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Artifact size and frequency in the analysis of Hohokam habitation refuse using a high resolution method

Archer, Gavin Harry, M.A.
The University of Arizona, 1990

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ARTIFACT SIZE AND FREQUENCY
IN THE ANALYSIS OF HOHOKAM HABITATION REFUSE
USING A HIGH RESOLUTION METHOD

by

Gavin Harry Archer

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ABSTRACT

The distribution of refuse artifacts by size and frequency is the result of site formation processes which involve artifact size-reduction and size-based artifact sorting. Previous archaeological research on artifact size is reviewed in detail. Important artifact size-reduction processes include foot traffic and the effects of a variety of natural forces. Important artifact size-sorting processes include discard behavior and refuse clearing activity. Artifact size and frequency is examined at a Hohokam habitation site in the upper bajada of the northern Tucson Basin using a high resolution method. The high resolution method is applied to a small surface area (10X50 meters) of habitation site "sheet trash." The results of the analysis include evidence for the preservation of large sherds in trash mounds, sherd size-reduction resulting from foot traffic, and refuse clearing.
INTRODUCTION

The objectives of this thesis are threefold. The first objective is to provide a comprehensive summary and synthesis of previous research on artifact size in the analysis of site structure and site structure formation processes. The second objective is to develop and test a high resolution field method designed to recover artifact size-related information. The third objective is to report the use and results of the high resolution method at a Hohokam habitation site and the implications for Hohokam site structure analysis in general.

Previous research on artifact size has included archaeological, micro-archaeological, ethnoarchaeological, experimental, and modern material culture studies. These investigations have been spurred by early reports of the "McKellar principal" (Schiffer, 1976; McKellar, 1983), which states that small artifacts are more likely to become primary refuse. Artifact size research has been summarized previously by South (1979: 218-219), DeBoer (1983), and Schiffer (1983: 679-681; 1987: 267-269). South's interest lies in "the relationship of size to the formation of the archaeological record" (p. 219). South (1979) addresses artifact size spatial distribution patterns resulting from "drop" and "toss" zones of refuse discard and refuse cleanup activity, terms first introduced by Binford (1978). The focus of DeBoer's (1983)
work is the distinction between primary and secondary refuse with particular reference to "sweeping" activity and the "Schlepp" effect. DeBoer says that "small objects, once discarded, are less likely to be removed in cleanup operations" (p. 23) and that as the "size of an object increases, one can expect a decrease in the ... distance between the object's use and discard loci" (p. 22). Schiffer (1983; 1987) approaches size as a "simple property" of artifacts. He states that "size effects come about because formation processes can (1) reduce the size of artifacts and (2) winnow artifacts by size" (1983, p.679).

In addition to including supplementary and recent references to research on artifact size, the synthesis provided here will involve expanded and detailed discussion of how artifact size affects and reflects archaeological formation processes. The emphasis is on the identification of archaeologically observable spatial patterning of artifacts by size that can be correlated with behavior.

Separate chapters address artifact size-reduction processes and size-based artifact sorting processes. Artifact size-reduction involves the interaction of artifact physical properties and a variety of possible cultural and natural forces. Artifact size can influence artifact sorting as a result of cultural and/or natural spatial displacement episodes producing size-graded artifact deposits.
The high resolution field method, developed to fulfill the goal of collecting data relevant to a study of site structure using artifact size, involves surface counts and collection, and sub-surface testing. The method provides quantitative, non-judgmental information that allows re-analysis and multiple interpretive efforts (Archer, Tani, and Wilson, 1990). The method permits the collection of information suitable for detailed analysis of site structure including the identification of subtle refuse aggregations, slight changes in artifact spatial distributions, and the use-intensity of different areas.

The high resolution method was implemented at an Early Classic Period Hohokam habitation site (AZ:AA:8:27) in the upper bajada flanking the western Tortolita Mountains, south-central Arizona. Discussion of the results of the high resolution method includes the identification of the formation processes contributing to the observed artifact patterns. Processes identified include refuse discard and refuse clearing behavior, occupation foot traffic, and natural disturbance.
CHAPTER 1: ARTIFACT SIZE-REDUCTION

The size of artifacts recovered from archaeological contexts is determined by the interaction between artifact physical properties and size-reduction processes. The size of functional artifacts will be dictated by the nature of their function whereas the size of non-functional artifacts, such as lithic debitage, is a result of the manufacturing process of which they are a by-product.

Following artifact discard, human activity and environmental forces serve to reduce artifact size. The physical properties of discarded artifacts will determine their resistance to these forces. Human foot-traffic has been identified as the principal cause of post-discard sherd breakage (DeBoer and Lathrap, 1979; Grebinger, 1971; Kirkby and Kirkby, 1976; McPherron, 1967; Meggers, 1957) during site occupation. Post-occupation cultural disturbance, including plowing, can lead to artifact size reduction (Ammerman, 1985; Schiffer, 1977; Wildesen, 1982). Natural forces, including trampling and scavenging by animals (Pastron, 1974), biodegradation (Archer, n.d.), and weathering (Behrensmeyer and Boaz, 1980; Gifford, 1978; Kirkby and Kirkby, 1976; Schiffer and Skibo, 1989; von Endt and Ortner, 1984) also promote artifact size-reduction.
Before size-reduction processes are discussed, the interaction between size-reduction forces and the physical properties of artifacts needs to be addressed. An exhaustive treatment of materials and their properties is not within the scope of this work and, because sherd size is most important in the analysis of Hohokam refuse, pottery properties are the focus of this discussion. In addition, physical properties influencing the size of chipped stone tools and waste flakes, groundstone, and faunal remains will be briefly discussed. Pottery, stone, and bone are the constituents of the artifact inventory recovered by the fieldwork reported below, and constitute the majority of prehistoric artifact materials. Only the physical properties of these materials that may significantly alter size-reduction patterns are of concern here, and not the details of their physical characteristics.

Properties of Pottery

The effect of pottery characteristics on sherd size has not been investigated extensively. Schiffer (1987, pp. 276-278) has suggested that vessel thickness and the hardness of paste and slip will affect the size of sherds produced by initial breakage. Schiffer and Skibo (1989) offer an
exhaustive list of ceramic properties affecting ceramic abrasion. The effects of firing temperature and thermal cycling during vessel use is likely to effect sherd size.

A vessel's thickness and shape are perhaps the most important properties affecting the size of sherds that are produced by its breakage. Shepard (1936) tested the effects of sherd thickness and sherd curvature on breakage rates using reproduced Pecos pottery pieces. Both variables accounted for only slight variation in breakage rates.

Systematic changes in pottery form over time or the exclusive breakage and discard of certain ceramic forms in particular areas could conceivably result in observable patterns in sherd size.

Properties of Stone

Stone artifacts, both chipped stone and groundstone, have greater resistance to breakage, abrasion, or disintegration than pottery or bone. Whereas sherd size, for example, may reflect foot traffic or other destructive processes, stone artifact size is the result of tool production, use, reuse, or recycling.

The characteristics of stone has great significance for tool production, yet has few implications for inadvertent artifact size-reduction. As will be discussed in detail below,
chipped stone tool production techniques produce distinct flake-size distributions. The properties of stone used for groundstone artifacts will affect rates of use-wear and breakage. The physical characteristics of stone artifacts and their effect on size-reduction have yet to be studied and the implications for recognizable patterns of size-reduction are unclear.

Properties of Bone

A variety of bone characteristics can influence the susceptibility of bone to size-reduction processes. Certain parts of faunal skeletons are targeted by butchers and suffer greater rates of breakage. Scavengers will prefer certain bones or parts of certain bones over others. Bone size and structure will affect resistance to natural forces such as biodegradation and weathering.

Butchering and cooking often selectively break or weaken certain bones, thus reducing their size. Bones bearing preferred meat are more likely to be cut and cooked, and marrow-bearing bones are more likely to be cracked (Yellen, 1977).

Scavenging carnivores often prefer to transport larger bones away from sites, especially larger, marrow bearing bones (Yellen, 1977). Smaller bones, however, will suffer greater
damage as a result of scavenger activity (Behrensmeyer and Boaz, 1980; Pastron, 1974).

Original size will affect the ability of bone to resist weathering or disintegration. Smaller bones are more susceptible to the effects of weathering, or disintegration in sub-surface or aqueous environments (Behrensmeyer and Boaz, 1980; Gifford, 1978; von Endt and Ortner, 1984). Conversely, smaller bones may be trampled into substrate and thus preserved (Yellen, 1977; Gifford, 1978). Similarly, Behrensmeyer and Boaz (1980) have noted that smaller bones are quickly covered by eolian and fluvial deposits and thus preserved.

Differences in bone tissue structure between skeletal elements and between species can cause differential size-reduction. Spongy bone tissue disintegrates rapidly, especially when spongy tissue is exposed by butchering or carnivore activity, whereas compact bone tissue is likely to be preserved (Yellen, 1977).

Bones as artifacts present great difficulties for analysis using size. The size of recovered bone may provide valuable information on butchering and cooking practices. However, given differential preservation and other factors effecting faunal assemblages such as body-part utility and transportability (Binford, 1981), the archaeological recognition of cultural bone size-reduction could prove to be
exceedingly difficult.

BEHAVIORAL ARTIFACT SIZE REDUCTION PROCESSES

A variety of both intentional and inadvertent behavior can cause artifact size-reduction. Tool production, use, reuse, and recycling lead to artifact size-reduction through abrasion and breakage. Pottery production produces sherds as a result of misfires and chipped stone tool production generates waste flakes. Tool use and reuse results in broken pots and chipped stone, retouching of chipped stone tools, and the abrasion and breakage of groundstone. Chipped stone tools are often recycled, resulting in considerable size reduction (Jelinek, 1976). A variety of ethnographic sources have reported sherd recycling for pottery temper, resulting in sherd pulverization (DeBoer and Lathrap, 1979; Stanislawski, 1978). Refuse clearing and foot traffic often cause artifact size-reduction. Refuse clearing, including tossing, sweeping, and dumping, is a principal cause of secondary sherd breakage (Fischer, 1985). Three kinds of behavior-related artifact size-reduction processes that have been investigated in detail are discussed below: foot traffic, chipped stone tool production, and post-occupation cultural disturbance.
Foot Traffic

The effect of trampling by humans on the size distribution of artifacts has received considerable attention. Foot traffic both reduces artifact size and may differentially displace artifacts both horizontally and vertically based on size. Foot traffic and displacement will be considered later as a size-sorting process whereas trampling will be considered here as a size-reduction process.

Most archaeological studies of trampling have examined the effect of foot traffic on sherd size (DeBoer and Lathrap, 1979; Grebinger, 1971; Kirkby and Kirkby, 1976; McPherron, 1976; Meggers, 1957). Gifford-Gonzales et al. (1985) investigated trampling as a cause of damage to lithics.

Observations at the Juntunen site prompted McPherron (1967) to state that "small sherds predominated in areas where aboriginal activities had been intense and large sherds in areas where either traffic was light or dune building had rapidly covered-over dropped vessels and large fragments" (p. 254). He further suggests that "under the hypothesis that low mean sherd weights indicate heavy foot traffic, the mean-sherd-weight measure could be used to plot areas of intense activity on the site, in which case the measure would represent an "index of trampling" (p. 254). Unfortunately, McPherron does not undertake traffic-intensity mapping at the
Juntunen site.

Grebinger (1971) hypothesized that reduced sherd size could be used to help identify food cooking areas at the Potrero Creek site. He suggests that, because these areas were used daily, sherds in these areas "would be badly worn and broken into smaller pieces as a result of heavy traffic" (p. 48).

Kirkby and Kirkby (1976) conducted a pioneering experiment in sherd breakage by trampling to observe how sherd size distributions change with consecutive "treading events." Each trial involved a person weighing 60 kg and wearing . . . Oaxacan flat sandals walking once across the sherds" (p. 237). The results of their experiment (Kirkby and Kirkby, 1976, Table 2) can be re-worked to show the percent of total sherds within each size category following each of five treading events on an original 100 sherds 4-8 cm in size (fig. 1). The distributions are increasingly left shifted and right-tailed with successive treading events. Kirkby and Kirkby (1976) state that "larger sherds are obviously more vulnerable to being trodden on, and being broken in the process, so that the rate of breakdown will decline through time and with smaller sherds" (pp. 236-237). Given this observation a hypothetical distribution of sherd size would appear increasingly left-shifted and leptokurtic with a decreasing right tail as treading events continued.
Figure 1: Breakdown of sherds in a sequence of experimental treading events (data from Kirkby and Kirkby, 1976).
DeBoer and Lathrap (1979), in their ethnoarchaeological study of Shipibo-Conibo ceramics, found that "sherds which occur along the path leading from the houses to the ceramics shed tend to be smaller in size than sherds in secondary refuse resulting from centrifugal sweeping" (p. 133). They attribute the smaller size of pathway sherds to greater foot traffic. The distribution for sherds along the path is left shifted and leptokurtic compared to the distribution for swept-up sherds (DeBoer and Lathrap, fig. 4.8).

Bradley and Fulford (1980), relying on Kirkby and Kirkby's (1976) report on sherd breakage, identify increased disturbance intensity with increased depth of deposit at Knossos and Carthage. They suggest that the percentage of rim sherds with 10 or 5 percent of the rim circumference surviving reflects the relationship between the duration and intensity of trampling. Divergence from a linear decrease in rim sherd size with age of deposit indicates fluctuations in the intensity of occupation over time (see Bradley and Fulford, 1980, figs. 1-4).

Recent experimentation by Nielson (n.d.) confirms two important results of Kirkby and Kirkby's earlier work: 1) the rate of sherd breakage decreases with successive treadage events, and 2) the sherd-size distribution of trampled assemblages is left-shifted and right-tailed. Nielson suggests that the positive skewness of sherd-size distributions may be
used as a relative measure of trampling intensity.

Gifford-Gonzales, et al., (1985), experimenting with lithic debitage, found that a greater percentage of large flakes (length >2 cm) fractured due to trampling than small flakes (length <2 cm). Expectedly, a greater percentage of both large and small flakes fractured when trampled on a harder substrate (see Gifford-Gonzales, et al., 1985, Table 2).

Chipped Stone Tool Production

Unlike sherd-size, the size of chipped stone artifacts is of little use as an indicator of foot traffic because stone is considerably more resistant to breakage (Gifford-Gonzales et al., 1985). More useful for the analysis of site structure is the fact that the size of chipped stone flakes is a direct result of chipped stone tool production techniques (e.g., Ahler, 1989; Mauldin and Amick, 1989; Patterson, 1990; Tomka, 1989). Patterson (1990), for example, states that "bifacial reduction gives an exponential curve form for flake-size distribution, which seems to be unique to the bifacial reduction process" (p. 551). Chipped stone flakes are subject to size-sorting processes, such as refuse clearing, as discussed in the following chapter. Size-sorting processes may preclude the use of flake-size distributions for the analysis
of lithic reduction activities. In addition, a variety of lithic reduction techniques may be employed at a single locus, obviously affecting flake-size distributions.

Post-Occupational Disturbance

Post-occupation artifact size reduction could conceivably result from later, possibly patterned and intense or consistent, foot traffic. Other cultural disturbances that can result in patterns of artifact size-reduction include the grazing of domestic cattle (Roney, 1977, cited in Wildesen, 1981), and recent, mechanized soil disturbance (see Wildesen, 1981, and references therein). Ammerman (1985) has found the extent of damage to ceramic tiles in a plowing experiment to be insubstantial.

NATURAL PROCESSES OF ARTIFACT SIZE REDUCTION

Obviously a variety of natural forces cause artifact size-reduction. The effects of natural forces on sherd size involve sherd breakage (Kirkby and Kirkby, 1976) and sherd abrasion (Schiffer and Skibo, 1989). Kirkby and Kirkby (1976) identified cycles of sherd wetting and drying, and cycles of sherd freezing and thawing as the principal causes of sherd breakage through "weathering." They also suggested that cattle
and other animals will break sherds by trampling. Schiffer and Skibo (1987) have discussed the abrasive effect of forces such as fluviation, frost heaving, and eolian "sand blasting."

The size-reduction of bone due to the effects of environmental degradation forces and scavenging by animals have been enumerated by Pastron (1974), Yellen (1977), Gifford (1978), Behrensmeyer and Boaz (1980), and von Endt and Ortner (1984).
The activity of site inhabitants and post-occupation visitors can cause artifact size-sorting. The effects of natural processes can also result in patterns of artifact size-sorting. In addition, archaeological field techniques often recover only larger objects, thus sorting out very small artifacts.

Many of the processes that can produce patterns of artifact size-sorting have been considered by previous researches and will be discussed in detail. Size-sorting as a result of discard and refuse clearing has received considerable attention, as have processes of loss and recovery, abandonment, scavenging and collecting, and post-occupational disturbance. Several natural forces having size-sorting effects, including fluvial and eolian action, frost heaving, the expansion and contraction of clay soils, and the activity of fossorial animals, have been identified. The size-sorting effects of artifact recovery techniques, such as screening and flotation, have also been examined in detail.

DISCARD AND REFUSE CLEARING BEHAVIOR

Several studies have investigated size-based artifact sorting as a result of discard, refuse clearing, and refuse
disposal behavior. These have included archaeological (Bradley and Fulford, 1980; Bradley, et al., 1980; Fergusen, 1977; Fischer, 1985; Henderson, 1987; Lightfoot, 1984; Rick, 1980; Thomas, 1983), ethnoarchaeological (Binford, 1978; DeBoer and Lathrap, 1979; O'Connell, 1987; Yellen, 1977), and recent-past (Hohman, 1975; McKellar, 1983; South, 1979) studies.

Archaeological Studies

Bradley, et al., (1980) and Bradley and Fulford (1980) have studied sherd counts and size in pits and post-holes surrounding a central round-house building at a first millennium b.c. settlement at Aldermaston, Berkshire, England. Their findings show increased sherd density (count by liter) in pit and post-hole filling with the increase in distance of the feature from the center of the round-house. Sherd density declines suddenly with a distance of 20-25 meters (Bradley, et al., 1980, fig. 21; Bradley and Fulford, 1980, fig. 5). The mean weight of sherds in the filling declines steadily with distance from the round house up to a distance of 25 meters.

The pattern of sherd density and size in pits and post-holes and the relationship of these variables to the proximity of a central structure is considered the result of refuse clearing and sherd breakage. Refuse was cleared outward from
the structure towards the periphery of the activity area. Sherds displaced the greatest distance suffered the highest rate of breakage. Larger sherds are those sherds that were quickly deposited into the nearest pit or post-hole and thus protected from breakage. Small sherds are those which were cleared from the vicinity of the structure as a result of multiple cleaning episodes, suffered high rates of breakage due to extended periods on the surface, and were finally deposited in pits and post-holes distant from the structure (Bradley, et al., 1980; Bradley and Fulford, 1980).

Rick (1980) has investigated the size sorting of preceramic refuse at Pachamachay in the Puna of central Peru. Rick observed concentrations of large bone in down-slope early and middle preceramic strata relative to up-slope occupation levels dating from the same period. Up-slope levels yielded "only 29 bone fragments larger than .47 cm . . . However, very few of these levels had less than [an estimated] 3 kg of well-preserved large mammal bones smaller than .47 cm per cubic meter of deposit" (p. 287). Given evidence for good bone preservation (p. 287) Rick states that large bone "was consistently removed from the upper occupation area and pushed down-slope" (p. 288).

Strata elsewhere at Pachamachay show evidence for refuse size sorting in the form of large debitage removal. Rick hypothesizes that the initial stages of tool manufacture that
produce large debitage were undertaken at habitation sites. The scarcity of large debitage in tool-dense strata at Pachamachay is cited by Rick as evidence for the clearing of large debitage from the "daily activity area" (p. 289). As evidence for size based refuse clearing this case is tenuous. Rick fails to provide evidence for lithic manufacture or to investigate the presence or absence of small debitage. If clearing of large debitage was undertaken it should be possible to locate concentrations of large debitage in refuse disposal areas.

Refuse clearing within a preceramic structure at Pachamachay is evidenced by greater refuse artifact density in wall matrix than in floor matrix. This pattern is a result of the "repetitive cleaning of living surfaces" (p. 289). In his analysis Rick states that "the continual [sic] pushing of materials towards the walls during cleaning is probably responsible for the size sorting and concentrations of materials in the wall matrix" (p. 290).

Fischer (1985) has identified patterns of sherd size distribution at Winklebury Camp, an Iron age hillfort in lowland Britain, which suggest sherd clearing activity. Postholes, pits, middens, and areas closest to the rampart are identified as containing sherds with high mean weight. Areas adjacent to hut doorways were identified as areas with sparse deposits of small sherds. Large sherd concentrations are the
result of rapid deposition away from areas of activity where sherd breakage is likely to occur. Post-holes served as artifact traps while pits and middens were areas of intentional dumping. The areas closest to the rampart were peripheral to intense daily activity and represent the limit to which refuse from the camp interior could be cleared. Low densities of small sherds adjacent to hut doorways suggest regular clearing and heavy use (Fischer, 1985).

Henderson (1987) attempts to use sherd size and density to illustrate yard sweeping behavior at two Hohokam sites: Rancho Derrio (AZ:AA:12:13) and Muchas Casas (AZ:AA:12:2) of the Marana Community Complex (Rice, 1987). Unfortunately, the resolution of the method is low and contour mapping of sherd size and frequency cannot be precise (see Henderson, 1987, Figs. 4.4-4.7). Artifacts used in the analysis were recovered from "random test units and feature control units (p. 57)." Sherd size is an average calculated from total sherd weight and frequency by unit (one cubic meter). Two size categories, small (0-9.99 grams) and large (>9.99 grams), and two density categories, low (0-24.99 grams/cubic meter) and high (>24.99 grams/cubic meter), were used.

The use of sherd weight and sherd mean weight as the two variables of analysis is unfortunate in that they are not independent. A few large sherds may easily out-weigh many small sherds. It is impossible to know if high density areas
are the result of large sherd size or high sherd counts.

Because sherd size (average weight) and density (total weight) were calculated by unit (random test unit or feature control unit) actual data points plotted on site locus maps (representing a horizontal surface) are sparse. Contours were drawn, presumably freehand, by interpolating and extrapolating from these points (Henderson, 1987; figs. 4.4-4.7).

The results of the analysis are unclear and clouded by Henderson's assignment of a limited set of formation processes for each permutation of the small/large and high-/low-density dichotomies. These are: (1) pit trash or primary refuse (large/high density), (2) yard periphery (large/low density), (3) yard interior (small/low density), and (4) midden or sheet trash (small/high density).

**Ethnoarchaeological Studies**

Binford (1978) observed discard, refuse cleaning, and refuse disposal at a Nunamiut Eskimo hunting stand. Refuse discarded by the occupants of the hunting stand was either dropped or tossed, resulting in the formation of two distinct refuse zones. He notes that there is a regular relationship between the size of an item and its disposal mode. Dropped refuse consisted of "marrow bone splinters or chips, shell casings, and rib tablets" (p. 347) whereas tossed refuse
consisted of the "articular ends of marrow bones, pop cans, and sardine cans" (p. 347). The largest refuse items, tin cans, were tossed the farthest, with informants reporting that tin cans "got in the way more than bones" (p. 349). Refuse at the site was distributed at the periphery of the activity area and in the activity area itself, with activity area refuse clustered in low-use areas. Binford notes a bias for larger refuse items to be located in the peripheral and low-use areas (Binford, 1978).

DeBoer and Lathrap (1979), in their ethnoarchaeological study of ceramic refuse in Shipibo-Conibo villages of eastern Peru, observe that sherds from broken pots are quickly swept away from household plazas into peripheral areas. They note that refuse is swept or raked "centrifugally away from the household" (p. 128) and refuse "accumulates exactly where behavior is minimal" (p. 129). Middens formed by refuse cleaning are "doughnut-shaped" when associated with a single household. Middens associated with several households sharing a plaza are "scalloped" and surround the entire plaza. Following rain, small sherds overlooked by cleaning efforts were observed to become embedded in the plaza surface (DeBoer and Lathrap, 1979).

DeBoer and Lathrap (1979) indicate that observed patterns of refuse disposal may be considerably altered by local topography. In the presence of bluffs or ravines ideal for
refuse dumping, midden formation will not occur.

O'Connell (1987) has observed refuse size sorting in modern Alyawara camps of central Australia. Household middens consist of broad bands of garbage encircling the activity area with refuse density decreasing with distance from the activity area. O'Connell notes that large refuse items are "tossed" into the nearby part of the midden at the time of discard whereas small items are generally discarded within activity areas. Sweeping of activity areas removes some of the small artifacts and deposits them at the edge of the midden. Despite sweeping, many small refuse artifacts remain in the activity area.

Using artifact density and artifact median length as variables to create contour maps of a household activity area O'Connell (1987, Figures 11-12) illustrates how Alyawara refuse is patterned by frequency and size. The central activity area is the zone of highest artifact density and the smallest median artifact length. Artifact counts decline and median artifact length increases with distance from the activity area. Furthermore, foot-paths leading away from the activity area are obvious in their lack of large artifacts.

Recent-Past Studies

Hohman (1975; Rathje, 1979) observed two zones of
beverage container discard at the termination of rural "dead-end" roads near Tucson, Arizona. An outer ring of refuse consisted of beer cans whereas an inner refuse zone contained broken beer bottles. Despite the fact that cans are equivalent in size to bottles yet are considerably lighter than bottles, he proposed that the outer ring formed as a result of tossing behavior. It is far more likely that all containers were dropped in the same area, heavier and often broken bottles remained in place, and cans were displaced outward by eolian action and scuffage.

McKellar (1983; Schiffer, 1976) studied the effect of artifact size on recent-past refuse discard patterns by examining modern litter. McKellar observed litter on the University of Arizona campus and found that larger items were more likely to be discarded into trash bins and smaller refuse items were more likely to be discarded onto the ground. McKellar's study involves discard during transit and does not consider factors other than discard that may have altered the observed record. Considering the location of the study and the properties of modern litter artifacts these factors could include foot traffic and wind action that would selectively remove large litter, into peripheral zones outside the study area. Regardless, McKellar's study provided the first discussion of the relationship between artifact size and the distinction between primary and secondary refuse.
South (1979) observed refuse associated with a "twentieth-century lower-socioeconomic-class dwelling" (p. 219). He links three zones of refuse (peripheral, adjacent, and central) with discard and sweeping behavior (South, 1979, fig. 2). Peripheral refuse, located at the household boundary and often associated with a fence, consisted of both large and small items. Adjacent refuse, located between the periphery and the structure, consisted of small refuse fragments. The adjacent zone was observed to be swept on occasion. The central zone, below the raised structure, consisted of both large and small items described as having been "tossed beneath the house" (p. 219).

Summary

In summary, investigations into the relationship between discard and refuse clearing behavior and artifact distribution by size have focused on household activity. Ethnoarchaeological and recent-past studies have the advantage of observing the creation and structure of these patterns before they are complicated by subsequent occupation and post-occupational disturbance.

Based upon these studies certain general patterns may be anticipated that can aid archaeological interpretations. The initial occupation of a habitation or semi-permanent camp site
can be expected to produce clear patterns of refuse density and size sorting as a result of household discard and refuse clearing behavior. Refuse is discarded in zones directly related to the use of space in daily activity. The formation of refuse zones is exemplified by the drop-zone and toss-zone at the Nunamiut hunting stand observed by Binford (1978). O'Connell (1987) also observed tossing behavior at Alyawara camps and South (1979) observed the formation of a toss-zones below modern dwellings. Drop-zones form in activity areas and consist of smaller refuse artifacts. Toss-zones form on the periphery of activity areas, consist of larger refuse artifacts, with the density of refuse declining with distance from the activity area.

Toss-zones form midden areas whereas drop-zones are subject to refuse clearing. Refuse clearing removes larger artifacts from drop-zones and deposits them on the periphery of activity areas. Intentional or inadvertent disposal of cleared refuse into peripheral areas, artifact traps, and areas of rapid deposition will protect large artifacts from breakage (Bradley, et al., 1980; Bradley and Fulford, 1980; Fischer, 1985). High density refuse will be located peripheral to activity areas with the density of large refuse artifacts declining with distance away from the periphery. The density of small refuse artifacts resulting from activity area clearing will be greatest in peripheral areas where it is
dumped.

OTHER ARTIFACT SIZE-SORTING BEHAVIOR

Certain non-discard behavior, including artifact loss and abandonment behavior, can result in the size selective placement of artifacts into an archaeological context. Similarly, behaviors such as loss recovery, scavenging, and collecting can selectively recover artifacts from an archaeological context based on size.

Artifact Loss and Recovery

Small, still useful artifacts are more likely to be lost and less likely to be recovered after loss (Fehon, 1978; Ferguson, 1977; Gifford, 1980; Schiffer, 1976; South, 1977).

South (1977) has reported deposits of pins and beads, lost through the gaps between floorboards, in the remains of Public House-Tailor Shop at Brunswick Town, North Carolina. Floorboard gaps served to trap only very small artifacts in their area of use and to preclude their recovery. He suggests that other artifact traps, such as a sand floor, will dictate the size of lost objects.

Fehon and Scholtz (1978) have formulated the probability that an artifact will enter an archaeological context by the
process of loss as the product of the probability that the object will be lost and the probability that the object will not be recovered. Clearly, diminutive artifacts will have both increased probability of loss and decreased probability of recovery.

Gifford (1980) has noted that small, easily lost items such as beads and fish hooks were the only functional artifacts recovered from a recently abandoned Dassanetch home settlement in Kenya. The fact that only lost items are found at the site is a result of the high rate of artifact curation practiced by the less-than-wealthy Dassanetch.

Abandonment Refuse

Curate priority has been implicated as the primary determinant of de facto refuse content (Schiffer, 1985). Artifact characteristics influencing curate priority are size, weight, replacement cost, and remnant use life. The influence of artifact size and weight will vary with "the means of transport and the distance to the next occupation locus" (p. 26).

Curate priority influences the likelihood that an item will be transported away at the time of abandonment, and the likelihood that the item will be scavenged (intra-settlement) or collected (inter-settlement) at a later time. When
scavenging occurs, the influence of artifact size and weight will be slight. The portability of items, as determined by size and weight, will be of much greater consideration to collectors (Schiffer, 1985).

Schiffer (1985) notes that, in addition to a propensity for larger, heavier artifacts to be left behind by potential curators, discard rates may increase and refuse clearing activity decrease prior to abandonment. Thus, de facto (still-usable) refuse may be associated with abandonment refuse items that "typically exhibit less damage than trampled artifacts of primary refuse" (p. 25).

Baker (1978) has suggested that the reuse of abandoned artifacts contributes to the "size effect" (Baker and Schiffer, 1975; House and Schiffer, 1975). The size effect, as proposed by House and Schiffer (1975), is a hypothetical bias in favor of large artifacts on site surfaces. Baker (1978) explains the cause of this bias to be, in part, the scavenging or collecting of partially buried large artifacts, their reuse, and their discard onto the current surface. The size effect is criticized in Appendix I on the basis of statistical significance in the case studies that Baker (1978) and Baker and Schiffer (1975) have used to support the hypothesis.
Several investigators have addressed artifact size-sorting resulting from human foot traffic (DeBoer and Lathrap, 1979; Gifford, 1978; Gifford and Behrensmeyer, 1978; Gifford-Gonzales et al.; Stockton, 1973; Villa and Courtin, 1983). Experiments designed to examine vertical and horizontal artifact displacement as a result of "treadage and scuffage" (Stockton, 1973: 116) have been carried out by Stockton (1973), Villa and Courtin (1983), and Gifford-Gonzales, et al., (1985). Others have attempted to discern trampling-induced artifact distribution patterns in the archaeological record (Bradley and Fulford, 1980; DeBoer and Lathrap, 1979; Gifford, 1978; Gifford and Behrensmeyer, 1977, O'Connell, 1987; Stockton, 1973; Villa and Courtin, 1983; Wilk and Schiffer, 1979).

Stockton (1973) experimented with broken glass artifacts buried 5 cm deep in a sand substrate. He found that the glass had "roughly sorted itself out in a scale of mean weights descending with depths" (p. 116)(fig. 2). Stockton also suggests that large artifacts are more susceptible to horizontal displacement. Repeated kicking events, for example, remove large objects from paths and other high-traffic areas.

Villa and Courtin (1983) experimented with lithic material, bone, shell, and pebbles placed on or in sandy soil
Figure 2: Approximate depth and mean weight of broken glass following treadage (based on data from Stockton, 1973).
subject to treadage. Unlike Stockton (1983), they found no correlation between artifact weight and the amount of vertical displacement (see Villa and Courtin, 1983, Table 4).

Gifford-Gonzales et al. (1985) recently experimented with the effects of treadage on the subsurface migration of lithic debitage in two substrates (compact sandy silt and unconsolidated sand). They found that "none of the [artifact] attributes indexing size or volume yielded a significant correlation with depth below surface" (p. 811).

In summary, experimental studies have proved inconclusive on the question of treadage-induced artifact size sorting. Problems include substrate characteristics and conditions, non-size artifact properties (e.g., shape), and experimental design (i.e., size category sample size, duration and intensity of treadage).

Several researchers have hypothesized that treadage will size-sort artifacts by displacing smaller artifacts into substrate. Thus, smaller artifacts may be trampled into older, underlying archaeological deposits. Stockton (1973) attributed dramatically decreased mean artifact size with greater subsurface depth at Shaw's Creek Shelter, Australia, to the effect of long term treadage (see Stockton, 1973, Fig. 2).

Gifford and Behrensmeyer (1977) investigated bone count and size at a recently abandoned Dassanetch three-day campsite at Lake Turkana, Kenya. The count for excavated bone,
attributed to discard during the brief encampment, far exceeded the surface count. Sub-surface bone was much smaller (<3 cm) than surface bone. Gifford (1978), in regards to the Dassanetch camp, states that "observations of newly vacated sites indicate that normal activity on a loose substrate will result in a sub-surface migration of most smaller [skeletal] elements." Yellen (1977) observed a similar pattern at Kalahari Bushmen campsites. Subsurface bone consisted of whole bone of small animals and small fragments of larger animal's bones. DeBoer and Lathrap (1979) observed the effects of treadage in Peruvian, Shipibo-Conibo village plazas. Small sherds were trampled into plaza surfaces - especially following rain. Plaza erosion, partly caused by foot traffic, constantly exposed small sherds on the surface.

Wilk and Schiffer (1979) observed that large objects in Tucson vacant lots are kicked or otherwise displaced from foot paths. On paths with a muddy or sandy surface small objects were trampled into the substrate.

Known footpaths leading from an Alyawara activity area are clearly visible as gaps in mapped contour lines for median artifact length (O'Connell, 1987, see Fig. 12). O'Connell notes that "refuse items along these paths are small and few in number" (p. 95).

The effects of foot traffic on vertical and horizontal artifact size sorting remains unclear. In general, larger
artifacts are more likely to be displaced horizontally whereas smaller artifacts are more likely to be displaced vertically. The details and archaeological visibility of these processes have yet to be thoroughly explored. Stockton (1983) provides the best example of vertical size sorting, probably a result of trampling, at Shaw's Creek Shelter. Ethnoarchaeological observations linking foot traffic to vertical and horizontal size-sorting obviously do not address the preservation of these patterns.

**Post-Occupational Disturbance**

Efforts have been made to quantify size-based differential horizontal and vertical artifact displacement resulting from post-occupational cultural disturbance. These efforts include studies of the effects of past and recent tillage (Lewarch and O'Brien, 1981; Odell and Cowan, 1987; Trubowitz, 1978) and a variety of modern, mechanized soil-disturbance activities (see Wildesen, 1981, for a review, and references therein).

Tillage, as a means of soil preparation for cultivation, is intended to "bring fairly large rocks and clods to the surface and to prepare a sub-surface zone of fine particles" (Lewarch and O'Brien, 1981, p. 18). In an experiment involving mechanical plowing and the displacement of lithic artifacts,
Lewarch and O'Brien (1981) found that the relative frequency of larger artifacts (>1/2") increases with each tillage event. Furthermore, larger artifacts suffer greater longitudinal displacement, supporting an earlier contention by Trubowitz (1978), and differential displacement increases with subsequent tillage. Odell and Cowan (1987), however, found no relation between artifact size and lateral displacement by tillage. Despite criticism of their methods (Dunnell, 1990; Yorston, 1990) they have maintained their position that "there is no correlation between displacement and artifact size" (Cowan and Odell, 1990).

NATURAL PROCESSES OF ARTIFACT SIZE REDUCTION

Certain natural forces have been linked to artifact sorting by size. These forces, in general, include fluvial action, pedoturbation, and the activity of animals.

Although a variety of factors influence the fluvial displacement of artifacts, artifact size has been identified as a critical criterion (Shackley, 1978). Shackley (1978) has stated that "the ability of a stream to pick up a certain particle is directly related to the size of that particle, and to its spacing from other particles" (p. 59). Taphonomists have given considerable attention to fluvial bone transport (Behrensmeyer, 1975; Behrensmeyer and Boaz, 1980) and a number
of flume experiments have been conducted (Behrensmeyer, 1975; Boaz and Behrensmeyer, 1976; Hanson, 1980; Korth, 1979; Voorhies, 1969). In general, larger or low profile bone forms a "lag" deposit whereas smaller or high profile bone is transported downstream. Studies of size-sorting by water action have been limited to the consideration of fluvial action. Other situations, such as sheet wash or micro-drainage, have not been considered.

Artifact size-sorting can occur as a result of persistent burrowing by fossorial animals (Bocek, 1986; Bruder, 1982, cited in Ohel, 1987; Limbrey, 1975; Wood and Johnson, 1978). The habitual activity of fossorial rodents leads to a classic pattern where "large objects sink below the rodent zone, while smaller objects may be carried towards the surface" (Bocek, 1986: 591). Horizontal movement, however, is "multidirectional, and thus homogenizes soil contents" (p. 591). Small artifacts moved to the surface by rodents range from 0.6 to 2.5 cm whereas artifacts larger than 5 cm, perhaps larger than 2.5 cm, cluster below the rodent zone (Bocek, 1986).

Pedoturbation, caused by frost heaving or the contraction and expansion of clays, can result in artifact size sorting (Pyddoke, 1961; Wood and Johnson, 1978). Frost heaving sorts coarse particles, including artifacts, to the surface (Wood and Johnson, 1978). Similarly, frost action can size-sort
surface particles to create geometric patterns. Shrinking and swelling of clay soil can sort larger stones and artifacts to the surface whereas smaller objects will often fill cracks that form in drying clay (Wood and Johnson, 1978). Eolian action has been implicated in the size-based, differential deposition and displacement of very small artifacts (Behrensmeyer and Boaz, 1980; Limbrey, 1975).

Animals often selectively scavenge bone or transport bone away from sites on the basis of size. Smaller bones are likely to be destroyed by scavengers whereas larger bones are likely to be transported (Behrensmeyer and Boaz, 1980; Yellen, 1977a). A variety of bone properties, discussed previously, effect this pattern.

RECOVERY BIAS AGAINST SMALL ARTIFACTS

Archaeological methods, such as screening, often impose a bias against the recovery of very small artifacts, ecofacts, and residues. In DeBoer's (1983) review of artifact size and the identification of cleaning behavior he notes that excavation methods fail to recover the very small artifacts that have remained in cleared areas. Recovery methods, screening in particular, sort or "winnow" artifacts and can distort the archaeologist's view of artifact size distributions.
The use of screening as an artifact recovery technique is well established as an archaeological method. Similarly, the disregard for artifacts and residues not recovered by a 1/8" or 1/4" screen is well accepted in archaeology. In 1951 Cook and Heizer declared that the use of a screen size less than 1/8" is "... disregarded as impossible to analyze without a prohibitive amount of labor and expense."

Ascher (1959) took exception to Cook and Heizer's (1951) disregard for the use of a screen size less than 1/8". He used 3/4", 1/4", 1/8", and 1/16" screen to recover shell, bone, and rock from a midden at Zuma Creek, California. He noted that "certain shells break up more easily than other shells and that shells generally break up more easily than certain rocks" (p. 170). The result was that the ratio of shell to bone and rock varied greatly depending upon the size of the screen used for recovery.

Payne (1972) conducted screening experiments designed to investigate recovery rates. His objective was not to ascertain the recovery rate of the 1/4" screen but to discover the effectiveness of artifact recovery "in the trench." His results were intended to demonstrate the merits of the 1/4" screen for the recovery of small animal remains, small finds (e.g., beads), small sherds, and small flakes. Payne demonstrates the inefficiency of excavation recovery yet fails to consider the recovery rate of the screen.
Zooarchaeologists have been adamant concerning the failure of 1/4'" screening to recover small animal bones and the need for fine sieving (e.g., Casteel, 1972; 1976; Clason and Prumel, 1977; DeMarcay and Steele, 1986; Schaffer, 1990). The use of screening by archaeologists biases any analysis of faunal remains in favor of larger species and larger skeletal elements.

The differential degradation of recently discarded artifacts (1949-89) in landfills has been used to illustrate the effects of artifact durability and depositional conditions on screen recovery rates (Archer, n.d.). Non-durable artifacts (e.g., paper), particularly those in older deposits and under adverse preservation conditions, suffer greater rates of size reduction. Proportionately large quantities of non-durable artifacts were found "hidden" in the soil by-product of the screening method.

The importance of artifacts and residues not recovered by screening has been recognized in recent years by archaeologists with specialized research objectives. These areas of specialization include microdebitage analysis (Fladmark, 1982; Henry, 1976; Hull, 1983; 1987) and the burgeoning sub-field of microarchaeology (Dunnell and Stein, 1989; Mathews, 1984; Rosen, 1985; 1989; Stein and Teltser, 1989).
CHAPTER 3: AN ARCHAEOLOGICAL APPLICATION

A test study of sherd-size variation in "sheet trash" was undertaken at a Hohokam habitation site (AZ:AA:8:27) in the upper bajada of the western Tortolita Mountains in the northern Tucson Basin, south-central Arizona. The study was undertaken as part of a project designed to test a high resolution field method (Archer, Tani, and Wilson, 1990). The results of this project are presented here in support of the sherd-size analysis.

The purpose of the sherd-size study was to test two provisional hypothesis regarding the nature of Hohokam refuse: 1) areas of refuse aggregation or "trash mounds" preserve large sherds and can be identified on that basis, and 2) sherd-size variation within Hohokam habitation refuse should reflect patterns of foot traffic intensity within the site.

The use of sherd-size analysis in Hohokam archaeology is considered a valuable addition to current techniques of site structure analysis. Previous research on artifact size, reviewed in the two preceding chapters, suggests that a variety of formation processes can be identified on the basis of artifact size analysis. The analysis of sherd-size variation is considered a particularly useful technique for mapping the organization of living space within habitation sites.
A brief summary of archaeology in the northern Tucson Basin will be followed by a description of the site and study area that was tested. The techniques and justification for the use of the high resolution method are detailed in the third section of this chapter, followed by a presentation of the results of the study and a discussion of their implications.

ARCHAEOLOGY IN THE NORTHERN TUCSON BASIN

Until relatively recently, very little was understood about Hohokam settlement in the northern Tucson Basin. New knowledge and expanded understanding of this region has largely been the result of the Northern Tucson Basin Survey (NTBS) (P. Fish, 1989; S. Fish, Fish, and Madsen, 1985; 1989; 1990). Prior to the NTBS the lowlands of the Santa Cruz River floodplain, as opposed to bajada uplands, were considered to contain the majority of sites (Doyel, 1977; McCarthy, 1982).

The results of the NTBS reveal that, by the Early Classic Period (ca. A.D. 1100-1300) in the northern Tucson Basin, sites occurred throughout all environmental zones. These range from the Santa Cruz floodplain, through the bajada, to the flanks of the Tortolita Mountains. Habitation sites parallel the river, and the lower bajada of the western Tortolita Mountains contains the Marana Complex, including a platform mound. Sites located in the middle bajada represent purely
agricultural activity at lower elevations, with a rancheria pattern above. The upper bajada contains a variety of large and small habitation sites, in conjunction with agricultural features (P. Fish, 1989; S. Fish, Fish, and Madsen, 1985; 1989; 1990).

Upper bajada sites are situated near the mountains and between three major drainages: Cottonwood, Derrio, and Guild Wash. Shallow bedrock in the upper bajada provides a high water table, and springs provide additional, year-round water. Structural features at large, upper bajada habitation sites include compounds with house mounds, compounds with cobble room outlines, dry-laid masonry structures, and isolated cobble-outlined structures. Large habitation sites coincide with agricultural features, including terraces, rock piles, and check dams (P. Fish, 1989; S. Fish, Fish, and Madsen, 1985; 1989; 1990).

SITE DESCRIPTION

Investigations were conducted at a large, Early Classic Period Hohokam habitation site (AZ:AA:8:27) located by the NTBS. The site is situated along a ridge that parallels the northern bank of Cottonwood Wash. The sight is very large, measuring over 1 km square in area.

The location of the site coincides with a confluence of
a split in the wash and an abrupt widening of the channel created by the decreased topographic slope encountered at the mountain-bajada boundary. The site lies along the top of an alluvial ridge forming the northern bank of the wash. The ridge is wide with small, shallow drainages feeding into the wash. Vegetation consists predominantly of bursage and creosote, a variety of cactus including abundant saguaro, cholla, and prickly-pear, and other varieties including palo verde and ocotillo.

The dominant structural feature of the site is a masonry compound with a housemound. A field of rock piles and stone check dams were noted in the area to the North-East of the structure by NTBS. Artifact scatters, including sherds, chipped stone, and ground stone occur with variable frequency along the ridge top. Trash mounds, identified during site reconnaissance by high artifact densities, slightly elevated surface topography, and dark soil color, are situated near the structure and are encountered elsewhere on the site.

A study area, located approximately 450 meters south and 250 meters west of the compound structure, was selected for quantitative study of artifact distributions. The study area, approximately 5000 square meters in area, is situated on a small promontory of the wash embankment overlooking the broad confluence. Artifact density is relatively high in the study area. The farthest extremity of the promontory shows evidence
of clearing, which includes the absence of large stones and peripheral rock piles. This cleared area contains an abundance of ground stone fragments. A large trash mound (approximately 100 square meters) is situated on the eastern edge of the promontory with high artifact densities extending down-slope.

A 10X50 meter study transect was placed to the north of the cleared area and to the east of the trash mound. This location was chosen for the purpose of testing the high resolution method in an area of "sheet trash." The transect is positioned in concordance with the grid system established for the site with the long axis running north-south. Within the study transect no features are readily discernable by visual reconnaissance. Artifact density is high relative to the site as a whole yet moderate in comparison with the rest of the study area and apparently homogeneous. A small, shallow drainage cuts east-west across the transect.

THE HIGH RESOLUTION METHOD

The resolution or scale of a field method directly affects the nature of archaeological conclusions. Low resolution methods tend to smooth, for example, terrain features and artifact frequency patterns (Kvamme, 1988). Method resolution may range from very low, as in regional site mapping, to very high, as in artifact point-proveniencing.
A high resolution method is necessary in order to collect information on artifact size variation within a Hohokam habitation site. Significant gradations in sherd size, for example, are likely to occur over distances of only a few meters. Low resolution methods commonly employed in Hohokam archaeology, such as 10 percent surface sampling, will not yield recognizable patterns of size grading.

The method described below employs an intensive surface study and sub-surface testing. The surface study is considered to be "high resolution" because it employs contiguous one-by-one meter provenience units. Artifact counts and surface elevations were obtained for 100 percent of the one-by-one meter units. Surface collection entailed a 25 percent sample of the units.

**Micro-Topography**

Surface elevation was measured across the entire study transect at one meter intervals, providing a high resolution fish-net map of micro-topographic change. Surface topography is often used in archaeological reconnaissance to identify features such as trash mounds, mound structures, compound walls, and pit-house depressions. Micro-topographic mapping quantifies slight changes in surface elevation and permits the identification of subtle topographic features. Topographic
relief can be correlated with artifact frequency, artifact size, and other information for the purpose of identifying refuse aggregates, remains of structures, and other features. Furthermore, micro-topographic mapping provides quantitative data for the analysis of natural surface features affecting environmental processes that can alter the archaeological record. Surface slope, for example, determines the course of drainage and slope-wash, which can displace artifacts and erode archaeological deposits.

**Ground Cover**

Surface visibility was estimated to the nearest ten percent interval for each one-by-one meter unit across the study transect. The recovery rate for the collection of surface artifacts and/or artifact counting accuracy will be affected by the extent of ground cover. Estimating surface visibility across the study transect allows the construction of a visibility contour map. The accuracy of measured artifact frequencies will be assessed on the basis of observed surface visibility.

In addition to affecting artifact recovery rates ground cover (vegetation) will affect rates of soil erosion. It is hypothesized that the surface of the study transect has experienced differential rates of soil erosion from rain and
sheet-wash action as a result of variable ground cover. Ground cover impedes soil deflation, with deflated areas having greater potential for higher artifact counts. Vegetation, perhaps bursage and creosote in particular, may have a propensity to grow on certain prehistoric features, such as trash mounds, which may be high in organic content. The activity of rodents and lagomorphs is observed to be associated with denser vegetation. Areas within low visibility contours correlate roughly to areas of greatest bio-turbation and possible artifact size-sorting associated with burrowing activity.

Artifact Counts

Surface artifact counts are often used to infer the location, intensity and duration of discard activity. High artifact counts, especially in cases where both sherd and lithic counts are high, are indicative of refuse aggregation. While this correlation is probably sound, only high-percentage sampling of artifact counts provides the accuracy and resolution necessary to satisfactorily draw inferences about the formation of frequency distributions.

Surface artifacts were counted for 100 percent of the study transect using one-by-one meter units for provenience. The result is 500 data points across the study transect
surface for each of three artifact types: sherds, chipped stone, and ground stone (including all basalt fragments). All diagnostic artifacts, including decorated sherds, chipped stone tools, cores, utilized flakes, and basalt with observable grinding or shaped surfaces, were point-provenienced and collected. Very small quantities of fragmented bone, burned bone fragments, and shell were also counted.

Artifact Collections

Surface artifacts (including all pottery, chipped stone, groundstone, basalt flakes, and bone) were collected for 25 percent of the study transect from evenly spaced one-by-one meter units. Artifacts were collected for the purpose of measuring total sherd and chipped stone weights. Total weights and counts were used to calculate average sherd and chipped stone weights.

The lengths and weights of individual sherds from all collection units were measured. Both length and weight of sherds are used as measurements of sherd size because each incorporates different aspects of a sherd's physical characteristics. Sherd length, a measure of the greatest dimension, is virtually always along the plane of the sherd's inner and outer surfaces. Length is deemed the most efficient
means of quantifying sherd dimension. Although the calculation of sherd surface area or multivariate measurements of length, width, and thickness may provide some slight analytic benefit, the labor intensity of acquiring such measurements precludes their use. Sherd weight can be efficiently obtained and is a function of sherd surface area and thickness.

The variables of sherd length and weight provide two means for investigating sherd size. Sherd length is best suited to the identification of processes that involve breakage, such as foot traffic. Sherd weight is appropriate for the identification of forces that interact with artifacts on the basis of mass, such as fluvial action.

Sub-Surface Testing

A 1X2 meter sub-surface test unit was positioned within the study transect on the basis of micro-topographic and surface artifact frequency information. Topographic relief and artifact counts suggested the presence of possible structural remains or other traces of an activity area, as discussed in following sections. The purpose of sub-surface testing was to explore the nature of sub-surface artifact deposits and to determine the relationship between surface and sub-surface artifact frequency and sherd size. In consideration of these goals the test unit was placed at the boundary of a possible
refuse aggregation and a possible activity area.

The 1X2 meter test unit was partitioned into eight 50X50 cm horizontal units and excavated in four 10 cm arbitrary levels. Thus, sherd and chipped stone artifact counts, weights, and average weights were obtained on the basis of units containing 0.025 cubic meters of fill. Screening with a battery of 1/4", 1/8", and 1/16" mesh-sizes was used for artifact recovery in fifty percent of the 50X50 centimeter units. A single 1/4" mesh-size was used in the remaining units. Artifacts were encountered throughout the depth of the deposits and excavation was terminated at the top of caliche layer.

Augering

A hand auger was used to probe the depth of deposits in the study transect along a center-line running north-south. Auger holes were placed at two meter intervals along the center-line. The results of the augering are used to determine depth of deposits between the surface and the underlying caliche layer.

RESULTS

The results of the fieldwork will be reported in four sections. The first section describes the information
recovered on topography, depth of deposits, and ground cover. The second section presents surface artifact frequency patterns. The third section details sherd size and the relationship between sherd size and other variables. The results of the sub-surface testing are reported in section four.

**Topography, Deposit Depth, and Ground Cover**

Several features of topographic relief are apparent in the study transect (fig. 3). Most notably, three subtle ridges are evident, enclosing an elevated, level or slightly concave area of roughly 100 square meters. Two parallel ridges traverse the transect in an east-west direction. The third ridge, oriented north-south, is sectioned by the western boundary of the transect. The three ridges adjoin, constituting three sides of an enclosed area.

The northern ten meters of the transect is an area of topographic relief. Separating this area from the northern ridge of the enclosure is a small drainage. The drainage channel is clearly indicated by the transect's topography. The drainage flows across the transect from east to west, cutting into the deposits.

Deposit depth along the north-south axis of the transect, as revealed by augering, illustrates the relationship between
Figure 3: Surface topography viewed from the southwest with X 20 vertical exaggeration.
the surface topography and the underlying caliche layer (fig. 4). The drainage channel cuts into the deposits to within ten centimeters of the caliche layer. The greatest deposit depth underlies the area of topographic relief in the north of the transect. Deep deposits also underlie the northern ridge of the enclosure.

Areas of decreased surface visibility reflect areas of greater vegetation and other ground cover, such as dead vegetation debris (fig. 5). Contouring illustrates the clustering of ground cover in the northern and southern extremities of the transect. The drainage is relatively free of vegetation, as is the enclosure. Vegetation appears to cluster along the ridges of the enclosure, particularly the ridge along the western boundary of the transect. It is possible that vegetation correlates with topography, with vegetation clustering in areas of topographic relief and deeper deposits. Correlation analysis finds the relationship between percent surface visibility and surface elevation to be statistically insignificant \((r=0.0499, p<0.2650, N=500)\).

**Surface Artifact Frequency and Weight**

Distinct areas of high artifact frequency, including sherds, chipped stone, and groundstone, indicate refuse aggregation. Three such areas are apparent in the transect at
Figure 4: Study transect cross-section showing depth of deposits.
Figure 5: Contour map of estimated percent surface visibility.
the northeast corner, the central or middle area, and the southwest corner (figs. 6-8). Correlation analysis reveals that sherd counts (fig. 6) and chipped stone counts (fig. 7) within the transect show a moderately significant, positive linear correlation (r=0.5984, p<0.0001, N=500). The use of groundstone/basalt flake counts (fig. 8) are considered improper for this analysis because most surface units contain either zero (N=464) or one basalt artifacts (N=36). This correlation suggests that refuse is indeed aggregated, rather than deposited as "sheet trash." In sheet trash, consisting of relatively dense, evenly distributed artifacts, variation in sherd counts, chipped stone counts, and groundstone counts can be expected to vary independently.

High total sherd weight (fig. 9) and high total chipped stone weight (fig. 10) obviously coincide, in general, with high artifact counts (fig. 6-8). Sherd counts and total sherd weights are greatest in the north-east corner of the transect and least in south-west corner (figs. 6, 9). Chipped stone counts appear relatively equivalent between areas of refuse aggregation (fig. 7) yet total chipped stone weight is markedly variable (fig. 10). Chipped stone weight is greatest in the central refuse aggregate and very slight in the southwest corner refuse aggregate. This pattern reflects the distribution of larger chipped stone artifacts and larger, core reduction flakes.
Figure 6: Surface sherd count viewed from the southwest.
Figure 7: Surface chipped stone count viewed from the southwest.
Figure 8: Surface groundstone and basalt fragment count viewed from the southwest.
Figure 9: Surface sherd weight viewed from the southwest.
Figure 10: Surface chipped stone weight viewed from the southwest.
The refuse aggregates in the center of the transect and in the northeast corner are separated by the drainage. They probably represent two portions of a large refuse aggregate, or "trash mound", that has been bisected by erosion. The topography of the transect illustrates the sharp down-cutting effect of drainage erosion on surface elevation (fig. 3). Erosion has probably altered artifact counts in the area of the drainage by deflating cultural deposits and by removing artifacts downstream.

**Sherd Size**

The artifact collection phase of the study recovered a total of 3030 sherds out of a total 9817 sherds counted within the study transect. All sherds were collected from evenly spaced one-by-one meter units providing a 25 percent sample of the study transect's surface, as described in the preceding section on field procedures. The size of collected sherds was quantified by both length and weight.

The relative frequency by length interval (5 mm) for all collected sherds (N=3030) is illustrated in Figure 11. The average length for sherds is 18.66 mm, with a standard deviation of 8.46 mm and a range from 1 to 89 mm. This distribution is positively skewed, with a skewness value of +1.46 and a mode value of 15 mm. The relative frequency by
Figure 11: Relative sherd frequency by sherd length (all collected surface sherds, N=3030).
weight interval (1.0 gm) for all collected sherds is illustrated in Figure 12. The average weight for sherds is 1.764 gm, with a standard deviation of 2.293 gm and a range from <0.1 to 43.8 gm. The distribution is also positively skewed, with a very high skewness value of +5.614 and a mode value of 0.5 gm.

The frequency distribution of sherds by size, on the basis of both length and weight, is indicative of a size-reduced assemblage. Previous studies, both experimental (Kirkby and Kirkby, 1976; Nielson, n.d.) and observational (DeBoer and Lathrap, 1979), indicate that left-shifted, right-tailed sherd-size frequency distributions reflect the effects of foot traffic. In general, however, this pattern can be the result of any size-reduction processes, such as weathering. Similarly, the displacement of large sherds as a result of refuse clearing could also produce a left-shifted distribution. Refuse clearing, however, because it is consciously intended to remove large debris, is less likely to produce a positively skewed sherd-size frequency distribution.

Cattle, currently active in the area of study, could be responsible for overall surface sherd size-reduction. Cattle prefer to walk where the ground is clear, rather than in dense, spiny vegetation. It is possible, given fairly stable patterns of ground cover by cactus and other vegetation, that habitual behavior by cattle could produce patterns of sherd-
Figure 12: Relative sherd frequency by sherd weight (all collected surface sherds, N=3030).
size variation. There is a slight correlation between increased ground cover and increased sherd size based on average sherd weight ($r=0.4296$, $p<0.0001$, $N=128$). However, there is also a slight correlation between increased ground cover and increased sherd counts ($r=0.4022$, $p<0.0001$, $N=128$). This correlation perhaps reflects a situation wherein large-sherd bearing trash areas provide conditions favorable to vegetation, rather than patterned traffic flow by cattle. Cattle ranching has only a seventy-five year history in the area (S. Fish, et al., 1985) and vegetation patterns may change, altering the flow of cattle traffic. Cattle traffic probably constitutes a relatively un-patterned, evenly distributed size-reduction effect, given the absence of actual cattle trails.

Mapping average sherd weight is one possible method for illustrating variation and possible gradations in sherd size across the surface of a site. This method has often been employed by previous archaeological studies of sherd size (e.g., Bradley and Fulford, 1980; Fischer, 1985; Henderson, 1987). Average sherd weight, calculated for individual collection units across the study transect, is illustrated in Figure 13. Aside from a few isolated dips and peaks, average sherd weight appears relatively constant across the study transect, although averages appear slightly higher in the central and northeastern portions.
Figure 13: Average sherd weight viewed from the southwest.
Although the sherd-size frequency distribution for the entire study transect is left-shifted and right-tailed, this pattern is not consistent between individual, one-by-one meter collection units. In order to discern patterns of sherd-size variation across the surface of the study transect contour maps have been constructed on the basis of sherd-size in individual collection units. The relative frequency of sherds by size interval (5.0 mm and 1.0 gm) was calculated for each of the individual collections. The midpoint of the size interval (i.e., 2.5, 7.5, 12.5, . . . 87.5 mm, or 1.0, 2.0, 3.0, . . . 44.0 gm) that contained the highest relative frequency of sherds, the mode of the distribution, is used as a measure of sherd size for each provenience (N=60). Only collection units which yielded 20 or more sherds are included in this analysis, in order to insure sufficient sample size. The contour map of the study transect generated on the basis of sherd length is shown in Figure 14 and the map generated on the basis of sherd weight is shown in Figure 15.

If the values illustrated in Figures 14 and 15 are indicative of activity intensity, as previous studies suggest (Bradley and Fulford, 1980; Kirkby and Kirkby, 1976; Nielsen, n.d.), then several areas of the transect appear to have experienced relatively less traffic than others. Notably, areas with the largest sherds correspond to areas of high artifact counts (figs. 6-8), suggesting that refuse aggregates
Figure 14: Contour map of mode sherd length (mm).
Figure 15: Contour map of mode sherd weight (gm).
contain larger sherds than other areas. Additionally, areas without large sherds correspond to: 1) the drainage, which runs east to west across the transect, as reflected by deflated and sloped surface topography; and, 2) the area between the topographic ridges described previously (fig. 3).

Counts for very large sherds, although dependant on sherd counts in general, provide an additional illustration of sherd-size patterning across the surface of the transect. For this purpose, very large sherds are defined as those with a length greater than one standard deviation above the mean for all collected sherds (Mean=18.7, Standard Deviation=8.5). The existence of very large sherds is indicative of relatively undisturbed, low use-intensity contexts. Thus, areas containing high counts of very large sherds were probably either peripheral to activity or experienced little activity after sherd discard. In addition, refuse clearing is a size-sorting process that displaces large sherds away from activity areas. Concentrations of very large sherds may be indicative of refuse dumping. Counts for very large sherds are shown in Figure 16.

High counts for very large sherds correspond with areas of high sherd counts in general, as expected. Large sherds "spill" over the northern ridge of the enclosure, especially in the enclosure's northeast corner. South of this "spillage" the frequency of large sherds is low, except in the area of
Figure 16: Counts for very large sherds (> 27 mm) viewed from the southwest.
refuse located in the southwest corner of the transect. North of the enclosure the frequency of large sherds clearly increases up to the drainage where large sherd counts decline precipitously. Larger sherd counts are greatest north of the drainage. Prior to erosion by the drainage, a pattern of increasing large sherd frequency with distance north of the enclosure probably existed.

Sub-Surface Testing

Sub-surface testing yielded sherds (N=1003), chipped stone flakes (N=243), groundstone fragments (N=2), basalt chips (N=7), and bone fragments (N=124). In addition, level one yielded a projectile point, level two a worked sherd and a human tooth, and level four a polishing stone.

Sherds decrease in frequency with depth below the surface (r=-0.6122, p<0.0001, N=34) as do chipped stone artifacts (r=-0.4116, p<0.0156, N=34). No significant relationship was found between level and average artifact weight. Similarly, horizontal provenience does not correlate with artifact counts or average weights.

No natural or cultural stratigraphy was observed in the excavation. Very little charcoal was recovered, and consisted of small fragments.
DISCUSSION

The term "enclosure" has been used above to describe a topographic feature observed in the study transect. The distribution of artifacts associated with this topographic feature indicated that it is probably the remains of an ephemeral structure or cleared courtyard. In addition, the refuse patterns observed in the study transect are believed to be the product of activity associated with this structure. Furthermore, sherd-size patterns suggest that foot traffic was relatively more intense in and around this area.

Three ridges form the enclosure, and demarcate inner, adjacent, and peripheral zones of refuse. A fourth ridge, forming an eastern boundary and completing the enclosure, is not observable within the study transect. These ridges are not readily apparent to visual reconnaissance, and a fourth, eastern ridge may lie outside the transect. Alternatively, a fourth boundary may have been obliterated by erosion, or be non-existent. The area within the enclosure is level, or slightly concave.

Sub-surface testing in the northwest quadrant of the enclosure failed to reveal evidence for an activity surface or other evidence for a formal structure. Excavation revealed shallow cultural deposits (>40 cm), indicating a single, relatively brief occupation.
The area encompassed by the enclosure is large, approximately 100 square meters, suggesting a compound rather than a closed structure. A likely possibility is the pre-existence of a brush enclosure (see Russell, 1908, Pl. VIb, for a Pima example). Such an enclosure would promote the build-up of cleared refuse against the inner wall and eolian deposits against the outer wall. Post-occupation deterioration of a brush wall would also contribute to the buildup of eolian deposits and the formation of the ridges currently visible. Sheet-wash erosion would be diverted by the structure and post-deterioration remains, probably creating the slightly elevated appearance of the feature.

Silberbauer (1981) observed the formation of a similar pattern in association with G/wi dwellings in the central Kalahari:

Shelters and their forecourts are swept several times a day. A ridge of detritus soon forms at the perimeter of the forecourt and this remains to mark the site long after the thatch and wooden framework have decayed to dust (Silberbauer, 1981: 230).

Refuse patterns observed within the study transect are believed to have been produced by activity associated with this ephemeral structure or courtyard. Post-occupational natural disturbance, as in the case of drainage erosion, have served to alter these patterns to some degree. Activity beyond
the study transect may have contributed to refuse build-up, yet refuse patterns appear to support a straightforward reflection of refuse discard associated with activity focused on the enclosure. All prehistoric bone fragments recovered from the transect were located within the area of the enclosure or within a few meters, perhaps reflecting the discard of food-processing waste (fig. 17). In addition, the majority of diagnostic lithic artifacts yielded by the transect are associated with the enclosure (fig. 17). Three out of five utilized flakes recovered from the transect were located within the area of the enclosure and a fourth was situated just beyond the southern ridge. One of two hammerstones, and two of three projectile points recovered from the transect were also situated within the enclosure. Three of four cores recovered from the transect were located within the enclosure and the fourth was recovered just beyond the southern ridge.

A scenario of intense foot traffic within the enclosure, refuse clearing within the enclosure, and refuse discard into the adjacent and peripheral areas to the north of the enclosure, is supported by observed artifact frequency and size. The relatively greater intensity of foot traffic within and around the enclosure, and away from refuse discard areas, produced deposits of size-reduced sherds. Refuse clearing re-deposited these size-reduced sherds into peripheral areas. Refuse discard, probably involving "tossing," deposited larger
Figure 17: Location of surface bone and diagnostic artifacts.
refuse beyond the enclosure into an intentional refuse area to the north. Refuse removed from the vicinity of the enclosure suffered less from the effects of size-reducing foot traffic.

Refuse within the enclosure contains size-reduced sherds, suggesting that foot traffic was indeed relatively intense. Sherd frequency is greatest within the compound at the northern boundary, adjacent to the refuse discard area or "trash mound," and grades to lower frequencies southward. Sherd frequency declines suddenly beyond the southern enclosure boundary. This pattern suggests that sherd frequency reflects natural filling of the enclosure with refuse from the northern periphery. Higher artifact frequencies, the presence of some large sherds, and a clustering of larger sherds in the northwest quadrant of the enclosure may reflect the build-up of refuse prior to its abandonment. Refuse aggregation adjacent to the northern boundary of the enclosure is dense, as indicated by high counts and weights, with increasing large sherd counts with distance from the enclosure. It is suggested that refuse was "tossed" from the enclosure area, sorting refuse by size, with distance from enclosure providing protection from size-reducing foot traffic.
CONCLUSION

The archaeological literature available on the topic of artifact size provides a basis for the use of artifact size in site structure analysis. Sherd size is particularly useful for the analysis of Hohokam refuse aggregates.

Sherd size can reflect activity intensity because foot traffic is a primary cause of sherd breakage. Refuse discard behavior can create sherd size patterns with larger sherds being disposed of away from activity areas. Refuse clearing activity will sort sherds by size and create disposal areas of size-reduced sherds.

Four basic patterns of sherd size-reduction and size-based sherd displacement have been identified at a Hohokam habitation site on the basis of surface artifact distribution and sub-surface testing. These patterns are: 1) the preservation of larger sherds in refuse aggregate areas; 2) foot traffic sherd size-reduction in and around an ephemeral structure, courtyard, or other activity area; 3) aggregations of size-reduced sherds peripheral to the structure resulting from refuse clearing; and 4) refuse size-grading with distance from the structure as a combined result of foot traffic intensity and disposal size-sorting.

Refuse aggregates or "trash mounds" contain characteristically large sherds. Thus, sherd size, in
combination with high artifact counts, micro-topographic relief, and even patterns of vegetation are criteria for the identification of subtle refuse aggregates. Sherd size is greater in refuse aggregates because of rapid deposition by refuse build-up in areas of low foot traffic intensity.

Foot traffic and refuse clearing is expected to produce sparse, size-reduced refuse in and around structures. The occurrence of uncleared refuse, that may build up prior to abandonment, and natural fill will alter this pattern by introducing large sherds into the structure. Aggregates of small sherds, produced by the disposal of foot traffic size-reduced sherds cleared from activity areas, are encountered near structure and structure area boundaries. These deposits can be used to identify boundary or peripheral areas for ephemeral structures.

Refuse aggregates adjacent to structures, yet beyond areas of intense foot traffic and peripheral dumping areas for cleared refuse, will show a pattern of increasing sherd size with distance from the structure. The study transect contained only a portion of a refuse aggregate adjacent to the structure. Hence, patterns of sherd size-grading beyond a distance of twenty meters are unknown. Sherd size-grading is believed to reflect "toss zone" size-sorting and decreasing foot traffic disturbance with structure distance. Toss zone refuse should continue to grade into larger refuse artifacts.
but drop off in refuse density with distance from the activity area. In a habitation site with multiple structures and other activity areas, and complex patterns of foot traffic and discard, size grading patterns are may not fit the idealized model.

The use of the high resolution method, involving high percentage sampling and small horizontal units, has allowed the identification of subtle refuse aggregates and an ephemeral structure or courtyard. High resolution also permits the study of slight changes in artifact size distributions over short horizontal distances. The study has been limited by the fact that only minimal sub-surface testing was possible. The inferences that have been made rely heavily on surface artifact distributions that may not be wholly representative. Furthermore, only a small area of a large habitation site has been studied. The results reflect only a glimpse of a complex artifact pattern.

The contribution of this work lies in the application of recently explored archaeological principles involving artifact size to the interpretation of site structure. Artifact size analysis has been shown to provide valuable information on subtle patterns in Hohokam refuse that are otherwise unrecognizable.
APPENDIX I: CRITICISM OF THE SIZE EFFECT

The so-called "size effect" was first hypothesized by House and Schiffer (1975). They stated that "the probability that any item will be visible on the surface is directly proportional to its gross size" (p. 380).

Baker and Schiffer's (1975) and Baker's (1978) efforts to illustrate the size effect using relative frequency are not definitive. Baker (1978), relying partly on cases published earlier by Baker and Schiffer (1975), calculates the relative frequency of artifacts by size category from the surface and in the site as a whole. In Baker's three case studies the relative frequency of large artifacts is greater for surface artifacts than for total surface and sub-surface artifacts (Tables 1-3).

<table>
<thead>
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<th>SURFACE</th>
<th>SURFACE &amp; SUB-SURFACE</th>
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<tbody>
<tr>
<td>SMALL ARTIFACTS</td>
<td>123 (81.5%)</td>
<td>720 (94.5%)</td>
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<tr>
<td>LARGE ARTIFACTS</td>
<td>28 (18.5%)</td>
<td>42 (5.5%)</td>
</tr>
<tr>
<td>TOTAL ARTIFACTS</td>
<td>151 (100%)</td>
<td>762 (100%)</td>
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Table I Counts and percentages for chipped stone artifacts from 3IN77 (Baker and Schiffer, 1975).

Baker does not test the significance of the difference between size category frequencies for surface and total...
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<th>SURFACE</th>
<th>SURFACE &amp; SUB-SURFACE</th>
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<tbody>
<tr>
<td>SMALL ARTIFACTS</td>
<td>106 (63%)</td>
<td>253 (73%)</td>
</tr>
<tr>
<td>LARGE ARTIFACTS</td>
<td>61 (37%)</td>
<td>92 (27%)</td>
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<tr>
<td>TOTAL ARTIFACTS</td>
<td>167 (100%)</td>
<td>345 (100%)</td>
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Table II: Counts and percentages of chipped stone and groundstone artifacts from the Riverton site (Baker, 1978).

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<th>SURFACE &amp; SUB-SURFACE</th>
</tr>
</thead>
<tbody>
<tr>
<td>SMALL ARTIFACTS</td>
<td>72 (77%)</td>
<td>200 (82%)</td>
</tr>
<tr>
<td>LARGE ARTIFACTS</td>
<td>21 (23%)</td>
<td>43 (18%)</td>
</tr>
<tr>
<td>TOTAL ARTIFACTS</td>
<td>93 (100%)</td>
<td>243 (100%)</td>
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Table III: Counts and percentages for chipped stone and groundstone artifacts from the Eva site (Baker, 1978).

artifacts. Calculating Chi-square values for each of Baker's case studies (Table 4) shows that only at the Riverton site is there a significant difference between the relative frequency of large surface artifacts and the relative frequency of total large artifacts at the .05 level. In the Riverton case, however, the phi-squared value is only 0.008, indicating that the substantive significance of the relationship is virtually non-existent.
Chi-square

<table>
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<tbody>
<tr>
<td>3IN77</td>
<td>1.95</td>
</tr>
<tr>
<td>Riverton</td>
<td>4.06</td>
</tr>
<tr>
<td>Eva</td>
<td>2.18</td>
</tr>
</tbody>
</table>

* Percentage point of Chi-squared for one degree of freedom and the .05 level of significance is 3.84.

Table IV: Chi-square values testing Ho: The relative frequency of artifacts in two size categories is equal between surface assemblages and total site assemblages.

The causes of the size effect have been attributed to "the reuse of certain categories of artifacts combined with natural site formation processes, such as sedimentation and erosion" (Baker, 1978, p. 288). Small artifacts are more likely to be displaced into soil by trampling, whereas larger artifacts are less likely to be completely covered by deposits and more likely to be revealed by erosion (Baker and Schiffer, 1975)(fig. 23). Thus, larger artifacts are more likely to be collected for reuse. Baker (1978) has stated that "the principal implication of the size effect is that surface artifact collections are not representative of a site's total artifact inventory" (p. 292).

The size effect is frequently cited by authors investigating the use of artifact size in site structure analysis (Bocek, 1986; Bradley and Fulford, 1980; DeBoer, 1983; Lewarch and O'Brien, 1981; Schiffer, 1983; 1987). Explanations for causes of the size effect are appealing yet no significant case of a manifestation of the size effect has
been reported by its proponents. The size effect should not be accepted as evidence for cultural artifact size sorting or as evidence against the representative nature of surface collections without further investigation.
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