Chapter 2
The Dimensions of Artifact Variability

Evidence of the cultural past comes to us, not as societies frozen in time, but as artifacts and ecofacts that have been transformed. Unfortunately, the transformations occurring at one settlement or site may be different from those taking place nearby. Even in one locality, formation processes can vary through time, often dramatically. Although archaeologists are accustomed to appreciating the nearly infinite variability in artifacts, variability in formation processes and their combined effects has not been as intensively studied. One first needs a general framework for describing variability—the differences and similarities among materials found in archaeological context—and for assessing the transformational effects of formation processes on artifacts and deposits. Also needed is an appreciation for the causes and consequences of variability in formation processes.

Traces and the Life History of Artifacts

The distinction between systemic and archaeological contexts calls attention to the two basic states that objects occupy at different times in their life history. The concept of artifact life history is a potent organizing principle for discussing how the traces of formation processes come to be "mapped onto" artifacts (see Sullivan 1978). Although every artifact has a life history that is unique in some respects, certain recurrent activities and processes cross-cut all life histories and make it possible to generalize about stages in systemic context (Schiffer 1972). The following discussion is based on a simple flow model that represents the basic stages in the life history of durable elements (see Schiffer 1976a:46–48 and Rathje and Schiffer 1982:84–89 for discussions of artifact flow models).
All artifacts begin as materials procured from the natural environment. Environmental materials are usually modified by additive processes (i.e., mixing of clay and temper for pottery) or reduction processes (chipping of flint to produce tools) or a combination of both in the manufacture stage. During use, artifacts participate in activities that may have utilitarian and symbolic functions (Rathje and Schiffer 1982:65–67). It is convenient to recognize three types of major artifact functions: (1) techno-function, which includes “extracting, processing, and storing resources, maintaining technology, and fulfilling the biological needs of people;” (2) socio-function, which “symbolically influence[s] social interactions,” and (3) ideo-function, which symbolizes ideology and conveys other information (Rathje and Schiffer 1982:65). Most artifacts, it should be emphasized, perform more than one major function. After use, artifacts may be reused or deposited. In the latter case artifacts enter archaeological context, where they interact with the natural environment and, at various times, can reenter systemic context.

Activities occurring during each stage usually leave traces—specific modifications—on the artifact. Sullivan (1978) has presented a model of archaeological inference that stresses the relationship between stages, such as manufacture or use, and the traces that are “mapped onto” artifacts by those activities. By the time an artifact’s life history intersects that of an archaeologist in the field and laboratory, the accumulated traces may represent a host of activities and processes. From the standpoint of archaeological inference, the problem is that of “partitioning” the traces according to the specific activities and processes responsible for them (Sullivan 1978:208–210). Partitioning of traces is made possible by a host of archaeological principles, including those pertaining to the formation processes of the archaeological record.

In practice archaeologists have tended to short-circuit the process of inference by simply selecting traces thought to represent the behaviors of interest (using correlates alone) while failing to rule out other possible causes of those traces. A biface of chipped stone serves as a convenient example of the basic problem of partitioning traces. Experimental work and archaeological experience have shown that microflakes can be “mapped onto” the edges of a biface during many activities and processes in its life history. During manufacture the knapper may roughen the edge with an abrader in order to create platforms for detaching retouch flakes, thereby producing microflakes. The process of use can contribute microflakes, as the tool’s edge comes into contact with resistant materials such as hide or bone. Artifacts may be trampled after use by people or beasts, which removes small flakes from the tool’s edge. Some soil-mixing processes and fluvial transport result in microflaking. Microflaking can also be produced by archaeological recovery and careless handling in the
laboratory or museum. Given the many different processes that create microflakes, an archaeologist would not be justified in asserting that all microflakes indicate use. Instead, the investigator must attempt to partition the traces by using other lines of evidence—type of microflake, for example, as well as their frequency and patterns of occurrence on the tool (Keeley 1980). Even after careful examination of these additional traces, uncertainties may remain, preventing the archaeologist from asserting unequivocally that the observed microflakes were caused by use. Nevertheless, the archaeologist has made progress by asking how specific traces were formed. The answers may not be definitive, but once raised the question reduces the likelihood of arriving at grossly incorrect inferences.

In ordinary usage, trace tends to be understood, narrowly, as a physical modification to an artifact. Sullivan (1978:194) defines trace more broadly "as an alteration in the physical properties of an object (or the relations between objects) or a surface (or the relations between surfaces)." Trace in this sense refers to any perceptible consequence of an activity or process. Building on this expansive conception one can recognize overarching categories of traces, corresponding to what Rathje and Schiffer (1982:64-65) label as the "four dimensions of variability" in artifacts. These dimensions are formal, spatial, quantitative, and relational.

The dimensions of variability, which are discussed below in more detail, provide a convenient vehicle for illustrating the diverse traces that formation processes "map onto" cultural materials. In addition, this framework calls attention to the persistent ambiguities that have resulted from archaeologists' failure to keep conceptually and operationally distinct the various contexts of cultural remains in which traces are produced (see Reid 1973, 1985).

**Formal Dimension**

The formal dimension pertains to the measurable physico-chemical properties of an artifact, such as shape, size, weight, color, hardness, and chemical composition. Each property in turn may be measured or described in terms of much more specific attributes or variables. For instance, color can be precisely described by three distinct variables: hue, tone, and intensity, each of which has appropriate scales and techniques for measurement.

Variability in the formal dimension is the basis of all artifact typologies. Regrettably, many terms that archaeologists apply to formal properties indiscriminately meld the systemic and archaeological contexts of artifacts, contributing to terminological, procedural, and even theoretical confusion. For example, in descriptive reports artifacts are often casually assigned techno-functional labels, such as "projectile point" or "scraper," despite the lack of analyses (such as use-wear) needed for establishing
the manner of artifact use. Moreover, many artifacts, including “projectile points,” have multiple functions and are reused; simplistic functional labels draw attention away from such interesting behavioral variability and so should be avoided (Schiffer 1976a). By employing terms that mix observations and inferences, archaeologists perpetuate sloppy thinking and, worse, continue to ignore formal variability caused by formation processes. In short, archaeologists must use terms that sharply distinguish between phenomena of the systemic and archaeological contexts (Reid 1973, 1985; Reid and Shimada 1982; Schiffer 1973).

The formal dimension of artifacts can be transformed by a host of formation processes. For example, recycling alters the metric attributes of lithic tools (see Grimes and Grimes 1985; Hoffman 1985). In addition, ceramics and glass sherds when trampled are reduced in size and abraded. In our own society, trash compactors break and crush objects. On the surface of the ground, bone artifacts exposed to sunlight will weather, becoming cracked and splintered (Fig. 7.11). Corrosion (rusting) of iron may, in a matter of decades, transform a handsome tool into a reddish-brown stain in the ground (Fig. 2.1).

Other changes in the formal dimension come about when substances are added to artifacts. For example, fluorine taken up from the depositional environment is incorporated into the mineral structure of bone. In alkaline environments, tenacious compounds such as calcium carbonate accumulate on an artifact’s surface.

Sometimes formal changes take place over long spans of time and can be observed only with the aid of instruments. For example, a freshly
fractured surface of an obsidian artifact adsorbs water from its surroundings, forming a thin hydration rind that can be observed when a section is viewed under the microscope.

The effects of formation processes on the formal dimension of artifacts are varied and pervasive. The possibility that any item or deposit survived to the present without undergoing some formal changes is indeed slight. Most in fact underwent many alterations, simultaneously and sequentially. If we do not discern such changes, it is probably because we have not looked hard enough or used appropriate instruments.

**Spatial Dimension**

The spatial dimension refers to the location of an artifact. In the field, artifact locations are recorded with reference to grid systems, but locations can also be described in terms of behaviorally significant divisions of space, such as activity areas and the domains of various social units (e.g., households, task groups, and even regional systems).

Archaeologists have devised a host of concepts that describe spatial location in archaeological context. One of the most useful of these is *provenience*, the archaeological find-spot of an artifact. Provenience allows documentation of where an artifact was at rest immediately prior to its discovery and (perhaps) removal by the archaeologist—its last place of repose before reentering systemic context.

Although provenience is a precise concept that applies to a specific moment in an artifact's life history, other spatial concepts are more ambiguous and, as a result, less useful. The most problematic of such concepts, which sees wide service in the writings of archaeologists, is *in situ*. By dictionary definition, the term denotes an artifact in its "natural or original position." For an artifact recovered archaeologically, however, does "original" position refer to its (1) location of manufacture? (2) location of use? (3) first place of cultural deposition? (4) last place of cultural deposition? or (5) location after first environmental disturbance? Unfortunately, *in situ* is used indiscriminately and refers in different monographs to all these "original" positions (and others). Because cultural and environmental processes move artifacts during their life history—in both systemic and archaeological contexts—no one location is more "original" than any other. The term, therefore, is without a precise referent and its use should be discontinued. A less drastic solution is to use *in situ* exclusively for the find-spot of an artifact—its original position of discovery, which is more consistent with usage in geology and paleontology.

It is becoming clear that a specialized vocabulary should be developed for describing the location of artifacts with respect to various segments of their life history. In some instances, of course, we can muddle along with available terms, such as *place of use*. For most other locations, however,
neither extant concepts nor terminology will suffice; new bits of jargon must be devised if we are to communicate efficiently. For example, with respect to certain cultural formation processes it has been helpful to define several refuse types according to artifact life history and space (see Chapter 4). For example, artifacts discarded at their locations of use form primary refuse; if discarded elsewhere they are secondary refuse. Because this process of transport and deposition can be repeated many times, it is obvious that a great many possibilities are not covered by these refuse types (Sullivan 1976, 1978).

There is literally no end to the variety of cultural and environmental processes that alter the spatial dimension of artifacts. Some, like secondary refuse disposal, have marked effects; not only are artifacts moved, but they can be concentrated into a finite, sometimes small, number of locations. Although some environmental processes have catastrophic effects, for example, the river that changes course and removes much of a site, most work more slowly, displacing artifacts a little at a time. Burrowing animals like earthworms and gophers are pesky creatures that gradually create turmoil in the spatial dimension (Wood and Johnson 1978). Decay of organic matter in trash mounds contributes to settling and slumping. Many cultural formation processes, from trampling to children playing in trash, are also slow-acting: undramatic in the short run, they are capable of inflicting substantial cumulative effects.

When the spatial effects of formation processes are discussed, archaeologists are apt to refer almost exclusively to the disturbance of patterning. But formation processes can also create new patterns. Sweeping up and refuse disposal, for example, establish areas of differential artifact density. Trampling and other disturbance processes can form a “fringe area,” adjacent to walls, containing clustered artifact distributions (Wilk and Schiffer 1979). Other “artifact traps” form in abandoned storage or borrow pits, or even low spots, leading to accumulations and patterned gradients in artifact density. The archaeologist should not lose sight of the considerable potential of formation processes to create as well as to alter spatial patterns.

**Frequency Dimension**

The frequency dimension refers to the number of occurrences of a particular type of artifact. One might expect frequency or quantity to be a clearcut variable, one readily measured in archaeological context. For the most part this is true; but there are important exceptions—for instance, pottery. In archaeological context, one finds mostly sherds, only rarely whole pots. There is something inherently unsatisfying about counting sherds, for they have no obvious or direct equivalence to any phenomenon in systemic context. Noting this discrepancy, a number of archaeologists have expended much effort in developing new techniques
for quantifying pottery, almost always with less than satisfactory results. Weights, maximum and minimum numbers of vessels (MNV), whole vessel equivalents, and others have been proposed (e.g., Orton 1980, 1982; Chase 1985). Usually those discussions proceed as if archaeologists were searching for one way—the best way—to count pottery. It has become evident, however, that each method furnishes evidence relevant to a different set of research problems. Thus, like all descriptions of the archaeological record, they must have a purpose. In Chapter 10 the methods of quantifying pottery most appropriate for identifying formation processes are set forth.

Many formation processes affect the frequency dimension of artifacts. For example, we can imagine a community that makes use of a particular type of artifact. These items wear out and are discarded at an average rate of 100 per year. This rate is influenced by many independently varying factors, such as the number in use in the community and the uselife of the object (see Chapter 4); the latter is determined by the formal properties of the object and by the conditions of use. Any change in conditions of use will affect uselife and thus the discard rate. Reuse processes of various kinds also affect discard rate. For example, potsherds are frequently crushed and used as temper in new pottery, thereby reducing the quantity of sherds that enters archaeological context. The spatial effects of cultural formation processes also lead to frequency variability. For example, the sherds of a single vessel may wind up in several secondary refuse areas, each subjected to varying amounts of handling and further breakage.

Decay and weathering processes, of course, degrade many materials, reducing their numbers in the ground, sometimes to zero. In the extramural areas of pueblos, for example, bone deposited on the surface will weather until it is no longer detectable—unless it is soon covered by trash or sediments. In contrast, bone left in pueblo rooms, sheltered from sunlight and other “elements,” is often well preserved.

The many influences of formation processes on the frequency dimension make it imperative that measures of artifact quantity be directed at specific variables. In most cases, work is still needed to determine how best to conceptualize quantitative variability and how to measure only the variables of interest. This is sometimes difficult because different processes can have similar effects on the frequency dimension. That is why multiple indicators, each sensitive to slightly different effects of formation processes, are required.

Relational Dimension

The relational dimension refers to patterns of co-occurrence of artifacts. Traditionally, such patterns are termed “associations;” the finding together of two or more items. With the advent of statistical analysis, however, it has become necessary to break down the relational dimension
into more precise properties. Following Binford (1972), it is useful to distinguish between association and correlation.

Associations, in turn, can be divided up into major types, singular and recurrent. A singular association refers to the discovery of two or more items in close proximity. Thus, a mano, a metate, and mineral pigments may be found together in the corner of a pueblo room. Singular associations, of course, are the basis of "features," although only a fraction of such associations are actually deemed important enough to be designated as features. Recurrent associations describe the situation one encounters when singular associations turn out not to be so singular after all, because the same items recur again and again, often in different recovery units. Thus, when manos and metates are found together many times, we may speak of their recurrent association.

Sometimes artifacts exhibit an even greater affinity for one another. Not only are they associated recurrently, but their frequencies are correlated. In the simplest pattern of correlation, conforming to a linear model, the ratio of one item to another remains relatively constant among different recovery units. For example, manos and metates that occur again and again at a site in the ratio of 3 to 1 are said to be correlated. Other patterns can become very complex, but however correlation is defined, correlated items all display a mutual behavior among recovery or analytic units.

It has been customary for archaeologists to assume that associations and correlations are determined by activity patterns. Items found together (in singular or recurrent association) must have been used together. Similarly, correlated items are often assumed to be part of a "tool kit." Unfortunately, formation processes of many kinds also affect the relational dimension, creating both associations and correlations (Carr 1984). Not only are items used in the same activities separated, but associations are created of items that were never together during use. These phenomena are the basis of the "principle of dissociation" (Rathje and Schiffer 1982:107).

In our own society no pair of items is more tightly associated in systemic context than toothbrush and toothpaste. In every bathroom one finds these items in close proximity. Because both artifacts have relatively low discard rates, however, the probability that a toothbrush and toothpaste tube will be discarded at the same time and deposited in the same trash bag is not very high. Moreover, toothbrushes tend to be reused as cleaning implements or even as hairbrushes for hamsters, leading to further "dissociations." On the other hand, almost every trash bag (a household's refuse for a week) will contain tissues and paper towels. Not only will these items, which were seldom used in the same activity, be associated recurrently in landfill deposits, but they will probably be correlated.

Although formation processes degrade correlations between artifacts
that were used together in activities, some meaningful patterns are often preserved as singular or recurrent associations. The potter's toolkit found in just one house or in a single burial will probably furnish more reliable behavioral information than a thousand factor analyses of house floor artifacts. The failure to appreciate that many relational patterns reflect the operation of formation processes and that systemic patterns must frequently be inferred from singular or recurrent associations lies at the root of much confusion in quantitative methods and spatial analysis in archaeology. (For a recent application of this perspective to house floor assemblages, see Seymour and Schiffer 1987.)

Various environmental formation processes also affect the relational dimension, often sorting materials by size. Many Paleolithic hand-axe sites in Europe, for example, consist of artifacts that have been redeposited by flowing water from their place of cultural deposition. Such deposits exhibit size sorting, creating associations that have nothing to do with tool kits. Animals inhabit the same sites as humans, both during and after cultural use of the area. Pack rats, hyenas, and porcupines are well-documented scavengers and hoarders of bone whose activities introduce ecofacts that can contribute to relational patterns (Brain 1981).

The relational dimension furnishes evidence for a wide array of archaeological inferences, frequently facilitated by elaborate statistical analyses. But formation processes have profound effects on the relational dimension, and are perhaps its major determinant, at least with respect to some kinds of deposits.

**Principles of Formation Processes**

The preceding discussion has documented the variety of traces that formation processes "map onto" materials recovered by the archaeologist. If formation processes were utterly capricious in their time and manner of operation, then the task of inferring past cultural behavior would be beyond hope. Fortunately, the transformations wrought by cultural and noncultural formation processes are quite regular in two important aspects: causes and consequences. First, the occurrence of specific formation processes is determined by specific causative variables, making these processes highly predictable. For example, in temperate forests we can anticipate that tree roots, rodents, and earthworms will disturb archaeological remains. In large settlements, such as cities, we can expect artifacts to be discarded predominantly as secondary refuse, probably in dense concentrations. Second, the effects of specific processes—their traces—are themselves regular and predictable. Earthworms move aside or ingest soil particles and deposit their castings on the surface. Over time, sediments become mixed, blurring boundaries between deposits, and larger
artifacts move downward. Trampling on firm substrates (i.e., hard-packed floors)—by people, beasts, and machines—crushes, fragments, and abrades objects, depending on their mechanical properties. Because they are regular, these effects can be used to identify the formation processes of specific deposits (Chapter 10).

The regularities of formation processes—pertaining to causes and consequences—usually take the form of experimental laws and empirical generalizations (Schiffer 1983). Boundary conditions on the former principles are specific parameters that govern the operation of a process. For example, the statement “in cities, most artifacts are discarded as secondary refuse” contains the boundary condition “in cities,” which specifies the domain of applicability of this principle. The principle remains general, however, because it applies whenever and wherever there are cities.

Following Nagel (1961), I refer to these general principles as “experimental” laws: lower-level regularities that are subject to direct empirical testing. Such testing ideally takes place in a setting where, having met the boundary conditions, the investigator may observe the interactions of the variables specified in the relationship. In studying the principles of formation processes, ethnoarchaeology and experimental methods furnish the primary laboratory settings. The laws describing general regularities in formation processes are known as c-transforms (for cultural) and n-transforms (for noncultural or environmental).

As the corpus of c-transforms grows, we can expect the development of middle- and higher-level theories to explain the empirical regularities. Examples of such proto-theories are presented in Chapters 3 and 4. Most n-transforms are embedded within theories and theoretical systems of other sciences, such as chemistry and biology (e.g., decay and weathering), geology (e.g., weathering and movement of particles by water), and ethology (e.g., behavior of nonhuman animals that affect sites). To note that n-transforms tie into the theories of other fields does not imply that everything about environmental formation processes is already known—far from it. But it does suggest that much knowledge is at hand, and cannot be ignored.

Archaeologists have long recognized that other regularities, also with a substantial empirical content, are used extensively in archaeological inference and in fieldwork but cannot be expressed as general laws. These regularities apply at the level of sites, communities, societies, and regions (Reid 1985). Their boundary conditions are thus highly restrictive and pertain to specific times and places. For example, during pre-Classic periods (ca. A.D. 500–1200), the Hohokam of southern Arizona practiced cremation of the dead, burying the human remains often in association with pottery in extramural areas—sometimes in mounds. Such generalizations refer to the patterned behavior of specific societies and cannot
now be subsumed by more general principles. It is these empirical generalizations that in part constitute what all archaeologists recognize as "local expertise." Although the emphasis in the remainder of this book is necessarily on general principles, the importance of empirical generalizations to the archaeological process is fully acknowledged.

Conclusion

This chapter has shown that evidence of the cultural past is created by a variety of cultural and noncultural processes that have varied and ubiquitous effects, introduce variability into the historical and archaeological records, and must be taken into account in inference. It is useful to view archaeological materials as exhibiting variability within four dimensions: formal, spatial, frequency, and relational. Specific traces within the dimensions of variability may serve as evidence for inferences. Because similar traces can be produced by more than one process, however, the archaeologist must demonstrate that the traces to be used as evidence were not caused by other processes, especially formation processes. Fortunately, the latter are highly regular in their causes and effects. As a result, the archaeologist can make use of a host of principles—c-transforms and n-transforms and empirical generalizations—to facilitate the process of partitioning traces and, especially, to rule out formation processes as the source of specific traces to be used as evidence for behavioral inference (see Chapters 10–12). We now turn to the most fundamental principles of formation processes, beginning with c-transforms.