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Beyond the Identification of Formation Processes: Behavioral Inference Based on Traces Left by Cultural Formation Processes

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Formation processes are generally considered as a negative factor for behavioral inference in archaeology. The concept of formation processes, however, can potentially be far more useful for behavioral inference in archaeology than simply identifying spurious variability in the archaeological record. Physical traces left by cultural formation processes convey a certain kind of behavioral information which may not be otherwise available. Variables related to site occupation, such as the occupation span, the number of occupation episodes, and the location of activities, can be inferred from characteristics of refuse deposits, or "refuse structure."

KEY WORDS: cultural formation processes; behavioral inference; refuse deposits; site structure.

INTRODUCTION

Variability in the archaeological record is the ultimate source of information for all archaeological inquiry. Patterned and recurrent variability in archaeological materials provides a major means to link the materials of today to the past. In the new archaeology era of the 1960s, some archaeologists initiated systematic explorations of behavioral inference based on variability observed in todays archaeological record. This movement yielded a number of studies that pushed archaeological inquiry beyond the classification and ordering of artifacts. In the 1970s, while behavioral inference continued to be the new focus of archaeological inquiry, the proponents of behavioral archaeology argued that the past behaviors of interest were

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not the sole determinants of variability in the archaeological record observed today (Schiffer, 1972, 1976). They view the archaeological record as an end product progressively formed by a series of processes that transform the state of artifacts. These processes, called formation processes, include those by natural and human agents and those occurring both during and after an occupation at a site (Schiffer, 1987).

The main thrust of formation process research by behavioral archaeologists was to contend that a significant portion of variability in the current archaeological record was determined by formation processes rather than by the behaviors of interest (target behaviors). Therefore, they further argue that without properly accounting for the effects of formation processes, it is almost impossible to draw sound behavioral inference based on the current material evidence. This framework views formation processes as a negative factor on archaeological inference which skews the configuration and association of archaeological materials and obliterates behaviorally significant variability in the archaeological record.

The concept of formation processes, however, potentially benefits behavioral inference in archaeology far beyond simply calling attention to the presence of spurious variability. This paper argues that formation processes are not exclusively destructive of behavioral information in the archaeological record, but leave behaviorally significant information in the record that can be utilized for behavioral inference. Of course, not all formation processes can positively contribute to behavioral inference. Most, if not all, natural formation processes are simply destructive of any behaviorally significant variability in the archaeological record. On the other hand, cultural formation processes (CFPs) are actually a set of certain behaviors which alter the state of materials in the systemic and archaeological contexts.

The premise of the approach advanced here is that CFPs do not occur at random; rather, CFPs are related to and constrained by certain characteristics of activities. Therefore, once CFPs are identified by using observable variables in the archaeological record, the characteristics of activities that affect CFPs can, in turn, be inferred. In order for formation process research to go beyond simply identifying the negative effects of formation processes on behavioral inference, the nonrandom relationship between CFPs and other activities should be explored. Once such relationships are established, traces of CFPs can positively contribute to behavioral inference.

The primary evidence for this approach is physical traces of CFPs. The traces are sought in the products of CFPs, refuse deposits. While conventional analyses use information from the *contents* of refuse deposits, this approach seeks other attributes of the deposits, such as location, size, shape, artifact density, number, and the like, for useful information. Thus, the three-dimensional configuration of these characteristics of refuse deposits at a site, hereafter called "refuse structure" for short, is the main target of this inquiry.

Two kinds of relationships need to be examined before behavioral inference can be drawn on the basis of refuse structure. The first is the relationship between refuse structure and refuse-management CFPs in order to identify particular CFPs based on certain characteristics in refuse structure. The second step of this inquiry is to explore under what behavioral conditions each CFP is executed. What constrains refuse-management CFPs seems mainly to be organizational characteristics of activities, such as variety, mobility, and duration. While the intensity of activities is undoubtedly a major factor affecting CFPs, intensity can be defined more specifically by these terms. The type of activities (site function) appears to be reflected more in artifact assemblages and features than in refuse structure.

With these two kinds of relationships, inferential steps can be taken from archaeologically observable traces of CFPs (refuse structure) to certain behavioral characteristics of past human activities. A discussion on how information from refuse structure may be used in behavioral inference is presented schematically at the end of this paper.

IDENTIFICATION OF CFPs

Primarily, there are two types of CFPs that form refuse deposits. The first type is responsible for primary deposition, such as discard; the second type of process alters the state of already deposited refuse, such as activity area maintenance. Processes of this second type can be called *secondary formation processes*, for they always operate after "primary" processes create refuse deposits. The importance of these secondary formation processes on refuse structure, however, is not "secondary." Rather, these processes are the major force that gives the final shape to a refuse structure. Without such processes, all sites would consist exclusively of primary refuse. Thus, the interaction between activities in an activity area and its maintenance is the key to understanding variability in refuse structure.

Relevant Processes

Primary Depositional Processes

Discard is the major process that creates initial variability in refuse deposits. Discard can take many different forms, including dropping, tossing, placing, and dumping [cf. Binford, 1983a (1978a), pp. 298–299]. Dropping is the simplest mode of refuse disposal, in which refuse is discarded as it is generated, where it is generated. Dropped items, usually small and unobtrusive, such as microartifacts, tend to remain at the primary location even after cleanup and to become residual primary refuse (Schiffer, 1987, p. 62). Under certain conditions, however, even large items, such as broken ceramic pots, are simply left at the location of breakage and, therefore, are "discarded" there. While such cases do not literally involve a "dropping" process, they can be considered comparable to dropping, as they remain at the primary location of refuse generation.

Tossing represents the most casual form of activity area maintenance, in which refuse is tossed away from the core of an activity area to the periphery. Therefore, a refuse deposit created by tossing would be classified as a secondary refuse deposit by a conventional definition because tossed refuse would be deposited outside the activity area. Dumping also removes refuse from an immediate activity area but involves more conscious planning than tossing. Tossing and dumping are distinguished here in the sense that tossing is the process whereby refuse is tossed away as soon as it is generated, while dumped refuse represents refuse that is initially stored somewhere in a primary location and then dumped after it is accumulated (cf. Binford, 1978a). Therefore, dumping is a secondary depositional process (see below).

Placing is a precondition of dumping, though intended dumping may never occur. Under conditions that preclude dropping and tossing, such as inside a formal structure, refuse may be placed in temporary storage with anticipation of future discard. Refuse could be stored in a container, such as a waste basket, or piled at a place where the activity level is low {see Binford [1983a (1978a), p. 302] for an example of placing}.

Provisional discard, described by Deal (1983; see also Deal, 1985; Hayden and Cannon, 1983), can be included in placing processes. Although placing principally implies discard at a primary location, such as "waste basket discard," provisional refuse could be placed at either a primary or a secondary location. Another difference between provisional discard and waste basket discard is that the former mainly implies that broken but still potentially usable items are stored for possible future use. However, these items can be soon forgotten or discarded later and might not be used in the future as intended (Deal, 1985, pp. 253–255). In such cases, provisional refuse is in the same state as placed refuse.

Secondary Formation Processes

Secondary cultural formation processes are defined here as those which alter the state of already-deposited refuse. They include dumping and diverse activity-area maintenance activities, such as cleaning, sweeping, and raking. These formation processes can completely alter the configuration, shape, size, and number of refuse deposits created by primary depositional processes and create their own patterns. Moreover, when these CFPs are repeatedly performed, patterns created by earlier processes are again obliterated by later processes. In addition to maintenance, other nonmaintenance activities, such as trampling, also alter the state of refuse deposits in the area. Such activities can further break down discarded artifacts into smaller pieces and displace them laterally and vertically (Kirkby and Kirkby, 1976; Wilk and Schiffer, 1979; Nielsen, 1991). Eventually, when these processes are combined, the result may be very complex patterns (Gould, 1980, pp. 197–199). Therefore, the mode and intensity of secondary formation processes appear to be the main determinants of the structure of archaeological refuse we see today (ignoring postoccupational processes).

CFPs and Refuse Deposits

Primary Refuse Deposits

Dropping forms simple primary refuse deposits. The distribution of such deposits, however, is limited, especially in sedentary communities (Schiffer, 1972), because dropped debris is usually cleaned up quickly. Isolated "pot breaks" often observed in desert areas may conform to the notion of simple primary refuse where no maintenance is performed after breakage. Roadside litter is probably next-closest to simple primary refuse. Wilk and Schiffer (1979) termed this type of refuse "in-transit refuse" based on observations of refuse patterns in vacant lots in Tucson, Arizona. Other primary refuse deposits along paths have been recorded archaeologically in southern Arizona in the Hohokam (e.g., Brown and Stone, 1982; Tani, 1991) and Patayan (e.g., Rogers, 1936, 1945, 1966) regions and ethnographically among Shipibo-Conibo (DeBoer and Lathrap, 1979, p. 129), Tzeltal Maya (Deal, 1983, p. 201, Table 26, 1985, Figs. 5 and 11), and Kalinga (Tani, 1994) communities.

Archaeological/ethnographic in-transit refuse deposits are characterized by a lack of material diversity, for they consist almost exclusively of pottery sherds. Since most sherds from broken pots would be left at the location of breakage, only a few vessels are represented by a large number of sherds (Tani, 1991). The elongated shape of a deposit is, of course, another strong indicator of in-transit refuse.

Another type of refuse deposit created by dropping is microrefuse deposits. The individual constituents of such deposits are not readily observable because of their small size. Nonetheless, primary deposits of microrefuse are common even in sedentary communities. Because these refuse materials are so small, typically less than 1 mm (cf. Fladmark, 1982, p. 205), they tend to remain at the location of dropping. Such refuse may include chipped stone and faunal and floral remains (Metcalfe and Heath, 1990; Rosen, 1986, 1989; Vance, 1987). Microrefuse overlaps into residual primary refuse (primarily deposited materials left on/in an activity surface after clean up). Such materials include microrefuse as well as larger but still relatively small and unobtrusive pieces, like small pottery sherds (Bradley and Fulford, 1980; Fischer, 1985; Henderson, 1987; Hally, 1983).

Tossing generates scattered deposits around an activity area. Tossing often occurs along with dropping at locations of short-term occupation. While small items are dropped, larger items tend to be tossed toward the periphery of an activity area. Binford (1978a) proposed a concentric pattern of refuse distribution by size-sorting (see also Stevenson, 1985). Consistent with size sorting, O'Connell (1987) recorded spatial dissociation between pull tabs and soft drink cans in an Alyawara camp site. At the Mask site (Binford, 1978a), larger articular ends of bones were located just outside its activity area. Larger discarded items were recorded in outliers in a Bedouin camp (Simms, 1988).

A refuse deposit formed by tossing is usually located around an activity area and consists of larger items, such as large fragments of bone, exhausted chipped stone cores, and cans. The concentration of artifacts in such a deposit as a whole is rarely very dense. It would be easier to identify a deposit created by tossing when it is in conjunction with a residual primary refuse deposit because the latter is a reliable marker of the activity area.

Placing, unlike dropping or tossing, concentrates refuse in a small area in the immediate activity area and generates a deposit that can be called clustered primary refuse. Since clustered primary refuse tends to be thrown into more permanent refuse deposits, archaeologically observed clustered primary refuse deposits may have been created shortly before site abandonment (Stevenson, 1982, 1985; Clark, 1991). Schiffer (1987, p. 98) termed such refuse "abandonment stage refuse." Clustered primary refuse, however, is also observed at limited activity sites, such as lithic quarries (Binford and O'Connell, 1984) and ceramic manufacturing sites (Ambler, 1987; Stark, 1984), and at short-term occupation sites (Binford, 1983b, Fig. 8; Stevenson, 1985, Figs. 6a and 8).

Secondary Refuse Deposits

Secondary refuse deposits are created by various forms of dumping and other activity area maintenance. Constant sweeping, raking, and other maintenance often create a distinctive midden of crescent, scallop, or doughnut shape along the edge of an activity area. Small-scale dumping at the edge of an activity area accelerates the formation of a doughnut-shaped midden. Such a midden area, often slightly elevated, contains dense and diversified artifacts, which commonly include pieces with wear from trampling and sweeping. This kind of midden is often observed in ethnographic contexts (DeBoer and Lathrap, 1979, p. 128; Deal, 1983, 1985; Hayden and Cannon, 1983; Meehan, 1982, Fig. 19) as well as in archaeological contexts (e.g., Archer, 1990; Wilcox, 1987, Fig. 3).

Refuse deposits formed by dumping may take all kinds of shapes and sizes. Clustering is sometimes very weak, as in broadcast refuse (Deal, 1983, p. 198), whereas in other cases is very tight, such as refuse in pits and privies. The size of discrete secondary refuse deposits varies from small "door dumps" (Binford, 1983b, p. 165) to enormous modern landfills.

Small-scale secondary refuse deposits are also present in sites of mobile groups; these tend to form very close to the activity areas where the refuse is generated. The Mask site occupants were once observed to dump temporarily stored refuse at the edge of the activity area (Binford, 1978a). These deposits are so close to the location of activities that they may be called "primary refuse." Another type of secondary refuse dumped adjacent to a primary activity area is a "door dump," small dumps of refuse generated in structures that form just outside of the entrance [Binford, 1983b, p. 165, 1989 (1987), p. 240; O'Connell *et al.*, 1991, p. 67]. Door dumps are also common among more sedentary people. For example, Pastron (1974) reported that broken ceramics were just tossed out through the front entrance of Tarahumara dwellings. The Tzeltal Maya often discard refuse generated in houses onto the backyard and the streets (Deal, 1983; Hayden and Cannon, 1983), where the refuse tends to be dispersed quickly by subsequent activities. What South (1977, pp. 47–82) calls "the Brunswick Pattern" is another example of door dumps among sedentary communities in British Colonial America. All door dumps share the characteristic of least effort in refuse disposal. This pattern is expected when refuse is unobtrusive, such as ceramic sherds and organic debris, and where the space is available for such disposal.

"Toft" refuse, described by Deal (1983, pp. 198–199), is an extension of door dumps and includes several kinds of refuse deposits, including discrete secondary refuse locations that are used for "final" discard when provisional refuse in and around houses becomes a nuisance (Hayden and

Cannon, 1983, p. 139). These locations are found usually where the activity level is lowest, such as along hedges and fences and under trees. The accumulation of secondary refuse under trees is also observed in Shipibo-Conibo villages (DeBoer and Lathrap, 1979).

BEHAVIORAL DETERMINANTS OF CFPs

CFPs related to refuse deposit formation can generally be arranged along the axis of intensity of activity area maintenance, from dropping to modern waste management systems. Waste management CFPs are performed to keep an activity area usable without being hindered by activity byproducts.

Schiffer (1976, p. 31) offered a proposition about the relationship between site occupation and refuse formation: "The larger the population of an activity area, and the greater the intensity of occupation, the larger the ratio of secondary to primary refuse produced." Binford (1983b, p. 190) provides a more lengthy proposition about this issue:

> . . .The care with which an area is maintained is related to the intensity of its use, other things being equal. Areas used intensively are maintained the most thoroughly and will therefore be associated with specialized disposal areas. The degree to which this is true, however, is also a direct function of the length of time that intensive use lasts—maintenance of areas used intensively only for short periods is minimal. This means we can expect a strong set of relationships in such areas between duration of occupation and the investment of effort in maintenance.

Both propositions identify the intensity of occupation as the principal factor affecting the intensity of activity area maintenance. As additional factors, Schiffer cited population size and Binford mentioned the duration of activity.

Hayden and Cannon (1983, p. 119) broke down the determinants of activity area maintenance and identified three principal factors—hindrance, effort, and value—affecting "how refuse will be sorted and where it will be dumped." Among the three potential factors suggested by Hayden and Cannon, hindrance potential is probably the most important determinant of how and where refuse goes. This is because no matter what the value of the refuse and no matter how much refuse disposal would cost, if the hindrance of the refuse is intolerable, the refuse must be managed in one way or another. Therefore, the intensity and kind of solid waste management (i.e., CFPs) depend largely on the net hindrance of refuse, and an understanding of what determines net hindrance leads to a recognition of the behavioral conditions triggering particular refuse management CFPs.

The net hindrance of refuse obviously has two components: what does the hindering (refuse) and what is hindered (human activities). In addition, physical settings, such as the size of an activity area (Arnold, 1990), the type of substrate (Gifford, 1978), and inside/outside the structure in which refuse is generated, also affect hindrance. These components interact to constitute the net hindrance of refuse. In general, more refuse is more hindering, and the same refuse is more hindering if more activities are carried out around it. The activity component obviously takes precedence in determining the net hindrance of refuse because refuse cannot be hindering if no activity is carried out around it (although this may not be the case with modern toxic wastes). A CFP (or a series of CFPs) is chosen as a waste management strategy in order to reduce the net hindrance of the refuse to a tolerable level as well as to minimize entailed efforts.

Refuse Component

In general, the greater the amount of refuse, the more the hindrance. In Schiffer's proposition cited above, "the population of an activity area" appears to refer to the amount of refuse generation. Thus, he suggested that more refuse leads to more intensive efforts to manage that waste, which is expressed in "the ratio of secondary to primary refuse" (see also Murray, 1980). Kent (1984, pp. 172–173) claimed that the introduction of bulky waste from commercial products among the modern Navajo has caused more intensive refuse management. Simms (1988, p. 206) also found that modern bulky packaging affected waste-management practices among the Bedouin. However, the simple volume of refuse is not the only factor affecting hindrance. Refuse may be sorted and deposited in different locations on the basis of size. In particular, larger items are more hindering and, thus, are more intensively managed (McKellar, 1983). The "size threshold" for refuse pieces that can be dropped depends on the intensity of human activities (Schiffer, 1976, p. 189) and the type of surfaces. For example, a sand floor can absorb larger items without hindering further activities than a plastered floor (Gifford, 1978). Microrefuse (pieces smaller than 1 mm) is commonly nonhindering, at least in small quantities, and tends to become simple primary refuse.

Differences in the materials discarded cause differential treatment of refuse (cf. Hayden and Cannon, 1983). Useless and low-hazard refuse tends to be most casually managed. Small-sized organic and inorganic debris, such as kitchen waste and ceramic sherds, are often tossed into streets in Highland Maya communities (Hayden and Cannon, 1983; Deal, 1983, 1985). Unobtrusive refuse, such as ash and daily sweepings, was discarded over the compound walls into the streets in the village of Darnaj, Syria (Kamp, 1991). On the other hand, refuse with some value or hazardous waste often receives special care. Valuable refuse, what Hayden and Cannon (1983, p. 131) call "clutter" refuse, usually becomes provisional refuse and is intended for future use or reuse. Hazardous refuse is disposed of in yet another way to ensure that such waste will not hinder future activities. Radioactive and biohazardous wastes in our communities are discarded with special care and at great cost. In nonindustrial societies, sharp objects, such as lithic and glass debitage, receive special treatment. Not only is such waste carefully contained as it is generated, but also it is disposed of in special locations, such as ravines, pits, and remote locations (Clark, 1991; Clark and Kurashina, 1981; Deal and Hayden, 1987; Gallagher, 1977).

Activity Component

In order to analyze how site activities affect the decisions of refuse management, it is useful to employ the concept of activity organization. Binford [1989 (1987), p. 259] defines organization as follows:

> Organization is not just behavior. It is the manner in which behaviors are juxtapositioned and integrated with one another, and these generalizations cannot be seen simply by the identification of discrete behaviors themselves, not by inventorying the different ones present at different sites.

In this sense, even the same type of activities would generate different refuse structures when they are organized differently. Thus, it is useful to break down the organization of activity into basic elements, such as variety, mobility, and duration. *Variety* refers to the range of activities performed in an activity area in a given time. *Mobility* of an activity measures the ease of relocating the activity elsewhere; for example, an activity that requires nonportable artifacts, such as facilities and structures, would be less mobile than another activity that uses only portable artifacts. Finally, *duration* is the length of time that an activity area is used, or the length of an occupational episode.

The *intensity* of activity-area use in a given time period can be defined by the three elements listed above; when there is more variety, less mobility, and a longer activity duration, there will be a higher intensity of activity-area use if the population size remains constant. In this sense, the same refuse in a more intensively used activity area is more hindering and is likely to be managed more intensively. These three elements are potentially inferable from refuse structure because they are closely related to waste management CFPs. It is important to note here that all the factors affecting differential site maintenance are ***anticipated*** entities, rather than retrospectively determined ones. Thus, the duration that matters is not an occupation span at a site "etically" measured after its abandonment but an occupation span "emically" anticipated during the occupation, i.e., planning depth (*sensu* Binford, 1987; see also Kent, 1991).

When planning depth is shallow, the area subjected to maintenance is confined to the immediate area of current use. At a limited activity site, such as a hunting stand, the anticipated occupation of the site is short, and a regularly maintained area is usually very small, which may simply be a sitting area around a hearth. This principle can also be applied to the formation of abandonment-stage refuse because anticipated occupation during planned abandonment is short (cf. Stevenson, 1982). On the other hand, the habitation site of a sedentary group usually has an indefinite planning depth. Thus, maintenance activities at such a location tend to be thorough, often with specialized dumping areas in order to support the conduct of various potential activities over a long time despite the substantial amount of refuse that might be generated in that span (cf. Schiffer, 1987, p. 65). Moreover, because of a greater number and variety of anticipated activities, maintenance usually covers the general activity area, such as an entire village (DeBoer and Lathrap, 1979, p. 129).

While the variety of activities and planning depth closely covary in a generalized activity area, such as a habitation site, this is not the case in a specialized activity area. If the activities performed at a limited activity location are highly redundant, planning depth has little effect on maintenance. Trailside refuse provides a good example. Whereas an established trail has an indefinite planning depth, the range of anticipated activities on the trail is very limited, i.e., transit. Although other trailside activities probably occur, in general the only area that must be maintained is a narrow path. The mobility of the activity area is low because an established path would be more comfortable to walk on. Trailside refuse does not have to be maintained because it can be anticipated that the refuse would not hinder the principal activity on the trail. For the same reason, manufacturing loci for ceramic or other craft items tend to accumulate more refuse in work areas than generalized activity loci. It is easier to predict where and what future activities would occur because such activities at specialized locations are highly redundant (cf. Ambler, 1987; Stark, 1984).

Lithic quarries provide an example in which the mobility of an activity plays an important role in refuse formation. Despite the high hindrance value of lithic debris, refuse at these sites is often unmanaged (Binford and O'Connell, 1984). Unless the distribution of source materials is very limited, the procurement/preliminary processing activities can be mobile.

Thus, refuse from previous quarrying episodes will not be very hindering to future activities. In other words, moving the activities is more economical than moving the refuse in this case. The mobility factor appears to be important in the comparison between semimobile and sedentary households. O'Connell (1987, pp. 87–88) recorded the high mobility of shelters for households *within* a settlement among the Alyawara. Thus, this is not mobility associated with subsistence activities. In this community, the major components of maintenance are size sorting, raking and picking up debris, and small-scale dumping at the periphery of activity areas (O'Connell, 1987; Binford, 1986). The accumulation of refuse is one reason for a household to relocate, but the relocation may be only 10–20 m away. Bartram *et al.* (1991, p. 98) report another instance of household relocation within a Kua San camp in Botswana when secondary refuse accumulations around household areas became intolerable. Either Alyawara or Kua San could employ more intensive maintenance strategies as do other sedentary communities, such as carting refuse to a designated area located away from the immediate activity areas, but since the investment in shelters is low, the latter can be moved more easily than refuse. This implies that separate locations for dumping secondary refuse are most likely to arise in communities that make a substantial investment in immovable features and structures.

DISCUSSION: BEYOND THE IDENTIFICATION OF CFPs

The previous sections of this paper have identified three major components in this inquiry: refuse structure, waste-management CFPs, and behavioral characteristics affecting such CFPs. The target of this inquiry is to infer such behavioral characteristics through physical traces left by CFPs in refuse structure.

There are two major uses of information from refuse structure through CFPs in behavioral inference. The first is to supplement conventional information from artifact assemblage characteristics for inferring site activities or site functions. The second is to use information from refuse structure for inferring behavioral aspects to which conventional information sources are not very sensitive. Such aspects may include the location of activities, the duration of an occupational episode, and the number of occupational episodes in the entire duration of settlement use; all of these behavioral aspects can be collectively called occupational variability (Sullivan, 1980).

Inference of Site Functions

Inference of site functions/activity types from refuse structure is generally less specific than from more conventional information sources, such as features and artifact assemblages. CFPs seem to be sensitive not to the kind of activities carried out, but to how such activities are organized. In other words, information left by CFPs is more suited for inferring occupational variability because occupational variability is closely related to the organization of activities. It is conceivable that the same type of activities may be organized differently and thus result in different refuse structures. Nonetheless, it is likely that the functional characteristics of an activity interdigitate to a certain degree with its organizational characteristics and both are manifest in refuse structure [Binford, 1989 (1987), p. 257, n. 14]. Thus, information from refuse structure can be useful for inferring the type of site activities when the organization of the activities is distinct from that of other types of activities.

The author, for example, examined artifact scatters left by the Hohokam in southern Arizona in order to infer primary activities at those locations. These sites all invariably consist of plainware ceramics, expediently chipped stone, and usually no features. Among numerous sites of that kind, a series of scatter sites on a ridge was considered to be the remnant of a prehistoric trail although there is no visible trace of the trail, on the ground (Tani, 1991). These sites contain several dense spots of artifacts along the ridge. The density is high enough to appear as if they are small-scale secondary refuse deposits. Careful analyses of the sherds by refitting and vessel identification (through tempering materials and surface finish techniques) determined that the scatters consist predominantly of primary refuse generated by dropping, rather than secondary refuse formed by dumping. This conclusion on refuse structure and CFPs furnished a strong line of evidence for arguing that the sites are remnants of a prehistoric trail rather than plant collection and processing sites as had been suggested previously.

Inference of Occupational Variability

Although nonassemblage characteristics furnish only weak evidence for inferring specific activities and site functions, such characteristics can comprise a strong line of evidence for inferring occupational variability. Since assemblage characteristics are not very sensitive to occupational variability, the investigation of refuse structure is promising in this area of archaeological research.

The Location of Activities

The most direct evidence that refuse structure contains is about the location of activities, an aspect of human behavior that has been extensively explored by activity area research (e.g., Kent, 1987; Binford, 1983b, Chap. 7). Since activity areas are almost always maintained in one way or another, locations free of visible artifacts are more likely to be activity areas than those with artifacts. At the same time, the presence of microartifacts is a strong line of evidence for actual activity locations (Metcalfe and Heath, 1990; Rosen, 1986; Hull, 1987).

Microartifacts, however, do not invariably indicate primary refuse and the location of activities. Microartifacts can exist in secondary refuse deposits by way of batch dumping (Simms and Heath, 1990, p. 805). Such a case can be distinguished from a primary microrefuse deposit formed by dropping on the basis of the distribution of artifacts in the deposit and the association of larger artifacts. Suppose that microdebitage were first deposited in a hearth and then later redeposited in a secondary refuse area along with the scooped-out contents of the hearth. The microdebitage should have a clustered distribution in the secondary refuse because such artifacts were scooped out and dumped all at once, and they should coexist with larger artifacts in the secondary refuse deposit. On the other hand, microdebitage as primary refuse deposited in the process of manufacturing or retouching a chipped stone artifact should have a wider distribution in the activity area. Moreover, the zone of the primary microdebitage deposit should be free of large visible debris because it was part of an activity area.

The issue of abandonment-stage refuse needs to be considered when evaluating the association between microrefuse and macrorefuse. During a planned abandonment, the standard of maintenance is more likely to be relaxed and primary refuse, which is usually managed, tends to be left in a normally maintained area. This problem may be resolved by examining the distribution of macrorefuse because primary *macro*refuse in a maintained activity area tends to be clustered—even in an abandonment stage—and so should be distinguishable from macrorefuse in a secondary refuse deposit.

A refuse structure formed by reoccupations may pose more serious problems in determining an activity locus from microrefuse (Hull, 1987). Suppose that one occupational episode generated a bona fide primary microrefuse deposit in a maintained activity locus, but a subsequent occupation at the same site established another activity locus and turned the original activity locus into an area of secondary refuse deposition. Thus, the primary and secondary refuse deposits are both real. In principle, it is possible to untangle a multicomponent refuse structure of this kind by examining microartifact samples in three dimensions, but such an analysis is probably very time-consuming (Simms and Heath, 1990).

Occupation Span

The planning depth of an occupational episode appears to be a major factor correlated with the intensity of activity-area maintenance. Therefore, after controlling for other factors affecting maintenance, such as population size and type of activities, the investigation can employ intensity of maintenance as an indicator of occupation span. Inferred occupation span would be only quasi-quantitative, such as "ephemeral" (days), "seasonal" (weeks–months), and permanent (year round).

The intensity of maintenance reflects mainly the size of the maintained area and refuse deposits. Generally, the shorter the planning depth, the smaller the maintained area, other things being equal (O'Connell, 1987, p. 100; Simms and Heath, 1990, pp. 806–807; Kent, 1991, Table 1). Kent (1991, p. 49) reported that "anticipated mobility [planning depth] is the single most consistent variable found responsible for variation between areas . . ." among Basarwa and Bakgalagadi camps in Botswana. This is probably because as the planning depth deepens, the range of anticipated activities tends to become wider, and therefore, it is necessary to keep a larger space usable for potential future activities. The size of area needed to be maintained is also related to refuse deposits to be formed.

Where a short stay is anticipated, just a small area needs to be kept trashless. At that site, only primary depositional processes, such as placing and tossing, are required to maintain a small area. A "dinnertime camp" of the Gidjingali in the Northern Territory, Australia, is usually occupied for a few hours at a time (Meehan, 1982), where people consume mostly shellfish. At these camps no evidence of maintenance is visible in refuse structure except for placing shells in peripheral piles (Meehan, 1982, Figs. 17 and 18). At an Eskimos hunting stand where people rarely stay overnight (Binford, 1978a), placing and tossing are, again, the major CFPs employed, which created a pattern of refuse distribution similar to that of the Gidjingali: a relatively refuse-free area around hearths for sitting, surrounded by zones of scattered refuse. Refuse deposits at !Kung Bushman camps, which are typically occupied for a few days, seem to be formed only by dropping and tossing (Yellen, 1977); however, Yellen testified that the Bushman used more intensive site maintenance techniques with longer occupations (O'Connell, 1987, p. 100). The main characteristics of sites with short occupations, therefore, include clustered primary refuse deposits within an area surrounded by scattered refuse of larger pieces.

When the occupation span lengthens from "weeks" to "months," activity areas are more consciously maintained by cleaning at a regular interval. Therefore, dropped and placed primary refuse in an activity area tends to be removed and dumped somewhere else. These cleanup activities not only remove most (i.e., large) refuse from an activity area but, at the same time, create a larger contiguous cleaned area for future activities. The Alyawara in central Australia live in semipermanent settlements, each of which holds a population of about 100. While a settlement as a whole is usually occupied for at least a few months to even more than a year, households constantly move their camps within the settlement every 50 + days on the average (O'Connell, 1987). Residents at Alyawara camps regularly clean up household activity areas, and refuse is either swept to or gathered and dumped along the periphery of the activity areas. However, there is no communal secondary refuse dump separately located away from immediate household areas.

Fisher and Strickland (1989) recorded Efe Pygmy camps in the Ituri Forest, Zaire. The Efe, a hunter-gatherer group, construct their campsites in the tropical rain forest by clearing vegetation. Each campsite consists of huts and inside and outside hearths, and the average duration of an occupation is about 6 weeks (Fisher and Strickland, 1989, p. 477). The central open area with hearths surrounded by huts is the activity area of the camp, which is maintained regularly. All refuse goes to refuse heaps along the perimeter of the camp, but there is no designated location for secondary refuse disposal outside the camp.

Home bases of the Gidjingali are generally occupied for a few months, depending on the availability of water, shellfish, and other resources (Meehan, 1982). Each household at a home base occupies a "hearth complex"—an area with several hearths and huts. The activity area is cleaned up with rakes, sticks, or feet every week or two (Meehan, 1982, p. 114), and the refuse is dumped along the periphery of the hearth complex. There is no communal dump associated with a home base. Therefore, dumping continues as long as the camp is occupied and the refuse eventually forms large banks. When the refuse heaps become a nuisance, such as having a lot of grass and attracting many flies, they are occasionally burned. But, in contrast to the Alyawara, the Gindjingali are not reported by Meehan to move hearth complexes within a settlement to solve refuse problems.

Based on these ethnographic examples, one can suspect that a seasonal occupation would leave a refuse structure in which cleared areas are surrounded by middens formed mainly by dumping as well as tossing. Dumping is likely to aggregate wastes and create denser middens than tossing. These cleared areas should be much more than the sitting areas maintained at the short-term sites above, but remain at a size level that is probably appropriate for a single, extended-family household. These "cleared" areas are by no means refuse free. As a matter of fact, the density of artifacts—mostly small-size refuse—at an Alyawara camp is the highest at the center of an activity area [O'Connell, 1987, Fig. 11; see Arnold (1990, pp. 920–926) for the same pattern in houselots in Mexico]. Cleaning only removes larger pieces; small and unobtrusive items either are left in the activity area or simply escape cleaning.

A potential problem using the absence of clustered primary refuse to distinguish occupations lasting at least a few weeks from those of a shorter duration is abandonment refuse (Stevenson, 1982, 1985; Schiffer, 1987). This is very important for any archaeological inference based on site structure because it is likely that activities in an abandonment phase would leave behind more archaeologically visible refuse deposits. Since the maintenance standards would be relaxed in an abandonment phase, the inhabitants of a long-term site may even tolerate the accumulation in activity areas of some clustered primary refuse during that time. In fact, several ethnographic cases record refuse left in places usually kept free of debris (Clark, 1991, p. 73; Fisher and Strickland, 1990, p. 478). The question then becomes whether abandonment activities are significant enough to alter the entire refuse structure. The answer, of course, depends on how long an abandonment phase lasts and how certain the planned move is. While the abandonment itself could add a significant amount of de facto refuse, regular discard during an abandonment phase should comprise a small fraction of all discarded materials when the overall occupation span is long. On the other hand, at a short-term occupation site, the abandonment phase could contribute a significant portion of refuse to the sites refuse deposits. But since the planning depth of this site should be short in the first place, the entire occupation can be considered as an abandonment phase. Thus, abandonment behavior should not significantly alter the characteristics of refuse structure at the site. In the case of an unplanned, abrupt abandonment, refuse structure should not be affected because the planning depth remains unchanged until abandonment.

Another characteristic of the refuse structure of these seasonal occupations is the lack of communal secondary refuse deposits outside the immediate area of activities, such as communal dumps (refuse heaps along the peripheral of an Efe Pygmy campsite may be called communal secondary refuse deposits, but the location of the heaps is within an immediate activity area). Only settlements with indefinite planning depth seem to be associated with community dumps (e.g., Hayden and Cannon, 1983). Even in such long-term settlements most refuse is disposed in and around each houselot, such as gardens and streets, rather than in communal dumps (Kamp, 1991; Arnold, 1990; DeBoer and Lathrap, 1979). One implication of this finding is that while the absence of trash mounds (a kind of prehistoric communal dump) does not necessarily mean the absence of year-round occupation, the presence of trash mounds is likely to indicate year-round occupation.

Occupational Episodes

Refuse structure is especially useful for inferring occupational episodes. When inferring the pattern of occupational episodes during a sites entire occupation span, one can ask, Was the site formed by one continuous occupational episode or by a series of intermittent occupations? If the occupation consisted of several shorter episodes, what was the nature of those occupations? It is difficult to obtain such information from a conventional analysis of artifact assemblages because, for example, the total quantity of refuse generated by one continuous occupational episode is probably comparable to that of several intermittent occupational episodes—assuming similarity in total occupation spans and in population sizes. Refuse structure and waste-management CFPs are sensitive to the planning depth of each occupational episode at a site, not to the entire site occupation. Therefore, the difference between intermittent occupational episodes and one long continuous occupational episode should be reflected in the refuse structure. Intermittent occupational episodes, for example, would leave more scattered and smaller refuse deposits located immediately around smaller cleared areas, whereas one long occupation would leave larger activity areas with larger but fewer refuse deposits (cf. Hitchcock, 1987). It is likely that other questions on occupational episodes can be also addressed by careful analyses of refuse structure through CFPs [see Simms and Heath (1990) for an example].

CONCLUSION

Refuse is an inevitable by-product of human activities. In order to sustain human activities, refuse has to be managed in one way or another. Although there are differences in notions of cleanliness, the bottom line is that refuse accumulations that significantly hinder further human activities cannot be tolerated. This paper argues, therefore, that material traces of waste-management CFPs are contained in refuse structure, and by examining refuse deposits one can learn diverse characteristics of past human activities because refuse-management strategies, or CFPs, were chosen to meet conditions prescribed by the organization of activities. While CFPs and any other formation processes in general are destructive in terms of breaking associations between artifacts and locations that once existed in systemic context, CFPs leave another kind of information that artifact assemblages cannot furnish.

Refuse structures provide a different type of information from that available in more conventional sources in archaeology. In order to use information from refuse structure, two things need to be done. The first is to investigate further the relationships between activity organization and refuse disposal in systemic context. Recent ethnoarchaeological studies on site structure almost always include refuse disposal and refuse deposits (Meehan, 1982; Hayden and Cannon, 1983; Simms, 1990; Fisher and Strickland, 1988; O'Connell, 1987; Binford and O'Connell, 1984; Clark, 1991; several studies presented in Kroll and Price, 1991). But they are limited mostly to domestic contexts; information on site structure in nondomestic contexts is not abundant [Binford (1977, 1978a, b) are notable exceptions]. And information on refuse disposal in conjunction with activities carried out by more sedentary groups outside their home base is almost nonexistent.

The second issue concerns archaeological fieldwork. Data collection in fieldwork has to be refocused in order to obtain and record relevant information on refuse structure. Although there are exceptions (e.g., Simms and Heath, 1990; Hull, 1987), archaeological fieldwork, especially excavation, tends to center around structures/features, and materials in refuse deposits are often recorded simply as "bulk" artifacts. In order to examine refuse structure, excavation units have to be systematic, arbitrary, and of equal size so that one can examine refuse distribution without reference to predetermined features, measure the artifact densities across the site, and determine the size and location of refuse deposits. Clearly, the main information on refuse structure lies between structures and features. This is analogous to a nonsite archaeology approach to regional survey in which no a priori significance is placed on any phenomenon.

This kind of data collection, admittedly, may be time-consuming and cost more than conventional approaches. The potential to obtain crucial information, however, may outweigh its costs.

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