition and Exchange Networks: A Diachronic Perspective on Households in the Owens Valley

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The last 2,000 years of prehistory in the southern Owens Valley of eastern California witnessed major changes in human subsistence, settlement, and technology. Using a household perspective, we test the hypothesis that these societies became increasingly focused on the nuclear and/or extended family as the basic economic unit. To this end, we examine patterns in the acquisition of exotic materials, especially obsidian and marine-shell beads, in relationship to other locally-produced artifact categories. Results show (1) an increasing geochemical diversity in obsidian and an increasing density of non-local beads, indicating increased and geographically wider trading activities through time; (2) an increasing heterogeneity between household units in terms of access to non-local obsidian after 650 B.P., indicating differential access to exchange networks; and (3) a correlation between house size and obsidian diversity after 650 B.P., suggesting that larger domestic units differentially participated in the movement of exotic goods. These findings support the notion that households, as basic economic units, were increasingly focused on internal subsistence and exchange pursuits, rather than village- or communal-level activities, and that exotic material goods became increasingly privatized over time in association with the privatization of subsistence resources.

Even a cursory reading of the ethnographic record demonstrates the importance of the movement of material goods to native Californians. Goods were transported along routes that crisscrossed the state, linking highly diverse linguistic and ethnic groups, fostering political alliance-building, inter-group marriage, and reducing the risk of resource shortfall in any given year. In a review of the ethnographic literature, Davis (1961) assembled a lengthy list of goods that were moved, ranging from consumables such as acorns and salt, to non-food goods such as clam and *Olivella* beads, to finished objects such as baskets, blankets, and clay pots. One of the most consistently mentioned commodities was obsidian, as both finished and unfinished product. Due to the volcanically-active geological history of California, there are an especially large number of obsidian sources in the state. These sources, comprising spatially restricted zones where workable nodules can be found, occur in many regions of the state, and were exploited to create a range of implements, including knives, scrapers, projectile points, and large ceremonial blades.

The archaeological record of California demonstrates that the movement of obsidian was important, not only in historic and protohistoric times (e.g., Silliman 2005), but likely from the beginnings of human occupation over 11,000 years ago (e.g., Vellanoweth et al. 2003). Although other items have occasionally been studied in attempts to track such prehistoric links—including such materials as shell beads (e.g., Bennyhoff and Hughes 1987; Eerkens et al. 2005), and ceramics (Eerkens et al. 2002; Pierce 2002)—obsidian has been the main artifact category employed in tracing regional interaction in California and the Great Basin (e.g., Bettinger 1982; Bouey and Basgall 1984; Ericson 1981, 1982; Hughes 1988; Jackson and Ericson 1994). Part of this focus is due to the visibility and preservation of obsidian in the archaeological record as compared to other items (such as food or baskets), as well as to the low cost and availability of sourcing techniques such as X-Ray Fluorescence (XRF) and Instrumental Neutron Activation Analysis (INAA). However, part of it is also due to historical factors, since some of the earliest obsidian fingerprinting studies worldwide were undertaken using California data (e.g., Ericson 1982; Jack 1976; Jack and Carmichael 1969). Indeed, the ability to track the conveyance of California and Great Basin obsidian using chemical methods has blossomed to the point where tens of thousands of artifacts are analyzed each year by various laboratories. These studies continue to refine our understanding of exchange and mobility patterns, as well as changes in these behaviors over time.

This paper continues in that vein, but takes an alternative approach in order to examine the movement of obsidian. While most previous studies highlighted regional patterns (e.g., Bouey and Basgall 1984; Eerkens and Rosenthal 2004; Ericson 1981; Jackson and Ericson 1994), we focus here on a much smaller social and spatial scale, that of the household. We hope that this smaller social scale can offer new insights into how obsidian was distributed and consumed. In particular, we evaluate patterns of differential acquisition between houses, and how those change over time in the Owens Valley of eastern California. Using households, rather than regions, as the basis of analysis brings us closer to the social scale at which goods were actually moved; namely, that of the individuals who were personally extracting or trading obsidian (e.g., Ashmore and Wilk 1988; Flannery and Winter 1976; Wiessner 1982).

Around 650 years ago, there were dramatic socioeconomic changes in the Owens Valley, including a significant increase in the use of small seeds and small game and the introduction of ceramic technologies. One of us has previously regarded these as dual components in the need for households to become privatized units (Eerkens 2004; see also Bettinger 1999 and Delacorte 1999). We believe that examining obsidian source distribution at the household level will afford further insights into the diachronic process of economic privatization and the development of differential wealth that was recorded ethnographically for the Owens Valley Paiute (Steward 1933). Moreover, because exchange has been implicated as a major factor in the development of sociopolitical complexity in this region (e.g., Bettinger and King 1971), we felt that this approach might offer new perspectives on this process.

In this paper we focus on the movement of obsidian. Trade is most often assumed to be the mechanism underlying that movement during late prehistoric and historic time periods, when it appears the landscape was more or less filled by semi-sedentary people. On the other hand, the presence of exotic obsidian in sites dating to earlier time periods, when population densities were lower and people were more residentially mobile, is usually attributed to direct procurement and the curation of tools. We generally follow this convention, but note that movement involving direct procurements late in time, and exchanges earlier in time, does not invalidate our arguments.

OWENS VALLEY CULTURE HISTORY

The culture historical sequence in Owens Valley has been well-established through survey and excavation (e.g., Bettinger 1975; Bettinger and Taylor 1974). Although important details remain to be worked out, especially in the earlier parts of the sequence, the later part of the chronology has been repeatedly tested through excavation and has held up well. For this paper, the most recent 2,000 years of prehistory are of interest, with three widely recognized culture historical units falling within the time frame. Locally, these are referred as the Late Newberry (ca. 2,000 to 1,500 B.P.), Haiwee (ca. 1,500 to 600 B.P.), and Marana (600 B.P. to contact) periods.

Late Newberry sites are primarily of two types: base camps with substantial structures (such as CA-INY-30, one of the sites considered in this study), and lithic reduction sites. Previous geochemical studies of obsidian suggest a high degree of mobility was practiced by at least some members of Late Newberry society (Basgall 1989; Delacorte 1999), representing either entire nuclear groups (Bettinger 1999), or perhaps just groups of men on hunting expeditions (Eerkens et. al. 2008). It has been argued that a focus on large game hunting using atlatls, mainly by prestige-seeking males, characterized this period (Hildebrandt and McGuire 2002; McGuire and Hildebrandt 2005). There is also ample evidence that obsidian extraction, primarily for producing bifaces, peaked at all the major regional obsidian quarries (Gilreath and Hildebrandt 1997).

Overall, less is known about the Haiwee period than the previous or subsequent ones. Data indicate dramatically reduced settlement ranges, which may have included semi- to complete sedentism in residential systems (Basgall 1989; Eerkens 2003). The introduction of new technologies, such as the bow and arrow (Yohe 1998), and the use of more casual flaked cutting tools (vs. bifaces), mark this period, though diets continued to be fairly broad, including large game, small game, water fowl, piñon nuts, and some seeds. Around the middle of this period (ca. 1,000 B.P.), production at obsidian quarries seems to have dropped off markedly (Gilreath and Hildebrandt 1997).

The Marana period is marked by continued small settlement ranges and the introduction of new material technologies (Bettinger 1989). New types of projectile points are introduced (Desert Side-notched and Cottonwood Triangular points) as well as cooking pots, which were used to boil increasing quantities of the small seeds that were coming to dominate the local diet (Eerkens 2004). There is also a marked increase in the density of groundstone and a focus on the harvesting of "green" piñon nuts; that is, cones that were not yet naturally ripened (Bettinger 1976; Eerkens et al. 2004; Garfinkel and Cook 1981). All of this indicates that there was a heavy reliance on gathered resources and, presumably, heavy demands on the time and labor of women. Faunal assemblages were also dominated by small-bodied resources, especially water fowl and lagomorphs (Basgall and McGuire 1988; Delacorte 1999).

PREDICTIONS

Eerkens (2004) suggests that these developments, especially those in the Marana period, marked a shift towards increasing household-level privatization; that is, decreased sharing between, but greater sharing within, economic units of production. In particular, he hypothesizes that rising population levels changed the social structure of communities. Growth in the size of communities resulted in a situation where, for any one individual, the ratio of relatives to non-relatives decreased over time. In a society where sharing was the norm, these demographic changes altered the costs and benefits of producing food versus freeloading off of others. Eerkens hypothesizes that around 650 B.P., the benefits of freeloading outweighed those of producing. Increasing numbers of freeloaders led, in part, to changes in subsistence practices and a focus on the exploitation of resources that could be more easily harvested and prepared by individual economic units (e.g., resources where inter-individual cooperation does not increase yield). These resources were privately owned by socio-economic units. Eerkens equates this socio-economic unit with the household, likely composed of nuclear to extended families. Prior to 650 B.P., there was much greater and open sharing between households, marked by a focus on publicly owned resources. After this time, economic units engaged less in inter-household sharing and concentrated more on meeting the internal needs of the household.

The pattern Eerkens (2004) describes for the late prehistoric period (after 650 B.P.) is consistent with that proposed by Steward (1938) for the Great Basin as a whole. Steward suggested that there was no stable social organization beyond the nuclear family, which was an autonomous unit. On the other hand, this pattern did not quite hold in the northern Owens Valley where Steward (1933) conducted fieldwork. There, leaders held formal positions with some degree of decision-making power above the level of the nuclear family. It is unclear if this pattern extended into the southern Owens Valley and, moreover, if it extended into prehistory or was a product of changes in the post-contact period; however, based on interviews with elders who remembered what it was like long ago, Steward clearly felt it extended into pre-contact times. Some have attributed this inconsistency to historic-period changes that took place in the Owens Valley (Delacorte and Basgall 2004), implying that the ethnographic record is not reflective of prehistoric patterns in this regard. This is clearly an important issue that requires additional research.

The model presented by Eerkens (2004) focuses specifically on subsistence resource use and ownership, but it could be expanded to include other aspects of prehistoric life ways. In that vein, we test his hypothesis by examining household access to exotic goods, either through direct procurement or through participation in exchange networks. The privatization model predicts that prior to 650 B.P., households should be characterized by greater levels of intra-community sharing. In the archaeological record, this should be reflected in a greater homogeneity and redundancy in the distribution of various resources, including those obtained by exchange. After 650 B.P., households should be focused more on intra-household activities and procuring family-owned goods, leading to greater heterogeneity between household units.

We test this model by examining patterns in the distribution of goods between houses in different time periods, especially obsidian geochemical diversity. On the basis of the foregoing discussion, we make the following predictions for each of the three time periods:

> During the Late Newberry Period, obsidian acquisition and production was at its peak, but at least some segments of households were highly mobile (either residentially or logistically), and divisible goods such as large game animals were shared communally. We predict Late Newberry households were redundant economic units with relatively unrestricted access to obsidian.
>
> The Haiwee Period was marked by decreasing settlement ranges (and stable residential bases), which likely resulted in a decreasing access to exotic obsidians. With restricted foraging radii in place, we predict a focus on local obsidian but continuing redundant household assemblages.
>
> The Marana period was marked by narrow settlement ranges, as in the Haiwee period, but larger population sizes. With an increased privatization of goods, we predict greater heterogeneity between households. In addition, differential access to exchange networks should be reflected in an overall increase in source diversity.

OWENS VALLEY HOUSEHOLDS

Houses have rarely been the focus of archaeological research in the southern Owens Valley, due largely to the amount of time it takes to locate and properly excavate, analyze, and report on such features. However, over the last 30 years, enough dwellings from different time periods have been excavated to facilitate a cross-temporal comparison. This study draws on prehistoric house remains from three sites: CA-INY-30, CA-INY-3806, and CA-INY-3812. These sites are within 20 km. of one another, near the shores of the former (prior to water diversions by the city of Los Angeles in the 1910s and 1920s) Owens Lake. We analyzed obsidian debitage from these three sites that was associated with 14 discrete house floors representing the Newberry (n=3), Haiwee (n=4), and Marana (n=7) time periods.

CA-INY-30 (see Fig. 1) was excavated in the mid 1980s by Far Western Anthropological Research Group, Inc. as part of a highway expansion project (Basgall and McGuire 1988). Twelve circular domestic structures were excavated (eleven of which are included in this study), a majority by means of a long trench bisecting the features. Radiocarbon dates and time-sensitive artifacts place four of these between about 2,000 and 1,400 B.P., corresponding to the late Newberry period. Three of the four Newberry houses were found closely situated to one another in the south-central area of the site. The fourth was found some 120 meters west of this cluster in the southwest site area. We analyzed debitage assemblages from two of the former and from the latter. All were substantial features, buried between 1.5 and 2 meters below ground surface, and they contained dense accumulations of debris, especially waste flakes and faunal materials, but there was little indication of their existence on the present ground surface. Radiocarbon dates for the Newberry houses largely overlapped and it was felt by the excavators that they were occupied contemporaneously (Basgall and McGuire 1988).

In addition, seven structures from CA-INY-30 date from the Marana period, between 500 B.P. and the protohistoric period. These houses comprised two clusters of three in the southeast and north-central parts of the site, with the seventh located near the late Newberry house in the southwest part of the site (it was possibly isolated; there were additional circular depressions at the site indicating the presence of additional houses, but these were not excavated). Marana houses are more shallowly buried (generally 0.5–1 m. in depth) and are more widely separated than the Newberry structures. They also contained a more sparse accumulation of debris on their living surface. Again, although it was difficult to demonstrate contemporaneity, many radiocarbon dates from these houses overlapped, and the excavators felt that several were likely occupied at the same time (Basgall and McGuire 1988).

CA-INY-3806 was excavated in the early 1990s (Delacorte and McGuire 1993; Eerkens 2003). Excavations revealed the presence of a well-preserved site with two spatially-separated occupations, both dating to the early Haiwee period. Although none were visible on the surface, three semi-subterranean houses were discovered during test excavations, in addition to a range

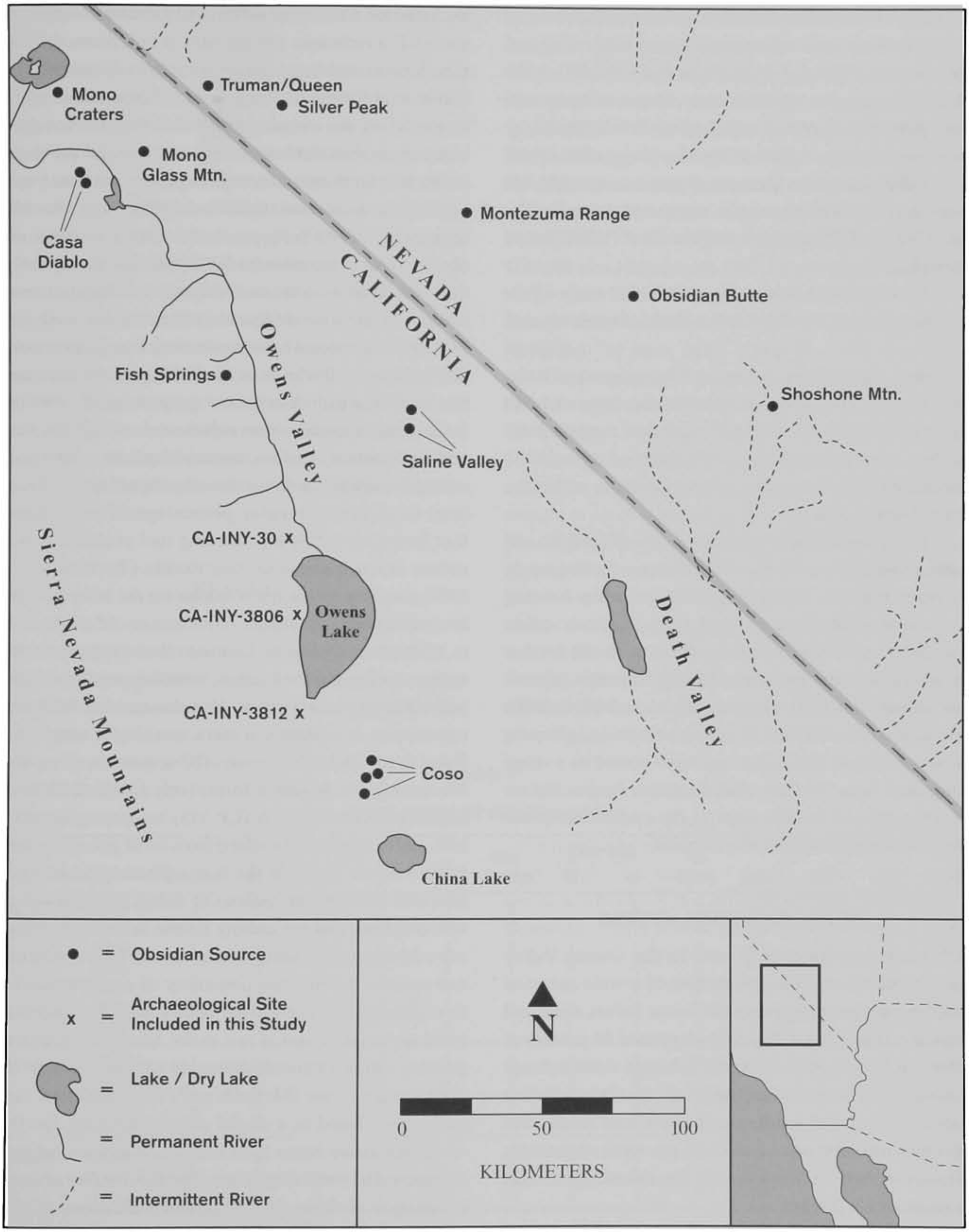

Figure 1. Map of region, sites, and obsidian sources.

of other domestic features (pits and hearths). Two of these houses were adjacent to one another and had overlapping calibrated radiocarbon dates at 1,300–1,500 B.P. The third was approximately 12 meters away and was part of a second occupation, as demonstrated by statistically later and non-overlapping radiocarbon dates that placed the house at approximately 1,150 B.P. Screen size (1/8-inch) was the same as that used at the sampled CA-INY-30 houses and the CA-INY-3812 house described below.

CA-INY-3812 was excavated in the early 1990s to make way for a fiber optics cable (Delacorte and McGuire 1993). A single large semi-subterranean structure was partially excavated. Two radiocarbon dates on charred posts returned uncalibrated dates of 1,340 ± 50 and 1,600 ± 60 B.P.; the older date was believed to be the product of older wood collected to build the structure of the house, thus placing the house within the early Haiwee period.

INY-3806 and INY-3812 are south of INY-30, and hence slightly closer to the Coso Volcanic Fields (simply Coso hereafter), which may have had some bearing on access to obsidian at these sites. However, other Newberry and Marana period sites near the former two include materials from a range of obsidian sources, including non-Coso sources (Byrd and Hale 2003; Delacorte and McGuire 1993; Gilreath 1995), indicating that societies in the region did have access to a range of glasses. Some of these sites contained houses, but we were unable to include them in the current study. We hope to accomplish this in future work.

METHODS AND SAMPLING

Obsidian was commonly used in the Owens Valley as a toolstone for the production of a wide range of implements, including projectile points, knives, drills, and casual cutting tools; it typically comprises 80 percent or more of both formal tools and debitage. Although not immediately available in the southern Owens Valley, obsidian is found to the north, east, and south. The closest Coso subsources are 30–50 km. south of each site. However, there are no less than ten chemically distinct sources within 200 km.

When the original excavations were carried out in the 1980s and early 1990s, only a handful of techniques were available for sourcing obsidian, and excavators opted to use XRF, a technique usually limited to artifacts thicker than 1.5 mm. and larger than 8–10 mm. in diameter (e.g., Davis et al. 1998). Due to frequent house cleaning of larger debris, the majority of the obsidian recovered in association with the houses consists of small pressure flakes that were not subjected to provenance analyses. As a result, most houses, particularly the later Marana houses at CA-INY-30, produced only a handful of obsidian artifacts suitable for XRF (usually less than five). Such small samples made it difficult to compare inter-household variation. Moreover, restricting the analyses to larger flakes would have resulted in lower geochemical diversity (e.g., Eerkens et al. 2007). This is because smaller flakes include a greater proportion of pressure flakes. Such materials often represent tool maintenance and rejuvenation activities that are frequently performed on highly curated tools. On the other hand, larger flakes tend to include a greater percentage of percussion flint knapping debris representing tool production. As shown in three separate case studies (Eerkens et al. 2007), focusing geochemical studies on the latter greatly minimizes source diversity.

Newer analytical techniques allow researchers to analyze extremely small flakes, including pressure flakes and other retouching debris. This presented us with the opportunity to reanalyze a more meaningful sample of flakes from CA-INY-30 houses (20 or more in all cases). We used Laser Ablation Inductively Coupled Plasma Mass Spectrometry (LA-ICP-MS) to accomplish this task, and only selected artifacts from on or just above the floors (within 20 cm. of the floor). Finished tools were rare, and we limit our analyses to flakes, primarily small tool finishing and retouching debris. Also, by limiting our analyses to very small flakes, we were able to control our samples against the possibility of contamination, as studies on the size-sorting effects of refuse disposal indicate smaller items are more likely to become primary refuse, materials discarded at their location of manufacture or use (Metcalfe and Heath 1990). All our analyses are based on a careful selection of items directly on or just above house floor contexts, which we believe minimizes the possibility of intrusion from earlier or later occupation at these sites. Previous evaluations of the obsidian sample, including geochemical results, suggest contamination is not a significant issue, and we refer the reader to Eerkens et al. (2008) for further discussion of these issues.

Within each house, we were interested in geochemical diversity. Because different statistics can highlight certain aspects within a data set, we report two measures of diversity for each house to show that the basic patterns we describe are robust. First, we report the Shannon-Wiener Diversity Index (SWDI; Chang Bioscience 2004). Second, we report a bootstrapped diversity measure, which better facilitates inter-sample comparisons when sample sizes are unequal (see Rhode 1988), as they are here (n=20 to 40 flakes per household). This was done within each household by randomly picking (with replacements) a predetermined number of artifacts (i.e., the size of the smallest house floor sample: n=20), and tallying the number of observed sources. This was done 100 times, and the diversity measures were averaged. As seen in the analyses, these two diversity measures are highly correlated.

RESULTS

Geochemical sources recognized in the sample include eleven major types. These are shown by house floor in Table 1. Although Table 1 separates them, in subsequent analysis we lump sub-sources of particular geochemical types together, except where specifically noted. We recognize, however, that had we treated subsources as unique "sources" of obsidian, the same patterns would exist (and in many cases would be reinforced). Thus, Sugarloaf, West Sugarloaf, West Cactus Peak, and Joshua Ridge were grouped together into a single analytical category called Coso, because all of these geochemical subsources are available in the same general area (e.g., Eerkens and Rosenthal 2004; Ericson and Glascock 2004; Gilreath and Hildebrandt 1997; Hughes 1988). Similarly, we grouped "Saline Valley" and "Queen Imposter" into a single analytical category called Saline (e.g., Johnson et al. 1999).

This lumping left seven source-types in our analyses, comprising—in decreasing order of frequency—Coso (81.2%), Casa Diablo (8.8%), Saline (4.1%), Fish Springs (3.6%), Queen (1.4%), Mono Glass Mountain (0.7%), and Mono Craters (0.2%). Our analyses treat these sources as equal in suitability for flint knapping over time. We suspect this is not entirely the case, primarily because tool size decreased slightly over time (e.g., potentially increasing the value of sources with smaller average nodule size), but we do not believe such differences have a dramatic effect on the outcome. Moreover, although we might be able to make subjective evaluations based on our experiences in visiting different quarries, we

Table 1

HOUSE FLOORS BY OBSIDIAN SOURCE

Cultural Period	Site	Structure	Coso				Casa Diameter	Saline Valley		Fish Springs	Queen	MGM	MC	Total
			WS	Sug	JR	WC		SV	QI					
Marana	INY-30	1	17	2	1	1	0	1	5	1	1	0	0	29
	INY-30	5	6	8	1	0	3	0	2	0	0	0	0	20
	INY-30	6	15	7	0	4	4	1	1	4	2	2	0	40
	INY-30	7	18	18	0	0	1	0	0	0	0	0	0	37
	INY-30	8	17	7	0	1	4	0	5	5	0	0	0	39
	INY-30	9	12	2	0	4	1	0	1	3	2	0	0	25
	INY-30	10	23	2	0	0	7	1	0	1	1	1	0	36
Haiwee	INY-3812	1	29	1	0	0	0	0	0	0	0	0	0	30
	INY-3806	1	30	2	0	0	0	0	0	0	0	0	0	32
	INY-3806	2	25	0	0	5	0	0	0	0	0	0	0	30
	INY-3806	3	29	1	0	3	0	0	0	1	0	0	0	34
Newberry	INY-30	12	19	1	0	0	9	0	0	1	0	0	0	30
	INY-30	14	17	1	5	0	7	0	0	0	0	0	0	30
	INY-30	15	23	1	1	0	3	0	1	0	0	0	1	30
	Total		**280**	**53**	**8**	**18**	**39**	**3**	**15**	**16**	**6**	**3**	**1**	**442**

Notes: WS=West Sugarloaf; Sug=Sugarloaf; JR=Joshua Ridge; WC=West Cactus Peak; SV=Saline Valley; QI=Queen Imposter; MGM=Mono Glass Mountain; MC=Mono Craters

Table 2

HOUSES AND RELATED INFORMATION FOR OBSIDIAN SAMPLES ANALYZED

Cultural Period	Site	Structure	^{14}C Date	Floor Area (m^2)	Sample Size	Richness	SWDI	Bootstrap Diversity	Average Distance to Source (km)
Marana	INY-30	1	310 ± 70 470 ± 70	11.3	29	4	0.79	3.1	57.8
	INY-30	5	410 ± 80	10.2	20	3	0.73	3.0	67.3
	INY-30	6	none	14.5	40	6	1.19	4.5	73.5
	INY-30	7	480 ± 60	8.0	37	2	0.12	1.4	57.3
	INY-30	8	270 ± 70 470 ± 50	9.1	39	4	1.05	3.8	63.9
	INY-30	9	180 ± 60	12.0	25	5	0.95	3.3	58.4
	INY-30	10	330 ± 60 390 ± 90	12.0	36	6	0.97	4.1	76.9
Haiwee	INY-3812	1	1,340 ± 50 1,600 ± 60	19.6	30	1	0	1.0	35.0
	INY-3806	1	1,340 ± 60	8.0	32	1	0	1.0	45.0
	INY-3806	2	1,400 ± 80 1,490 ± 70	19.6	30	1	0	1.0	45.0
	INY-3806	3	1,160 ± 60	21.2	34	2	0.13	1.4	45.7
Newberry	INY-30	12	1,530 ± 80 1,860 ± 70	15.9	30	3	0.75	2.5	80.7
	INY-30	14	1,650 ± 100 1,840 ± 80	13.9	30	2	0.54	2.0	74.8
	INY-30	15	1,460 ± 60	18.1	30	3	0.43	2.5	64.2

currently lack quantitative data on the average cobble size at most quarries and/or its suitability for making different kinds of tools.

Table 2 presents the results of the obsidian analyses, including the actual diversity measures (richness), SWDI, and the sample-size adjusted diversity measure (bootstrapped diversity). The table shows that there is little source diversity among the earlier house structures from the late Newberry and early Haiwee periods. However, there are important differences between these two time periods. The earlier Newberry houses contain materials from two or three different sources, though some of these artifacts are from quite distant locations, particularly the Casa Diablo source (140 km. north). On the other hand, Haiwee period houses (INY-3806) contain materials that are nearly homogenous, as 95 of 96 pieces analyzed are from Coso, the closest source to the sites (45 km. away). The only non-Coso flake is from a second nearby source, Fish Springs (70 km. north).

Marana flakes traveled, on average, fewer kilometers than Newberry ones, indicating people were obtaining their obsidian primarily from nearby areas. However, Marana households had access to a much greater number of obsidian sources than either Haiwee or Newberry households. This may be indicative of a greater importance of trade, as residential mobility appears to have been low during this time period (Basgall 1989).

Measures of source diversity across households within particular time periods are even more interesting. Within the Newberry period, houses are fairly redundant in terms of the range and diversity of sources represented. The same basic suite of sources shows up in all three houses, and there is little difference in the overall diversity of obsidians (n=2–3). This pattern holds, and is heightened, in the Haiwee period. These houses display extreme homogeneity, in that a single common source (Coso) basically dominates.

The Marana period offers a stark contrast in this regard. First, there is greater overall diversity; this is true even if we restrict the analysis to just the four Coso subsources, indicating that when accessing Coso obsidian, a broader range of subsources was available to each household. Second, in terms of the overall diversity of major sources, there are marked differences between households. Some have many sources present (e.g., Structures 6, 9, and 10), while others have very few (e.g., Structures 5 and 7). This suggests significant differences in the ability of households to access various obsidians. By contrast, late Newberry and early Haiwee households generally had access to the same number and the same range of sources, and there is very little evidence for inter-household inequalities. The results are illustrated in Figure 2, which shows SWDI measures across houses, grouped by time period.

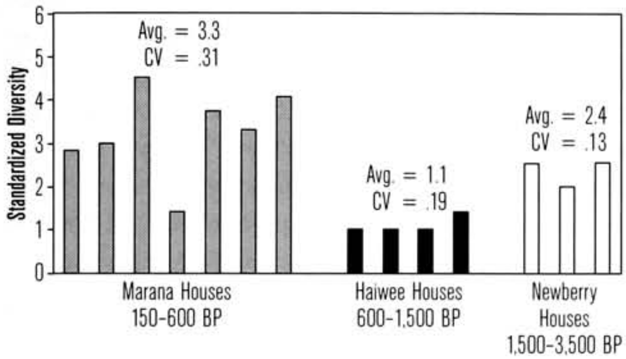

Figure 2. Obsidian source diversity within households over time.

DISCUSSION

Distribution of Obsidian

If the diversity and range of geochemical types within a household says something about access to the networks governing the distribution of obsidian across the landscape, we could interpret our results as an indication of relatively egalitarian access during the Haiwee and Newberry periods, as predicted. That is, during both time periods, each house displays the same range of geochemical types, though the total number of different types is clearly higher in the earlier Newberry period.

Elsewhere (Eerkens et al. 2008), we have argued that (at least during the Newberry period) access to obsidian largely involved direct procurement by highly mobile segments of society, most likely male hunters. These individuals appear to have had access to ample obsidian from quite distant sources, with little or no evidence for a distance-decay pattern (e.g., Renfrew 1977). This is revealed by the high average-distance-to-source for Newberry flakes, and by the lack of a decrease in the size of flakes with distance from the source (Eerkens et al. 2008). If mobile hunters were accessing obsidian in such a manner, the patterns in obsidian use shown in Figure 2 suggest one of two things. First, it is possible that at least one male in each household was participating in such long-range hunts and was directly procuring obsidian. Alternatively, males from only certain households were participating in obsidian procurement expeditions, but upon returning to base camps such as CA-INY-30, were widely and evenly sharing obsidian among all households. In either case, households were fairly redundant units in terms of their access to obsidian. If the Newberry houses at CA-INY-30 are not contemporaneous, as the excavators (Basgall and McGuire 1988) assumed, this implies that access to different obsidian sources was (also) relatively fixed over longer periods of time.

The acquisition of obsidian during the Haiwee period did not follow Newberry patterns. As predicted in our hypotheses, distribution networks were highly constrained, providing access only to the most local source, Coso (save one flake from Fish Springs). If hunters were still visiting distant hunting grounds, they were no longer bringing obsidian back with them. As well, they were apparently not scavenging large amounts of obsidian from Newberry sites, in which case we would have expected to see more source diversity (unless they selectively scavenged Coso obsidian). More likely, mobility (logistical and residential) became highly constrained during this period (Basgall 1989; Eerkens 2003), and obsidian was either traded or obtained directly from the most local source, West Sugarloaf. However, as in the Newberry period, it appears that households were redundant units. All households obtained obsidian from the same range of sources, with no inter-household differentiation, again suggesting egalitarian access to obsidian and/or high rates of sharing (if the houses are contemporaneous).

Clearly a fundamental change took place around 650 B.P., which is consistent with our predictions from the model of increasing household-level privatization and social differentiation. Not only is there greater evidence for wide-ranging trade networks in the Marana period, as marked by the increase in average geochemical diversity, but there seems to be marked inequality between houses. Some households had access to a range of obsidians from all different directions (north, south, and east), while others were able to obtain obsidian from only the most nearby sources (Coso, Saline Valley, and Fish Springs). We have argued elsewhere (Eerkens et al. 2008) that the movement of obsidian during the Marana period was largely mediated through exchange. The patterns here suggest, then, that certain households were well connected to such exchange networks, while others were not. Moreover, obsidian was apparently not redistributed locally following its acquisition, leading to archaeological assemblages that are highly variable from house to house.

There is a further pattern in obsidian source diversity that is of relevance to the discussion here. There is a strong and positive linear correlation between house size (as measured by area in square meters) and obsidian source diversity ($r^2=0.66$), shown in the upper part of Figure 3. If house size is an accurate predictor of the number of individuals in a household, this correlation indicates that larger households had more expansive

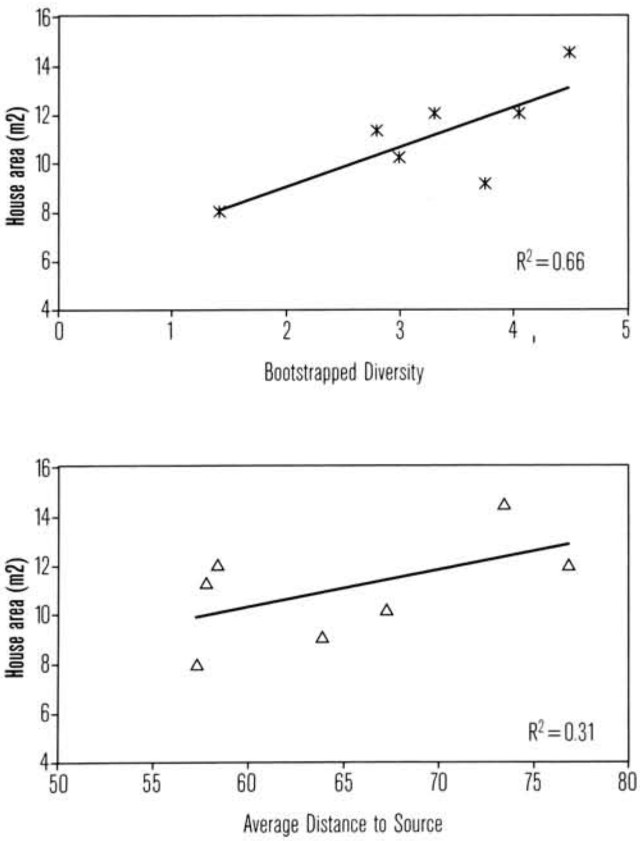

Figure 3. House floor area vs. geochemical diversity (upper) and average distance to source (lower) for Marana Period houses

social networks with a corresponding increase in access to obsidian from a larger geographic region. More detailed examination of the specific obsidian sources present within the houses indicates, further, that smaller houses had access mainly to the most proximate obsidian sources, while larger houses had access to more distant sources. This is reflected in the positive, though weaker, correlation between average-distance-to-source and house size ($r^2=0.31$; see Table 2 and lower part of Fig. 3).

Distribution of Beads

Obsidian is but one non-local artifact category commonly encountered in Owens Valley sites. This section compares the distribution of obsidian with that of four different types of beads, two clearly non-local in origin, one likely non-local, and one likely local. Beads made out of the marine snail shell, *Olivella biplicata*, are most common and were widely circulated throughout western North America (Bennyhoff and Hughes 1987). Chemical analyses of *Olivella* beads from Owens Valley suggest most if not all came from southern California (Eerkens et al. 2005). According to Steward (1933), *Olivella* beads could be used to purchase various goods and services at agreed-upon rates. The practice of using *Olivella* beads as a type of currency was widely reported by ethnographers in California. Glass beads are also obviously non-local and were widely traded in the protohistoric and historic periods, and may have replaced *Olivella* beads as a form of currency. Glass beads date primarily after the 1770s and were traded into the Owens Valley well before the encroachment or settlement by Euroamericans. Stone beads, often steatite, are less common than *Olivella* beads. Though steatite is available on the western slopes of the Sierra Nevada, it is likely that these beads were traded into the Owens Valley from the west, but there has not been a definitive study attempting to track their source. Thus, they are likely non-local in origin, but additional research is necessary to demonstrate this. Finally, bone beads are commonly found in Marana period sites; they are usually made from bird bone, presumably local in origin.

Table 3 shows the distribution of beads associated with the same 14 house floors discussed above, standardized by the area exposed during excavation. The overall patterns are similar to those seen involving obsidian flakes. Newberry and Haiwee houses contain small numbers and there is an even distribution of

Table 3

DENSITIES OF LOCAL AND NON-LOCAL ARTIFACTS RECOVERED, PER SQUARE METER OF EXCAVATED FLOOR

	Site	Structure	Area Exc.	Shell Beads	Stone Beads	Bone Beads	Glass Beads	Ground-stone	Bone Tools	Pottery
Marana	INY-30	1	2.0	-	-	-	-	2.5	1.5	7.5
	INY-30	5	2.8	-	-	1.5	-	-	0.4	3.3
	INY-30	6	2.5	1.6	-	-	-	1.6	2.0	2.4
	INY-30	7	2.0	3.0	0.5	1.0	0.5	1.5	-	14.5
	INY-30	8	3.3	4.9	0.3	0.9	0.6	-	0.3	11.7
	INY-30	9	2.8	21.5	2.9	2.2	2.9	-	0.4	16.0
	INY-30	10	9	0.1	-	0.6	-	0.3	0.3	14.7
Haiwee	INY-3806	1	7.5	-	-	-	-	0.1	-	-
	INY-3806	2	4.0	-	-	-	-	0.5	-	-
	INY-3806	3	5.0	0.2	0.4	-	-	0.2	-	-
	INY-3812	1	5.0	-	-	0.8	-	-	0.6	-
Newberry	INY-30	12	15	0.2	-	-	-	0.5	0.6	-
	INY-30	14	10	0.6	0.1	-	-	1.3	0.5	-
	INY-30	15	15	0.1	-	-	-	0.3	0.9	-

Notes: Area Esc. = Area of the floor excavated in square meters.

beads across houses, again suggesting redundancy. Marana houses, on the other hand, have higher average numbers of beads, especially Structure 9, and—more importantly—have a greater diversity from house to house in the density of beads. Furthermore, there are strong correlations between the densities of various types of beads; thus, houses with large numbers of shell beads tend to have higher numbers of stone, bone, and glass (when they are present) beads. This suggests that the results are not a result of excavators merely finding the remains of a single necklace composed of multiple beads. More importantly, if beads represented a form of wealth, especially *Olivella* beads, this indicates that certain households had a greater access to such wealth, and (presumably) the exchange networks through which those currency beads were obtained.

It is also worth noting that the three Marana houses with higher bead densities and a greater diversity of material types (Structures 7, 8, and 9) are part of the same spatial cluster in the northwest part of the site, while houses from the southeast section of the site (Structures 1, 5, and 6) have much lower frequencies. If the Marana houses at INY-30 are contemporaneous, this suggests there may be additional higher-level community patterning in the distribution of goods, above the level of the household. On the other hand, if the houses are not contemporaneous, this distribution could indicate an occupation by groups of families separated in time by decades or centuries, or could also indicate differences in the duration of occupation.

It is interesting to note that while there is a slight correlation between obsidian geochemical diversity and the density of beads during the Marana period, the correlation is far from perfect. Thus, some houses with high obsidian diversity (e.g., Structure 9) also have high densities of beads, and some houses with low obsidian diversity have few beads (Structure 5). On the other hand, Structure 10 has high obsidian diversity but low bead density, and Structure 7 has low obsidian diversity and moderate bead density. This again emphasizes the heterogeneity of Marana houses. It further suggests that different goods moved into and out of household units through different networks. At the same time, locally available beads (i.e., bone beads), are much more evenly and ubiquitously distributed than the other types.

Finally, it is worth comparing the diversity of obsidian and the density of beads to the distribution of other types of artifacts made from locally available raw materials, such as groundstone, bone tools, and pottery (in the case of Marana houses). Those results are also presented in Table 3, again as densities per square meter of house floor. Granitic and other volcanic rocks, commonly used to make groundstone, are ubiquitous in the region, and are found primarily as bed load in local creeks emanating from the adjacent Sierra Nevada Mountains. Similarly, residual sources of clay to make pots are widespread, and bone to make tools such as awls and needles was easily acquired by hunting the local birds and large mammals, which were commonly eaten.

Although the sample sizes are often small for these artifact categories, inter-household differences are much less marked for all time periods, including the Marana. For example, in the Marana period, the coefficient of variation (C.V.; standard deviation divided by the mean), which measures the degree of variation within a dataset (see Eerkens and Bettinger 2001), is higher for the density of exotic beads (C.V.=1.44) than for local bone beads (C.V.=0.51), groundstone (C.V.=0.61), bone tools (C.V.=0.91), and pottery (C.V.=0.56). The implication, of course, is that Marana households were much more redundant when it came to domestic types of artifacts requiring locally-available raw materials, and more heterogeneous when it came to access to exchange networks.

CONCLUSIONS

Previous research in the Owens Valley has suggested that the Newberry-Haiwee-Marana period represents a time of decreasing residential mobility and increasing privatization of economic resources (Bettinger 1999; Delacorte 1999; Eerkens 2003, 2004). All three of the predictions derived from this hypothesis were borne out in our analyses of obsidian and beads from households, and offer further support for the model.

Together, we offer the following scenario as part of a reconstruction of changes in sociopolitical and demographic processes in the valley. This reconstruction should be tested through additional excavation and survey, but with a focus on smaller-scale social units such as households. Archaeological data are, of course, limited and fragmentary by their very nature, and comparing houses excavated by different research teams, often decades apart, makes it difficult at times to compare those houses in a standardized manner. But attempts to establish whether houses within a site were contemporaneously occupied or not (for example, through a refitting of bone or lithic materials and/or the measurement of archaeomagnetic signature of features) should be part and parcel of future research. In addition, attempts to measure the duration of occupation, as a means of standardizing inter-household comparisons, would be worthwhile (though often difficult in practice).

Overall, our research suggests a shift away from community organization, where multiple households or whole villages were involved in extracting resources and sharing them, to one where individual families were the locus of production and there was much less sharing between such economic units. This notion is consistent with similar arguments made by Bettinger (1999) and Delacorte (1999) for the Owens Valley region. Eerkens (2004) has argued that the shift to intensive seed harvesting that is so characteristic of the Marana period was a conscious effort on the part of household units to focus time and labor on the extraction of a type of resource that could be individually collected and processed (using tools that could be individually made and operated), and therefore did not have to be shared. That resource was small seeds. The distribution of pot sherds across domestic sites, relative to other artifact categories, and the organization of potting technologies, each point to a household-level production, use, storage, and consumption of seed resources. The focus on seeds occurred at the expense of other foods that typically provided higher return rates (e.g., hunted game) or were communally or openly prepared (e.g., roots and bulbs), but that were subject to wide-spread sharing due to long-standing norms that governed the distribution of food.

Sometime between the later Haiwee period (after 1,100 years ago) and the beginning of the Marana period (around 650 years ago), there was a switch from more-or-less egalitarian access to exotic goods to one in which there was much greater disparity. Socioeconomic units in the Marana period seem to have kept exotic goods within the local household, and not transferred them to other units (for example, through redistribution). In this sense, exotic goods and the exchange networks they represent seem also to have been privatized (e.g., more restricted) later in time. Unfortunately, there are very few excavated sites that date to the window of time between 1,100 and 600 B.P., and more work will be needed to examine the evolution of this process in detail.

In the southern Owens Valley, obsidian was not a scarce commodity. Obsidian is ubiquitous in archaeological sites, and even today a few minutes of surveying on the landscape is sure to produce several decent-sized flakes that can be worked into a serviceable tool. Ancient peoples could easily have scavenged such artifacts if needed. Although the scavenging of obsidian certainly occurred, as demonstrated by double hydration bands on artifacts, the evidence for such scavenging is not extensive, as we noted above (see also Eerkens and Rosenthal 2004). Had scavenging been more extensive, we would expect to see more homogenous source distribution patterns over time (i.e., due to the recycling of existing material).

Instead, people continued to quarry obsidian from source zones, even in the Marana and historic periods (Gilreath and Hildebrandt 1997), and they moved this commodity through exchange networks (Davis 1961). The reason for that, we believe, was not due to an urgent need for obsidian and/or shell beads in and of themselves. The social networks that facilitated their movement, we argue, were more significant. In small-scale societies, trade often serves a number of purposes for both individuals and families (e.g., Bettinger and King 1971; Bettinger 1982; Earle 1994; Gregory 1982; Halstead and O'Shea 1989; Winterhalder 1997), including acquiring information, gaining access to potential exogamous marriage partners, obtaining necessary resources not available locally (e.g., salt or pigments), acquiring rare items to either demarcate and symbolize social inequality or to redistribute locally to create social debt, and providing access to territories outside one's own during times of resource shortfall (i.e., to reduce risk). Reducing risk is particularly important in desert environments with high spatial and temporal variation in rainfall and environmental productivity (Halstead and O'Shea 1989), such as eastern California.

Indeed, there is support for this latter factor in accounting for the conveyance of artifacts across the regional landscape. In a study examining the distribution of pottery, also a marker of the Marana period, Eerkens et al. (2002) found that pots tended to move between regions with the greatest differences in prevailing precipitation patterns; by contrast, they generally did not move between regions with similar precipitation patterns. Although the total number of pots that were moved was small (ca. 5–10%), this pattern indicates that Marana families were occasionally leaving their home territories to harvest and cook seed resources in other regions, using pots they had brought with them. These regions differed climatically from their home territories. This pattern is consistent with the notion that when people experienced local resource shortfalls, they would occasionally move to areas where conditions were less likely to be the same. Of course, these regions were likely to be occupied by other groups; therefore, maintaining relations with such people would have been important in guaranteeing future access. In addition to marriage, exchange is one likely way such relations would have been maintained.

If obsidian was moved largely through exchange in the Marana period, as we have argued elsewhere (Eerkens et al. 2008), the data suggest that there was differential access to such exchange networks between households. Some households appear to have been well-connected and others less so, with little evidence for a redistribution of goods. That some households had greater access to exchange networks also suggests that they had differential access to the material wealth that flowed through them, and greater access to non-local territories that could be exploited during times of resource shortfall. Furthermore, there were differences in the ability of households to acquire various kinds of goods; some had greater access to beads, and others to exotic obsidian. In the case of obsidian, such differential access appears to have been correlated with house size, though that pattern is less evident for beads.

Exactly why we see these changes in the Marana period remains unclear. As discussed, these patterns are consistent with the hypothesis that Marana households were more inwardly focused, and that there was less economic cooperation and interaction between household units within local communities. We suspect that a breakdown in the egalitarian social order around 650 B.P. may have been responsible, with an increasing focus on the smallest economic unit (i.e., the household). But additional research will be necessary to examine this important issue. An increasing privatization of goods and acquisition networks appears to have been an integral element in this process. Further excavations at CA-INY-30, in the unexcavated portions of those houses discussed above, as well as in additional, unexcavated houses, would be warranted in an attempt to explore such issues. In addition, a diachronic exploration of interactions between households that considered such factors, for example, as evidence for intermarriage, the sharing of animal carcasses, and/or household territoriality, would shed further light on these issues. Our future research will seek to highlight such interactions on a smaller, family-level scale in order to better understand these processes.

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