

2

A Review of Site Formation Processes and Their Relevance to Geoarchaeology

JULIE K. STEIN

1. Introduction

Someone unfamiliar with the history of archaeological methods and theory who read the title of this chapter would guess that the content addresses the processes responsible for the formation of archaeological sites. That guess would be based on the English use of the word “formation”; an act of giving form or shape to something, or of taking form. The word formation in archaeology, however, has a connotation that goes well beyond this English definition.

A chapter concerning site formation processes is included in this book about earth sciences and archaeology because the study of site formation processes in the discipline of archaeology means more than just analyzing the processes responsible for the formation of archaeological sites. Formation processes are crucial to the discipline because archaeologists use the patterns of artifacts in the ground to infer behaviors. They identify patterns that are created by ancient behaviors and separate those patterns from the ones created by later cultural and natural processes. Earth science methods are required to decipher any natural

JULIE K. STEIN • Department of Anthropology, University of Washington, Seattle, Washington 98195.

Earth Sciences and Archaeology, edited by Paul Goldberg, Vance T. Holliday, and Reid Ferring. Kluwer Academic/Plenum Publishers, New York, 2001.

process that may have disturbed the original patterns created by behaviors, and is, therefore, an integral part of site formation analysis. Rather than just a concern with formation, site formation analysis focuses on a broad array of theoretical and methodological issues.

In many ways site formation analysis links archaeology and the earth sciences as no other concept in archaeology ever has. In archaeology, site formation studies grew out of a theoretical approach involving the identification of behaviors common to all people that was called “New Archaeology” (S. R. Binford and Binford, 1968; Clarke, 1968; Reid et al., 1975; Schiffer, 1976, 1995; Taylor, 1948; Watson, 1986; Watson et al., 1971; Willey and Sabloff, 1993; Wylie, 1989). Although many people suggest that the new archaeology did not contribute significantly to changes in theory (Dunnell, 1986), everyone agrees that it had a powerful impact on fields ancillary to archaeology. The systematic and scientific methods advocated by the new archaeologists became the focus of such subdisciplines as geoarchaeology, archaeometry, taphonomy, experimental archaeology, ethnoarchaeology, and lithic analysis. The new focus on formation of sites, depositional history of artifacts, and reconstruction of paleoenvironments linked archaeology and earth sciences. This focus took hold because archaeologists wanted to infer behavior from artifacts and new studies of site formation processes demonstrated that the placement of artifacts shifted since they were deposited (Goldberg et al., 1993; Nash and Petraglia, 1987) and required an earth science approach to be understood.

In this chapter I discuss the history and kinds of formational processes in archaeology, in the hope of clarifying their various connotations and the potentials for misunderstanding. My approach is admittedly Americanist in orientation, as has been my training, but it should provide a starting point for a more international synthesis. The emphasis on formational processes in the decade of the 1970s influenced greatly the subdiscipline of geoarchaeology and the interactions of archaeologists and earth scientists. To clarify this impact I discuss the history of site formation studies and point out the theoretical orientation of such studies as well as the methodological ones. I emphasize the effects of shifting from the artifact assemblage for empirical observations to the deposit as the appropriate unit for analyzing formational processes. In the end, I note a number of successful research examples where site formation analysis contributed to the archaeological research, each example chosen for its strongly contrasting approach.

2. History and Definitions of Formation Processes

The history of collaboration between archaeologists and earth scientists most certainly began early in the history of the discipline (e.g., Butzer, 1964; Pyddoke, 1961), but the person given most credit for championing the particular emphasis of site formation analysis is Michael Schiffer (1972). He was likely influenced by the research of many influential archaeologists and colleagues (e.g., Binford, 1962; Isaac, 1967; Rathje, 1974, 1979; Reid, 1985; Taylor, 1948) but he seems

to be the one archaeologist who wrote in such a way as to capture the attention of the archaeological community.

In the 1970s, Michael Schiffer was one of the developers of the behavioral theoretical approach that included this new wrinkle of formation processes. Like many others during this decade (e.g., Binford, 1962, 1964; S. R. Binford and Binford, 1968), Schiffer was interested in gleaning more from the archaeological record than just the classification and ordering of artifacts. Schiffer (1972) asked the questions “How is the archaeological record formed by behavior in a cultural system?” (p. 156), and how is that behavior obscured by later natural and cultural processes? He was trying to create theory and laws to account for characteristics of the archaeological record. He emphatically pointed out that archaeologists had to recognize that both cultural and natural processes operated on the artifacts while they lay in the archaeological record. These natural and cultural processes had to be identified and accounted for to obtain the behavioral information that was of real interest.

Formation processes analysis requires consideration of three kinds of processes, each of which encompasses different fields of study. First, the cultural processes (the behaviors) are the ones of primary interest to the archaeologists. These are responsible for the formation of the archaeological record, including the manner in which objects are procured, used, maintained, and discarded. These behaviors create patterns of artifacts over various locations. They involve the activities that create and use the artifacts, as well as those that result in their deposition. Second, the cultural processes that alter, or obscure, the original behavioral signatures are analyzed. These cultural processes include the actions of people contemporary with deposition, as well as the actions of the archaeologists well after deposition. These actions can either create their own patterns, alter them slightly, or even obliterate them. Third, the natural processes are those non-cultural events that alter, obscure, or preserve the original behavioral signatures. These fall mostly in the realm of the earth sciences, and include a wide variety of environmentally produced actions.

Some people consider formation processes to be only the second and third cultural and natural processes discussed previously. Confusion occurs because most archaeologists do not explicitly differentiate between these three kinds of processes or understand which cultural processes are the target of theoretical and behavioral questions and which relate to formation processes.

2.1. Definition of Site Formation Analysis

Schiffer, in 1972, devoted much of the article to a “simple flow model with which to view the life history of any element, and account behaviorally for the production of the archaeological record” (1972:157). Simply put, an element within a behavioral system goes through states. First is the *systemic context* that “labels the condition of an element which is participating in a behavioral system” (1972:157). Second is the *archaeological context* that “describes materials which have passed through a cultural system, and which are now the objects of investigation of archaeologists” (1972:157).

The systemic context is defined as the activities in which an element participates during its life, and Schiffer (1972) suggested five processes for durable elements: procurement, manufacture, use, maintenance, and discard. Each process consists of stages, and stages can consist of one or more activities. The most important notion of systemic context is that the processes take place in specific locations, and the locations are places where the probability of finding an element is high (1972:160).

Discard is the termination of an element's use-life; it is then considered refuse. Three kinds of refuse can be identified, if location is considered along with discard. *Primary refuse* is material discarded at its location of use, and *secondary refuse* is material discarded in a location different from its location of use. Elements that reach archaeological context without the performance of discard activities are called *de facto refuse* (Schiffer:1972:160).

The 1972 introduction of formation processes was embedded in an introduction to behavioral archaeology, called a life history model of artifactual elements. Schiffer did not even offer a definition of formation processes in this article. He merely supplied a statement introducing a nameless concept as "the conceptual system that explains how the archaeological record is formed" and stated, "the cultural aspect of *formation process concepts* has not been appreciably developed" (Schiffer, 1972:156). In subsequent publications (e.g., Schiffer 1976) the term "formation processes" and the definition come together, as "the factors that create the historic and archaeological records are known as formation processes" (Schiffer, 1987:7).

From the beginning, as the new archaeologists and behavioral archaeologists recognized patterns in assemblages of artifacts, their behavioral conclusions met with criticism almost immediately. The patterns they recognized were not the result of behavior but rather were produced by decomposition, by sampling biases, and (even more problematic) by cultural and noncultural processes (see discussion in Schiffer, 1983:676–678). One had to be sure that the patterns noted in the artifact distributions were really the result of the behavior of the original makers and users and were not identified mistakenly as the result of behaviors associated with the systemic use of the artifacts.

Recognizing that patterns introduced by cultural and post depositional processes alter the original (behavioral) patterns became known as a transformational view of the archaeological record (Schiffer, 1976; Schiffer and Rathje, 1973). The remains in an archaeological site "experienced successive transformations from the time they once participated in a behavioral system to the time they are observed by the archaeologist" (Schiffer, 1975:838). These transformations could be *cultural formation processes*—processes of human behavior that affect or transform artifacts after their initial period of use in a given activity (Schiffer, 1987:7)—or *natural (noncultural) formation processes*—processes of the natural environment that impinge on artifacts and archaeological deposits in systematic or archaeological contexts.

Schiffer assumed in 1972 that natural processes were the realm of study of the earth scientist (e.g., geoarchaeologists and archaeometrists) and that these processes are governed by laws already identified within the earth sciences, and therefore were in need of little more research. By 1983, Schiffer's assumptions

about natural formation processes changed (Schiffer, 1983). He no longer assumed that all natural processes relevant to archaeology had been studied adequately by other scientists (a fact pointed out early by earth scientists such as Butzer [1964, 1971, and 1982]), and he encouraged a wide variety of research related to pattern recognition. This research and the patterns are described in great detail in a book devoted to the subject (Schiffer, 1987).

Almost immediately following the appearance of these early publications, and for at least a decade, archaeologists and earth scientists offered anecdotal examples of patterns within artifact distributions produced by processes other than the original behavior (Bocek, 1986; Erlandson, 1984; Gifford and Behrensmeyer, 1977; Johnson, 1989; Rick, 1976; Stein, 1983; Stockton 1973; Thomas, 1971; Villa, 1982; Villa and Courtin, 1983; Wood and Johnson, 1978). Experimental research replicated in the lab the patterns observed in artifact distributions of archaeological sites but which were imposed by noncultural processes. This research threw in the face of every archaeologists the fact that if they wanted to identify patterns of artifacts in the archaeological record for the purpose of inferring behaviors, then the transformations (i.e., all the other pattern-producing processes) had to be identified first and taken into account.

From the standpoint of inference, then, the behavioral and organizational properties that interest archaeologists are reflected—sometimes redundantly and often in complex or subtle ways—in artifacts. However, except in ethnoarchaeological settings and modern material culture studies, we do not deal with items in systemic context. Artifacts recovered archaeologically have been deposited by adaptive systems and subjected to other cultural and natural processes. Thus, in order to infer the *systemic* properties of interest, the archaeologist must identify *and take into account* these formation processes. (Schiffer, 1983:676; emphasis in original)

Many researchers consider wrongly that these other pattern-producing processes are the entire purview of site formation processes. The archaeologists central to the development of site formation analysis perceived site formation studies as central to the building of theory about cultural formation processes. These archaeologists (increasing in numbers in the late 1980s and early 1990s) are mostly associated (as faculty or students) with the University of Arizona. Their theoretical approach is called behavioral archaeology, and their focus is primarily on (but not exclusively) artifacts and sites within the southwestern United States. They did not restrict themselves to the identification of cultural and natural processes that produce or alter patterns of artifacts in assemblages (that was the work to be done by others), but they examined behavioral inferences that affected material objects to identify behavioral laws operating within systemic contexts. To them, formation processes are behavioral processes important for theory building in archaeology.

Thus, the term formation processes describes research about the transformations of the record, but also describes the original behavior surrounding the artifacts. Formation processes connote cultural and natural processes transforming the archaeological record and the cultural processes inferred in theories and laws.

The multiple aspects of site formation analysis is important to note. Those archaeologists not interested in theory building consider formation processes

primarily as the identification of processes that create the archaeological record (e.g., Bar-Yosef, 1993; Nash and Petraglia, 1987; Straus, 1993). The different kinds of cultural or natural processes and their relationship to theory is not relevant to them. There exist, therefore, nontheoretical archaeologists who ignore those archaeologists with theoretical concerns who are using the phrase “cultural formation processes” in their search for the laws that dictate behavior, and there are theoretical archaeologists who ignore those archaeologists with earth science concerns who are using the term in their search for natural processes that alter the spatial distribution of objects in the archaeological record.

Site formation analyses are not mutually exclusive—all archaeologists and earth scientists can continue to pursue their search for theory or their search for natural processes that create the archaeological record. The differences are important to understand, however, because each reads the literature of the other, resulting in the potential for confusion.

2.2. The Unit of Site Formation Analysis

As site formational studies increased in popularity in the 1980s, the unit of analysis in the discipline began to change. Previous inferences about behavior (and the preoccupation with chronology), lead archaeologists to focus on the “artifact” as the unit of analysis, or the assemblage. The emphasis on patterns, and recognition of all the forces acting on those patterns, required that attention be shifted to the “deposit.” Schiffer (1983) stated that the analytical level at which the identification of formation processes occurs is the “deposit.” He expanded this idea later when he stated that

the perspective elaborated in this chapter leads us to view deposits themselves as peculiar artifacts, the characteristics of which must be studied in their own right. Deposits are the packages containing evidence that might be relevant to one's research questions. Establishing such relevance, however, requires that the genesis of deposits be determined, in terms of both cultural and noncultural formation processes. (Schiffer, 1987:302–303).

Clearly, archaeologists had recognized the importance of the artifact, the assemblage, and the deposit.

Schiffer did not invent this idea independent from other events in archaeology. Karl Butzer had been advocating regional approaches, paleoenvironmental reconstructions, and a focus on deposition through his research in Egypt, in Europe, in South Africa, and in North America (e.g., Butzer, 1960, 1965, 1973, 1976, 1977, 1978, 1981). Others, such as Francois Bordes (1961, 1972) in France, Vance Haynes (1964) in North America, George Rapp Jr. (1975) in Greece, and Myra Shackley (1975) in Great Britain, added volume to the advocacy. As archaeologists shifted their emphasis to patterns and transformations, the deposit as described by earth scientists became the necessary analytical unit.

Immediately a problem appeared, associated with the shift in analytical units. Archaeologists knew how to describe deposits during excavation and in wall profiles (they had been grouping artifacts into assemblages for years; Browman and Givens, 1996), but they were not as comfortable describing or analyzing the

deposit itself (the deposit from which the assemblage came). Most archaeologists could not make the leap from describing deposits for the purpose of grouping artifact classes (assemblages) and telling relative time to the purpose of describing them to infer depositional histories and complex postdepositional alterations. These archaeologists had to either attempt the description and interpretations themselves (and make mistakes) or hire earth scientists (who were often untrained in archaeology and make other mistakes).

The collaboration that developed out of this descriptive and interpretive necessity contributed to the growth and emergence of the subdiscipline called geoarchaeology. Geoarchaeology, as a name, was coined by Renfrew in 1973 in his introduction to a conference later published as a book of the same name (Davidson and Shackley, 1976). His definition indicates that on both sides of the Atlantic concern for the archaeological record, patterns, and transformations had lead to an increase awareness of the need for interdisciplinary cooperation between archaeologists and earth scientists. Formation processes and geoarchaeology gained in popularity at about the same time.

This discipline employs the skills of the geological scientist, using his concern for soils, sediments, and landforms to focus these upon the archaeological "site," and to investigate the circumstances which governed its location, its formation as a deposit and its subsequent preservation and life history. This new discipline of geoarchaeology is primarily concerned with the context in which archaeological remains are found. And since archaeology, or at least prehistoric archaeology, recovers almost all its basic data by excavation, every archaeological problem starts as a problem in geoarchaeology. (Renfrew, 1976:2)

Now archaeologists had reason to believe they needed geoarchaeology to accomplish their basic study of artifacts and assemblages. Because the pattern (context) of artifacts had been transformed, they absolutely had to utilize earth science methods. Geoarchaeology was not a set of methods used only by archaeologists who excavated very old sites or by those who witnessed massive climatic or geomorphological changes. Everyone had to face the concerns of formational processes, which included geoarchaeology and the deposit. Earth scientists had been offering assistance to archaeologists for over a decade, but as site formation analysis gained popularity, numerous articles were added that explained basic tenets and emphasized its potential (Butzer, 1982; Cornwall, 1958; Davidson and Shackley, 1976; Gladfelter, 1977, 1981; Hassan, 1978; Haynes, 1964, 1971; Limbrey, 1975; Pyddoke, 1961; Rapp, 1975). These articles were now being read by a larger proportion of the archaeological community.

Evidence of the problems associated with the shifting of analytical unit from artifacts and assemblages to the deposit is expressed clearly in criticisms of the deposit: the severe shortcoming of the "deposit," as the appropriate unit for archaeological analysis, is that it represents a single depositional episode, which is too simplistic as an organizing principle in archaeology. Schiffer (1987) articulated this concern that a minimal unit of deposition means a *single* event of deposition with the implication that a single activity was responsible for the deposition of the single deposit (or assemblage). This view follows archaeologists'

expressed interest in defining specific patterns of artifacts in particular locations. The pattern of artifacts (assemblages) is the information that they investigate to infer behavior, and the minimal unit of deposition had been described in terms of a single activity and behavior that results in single sets of artifacts (assemblages). The grouping (archaeologists refer to it as an assemblage, but here it is referred to as a deposit) is thought to be based on the activity, and because a deposit would likely contain other objects not related to a single activity, it is problematic.

Traditionally in archaeology, the level is a unit created to group artifacts into assemblages (Phillips et al., 1951), and assemblages are grouped because they are considered one kind of behavior (component) or period of time. Given this perspective, a deposit is problematic for the following reasons: a single depositional process can give rise to materials in different deposits, items originally deposited together by one process can be divided up subsequently among several deposits, and a single deposit can contain the products of many different depositional processes (Schiffer, 1987:266). Although articulated most clearly by Schiffer, this list reflects the long tradition of considering artifact deposition as behavior and a heterogeneous deposit only as artifact assemblages.

Earth scientists consider the deposit differently, emphasizing the history of all particles in the deposit through analysis of their source, transport agent, and environment of deposition (Birkeland, 1999; Krumbien and Sloss, 1963; Pettijohn, 1957; Selly, 1988). If the phrase “depositional processes” in each of the three concerns is replaced with the phrase “behavioral processes” or “cultural activities,” then the difference between the sedimentologist’s view of a deposit and an archaeologist’s view becomes clear: a single *cultural activity* can give rise to materials in different deposits, items originally deposited together by one *behavioral process* can be divided up subsequently among several deposits, and a single deposit can contain the products of many different *cultural activities*. The concept of deposit or depositional processes as seen by earth scientists includes more kinds of particles than just artifacts. There are differences between earth scientists’ use of depositional processes and the use by some theoretical archaeologists. To study site formation processes, the differences should be understood.

The point here is that earth scientists (and geoarchaeologists) define deposits by their lithology for the ultimate purpose of inferring the sedimentological history of the depositional event (Hassan, 1978; Reading and Levell, 1996; Salvador, 1994; Stein, 1987, 1990). They realize that a depositional event is defined on the basis of what they see before them—the group of particles that look alike. Archaeologists call such a group a *natural level*. The processes involved in the creation of the depositional event (as defined by the analyst in the field) are diverse, bringing particles from many sources, many transport agents, and at variable rates. The deposit is an organizational unit (defined at any scale) in which to decipher the depositional event that created it. It is not only a unit useful for recognizing behaviors or patterns in the artifacts produced by one cultural activity. It is a unit that can provide information about cultural or natural processes at a scale different from that of a single artifact. These groups of objects can add to information derived from single artifacts by adding the contextual relationship of all grains. Deposits are units to study groups of objects brought

together through deposition (Stein, 1987, 1990, 1992). For example, analyzing groups of bones (referred to as bone beds) led archaeologists such as Joe Ben Wheat (1972) and George Frison (1974) to innovative conclusions concerning kill sites. Examining individual bones could not provide the depositional perspective that the group of bones provided. Earth scientists examine all grains in a deposit to analyze the depositional history of the entire entity.

This historic review of site formational analysis, and its relationship to earth science, indicates the variety of meanings for the term “site formation”—meanings that go far beyond the English use of the word. Schiffer captured the attention of Americanist archaeologists by using the term to describe both a theoretical approach and a methodological one. The methodological approach emphasized the need to collaborate with earth scientists, and it is the one with which most readers of this book will be familiar. The theoretical approach, however, is found in the literature under formational processes and should be recognized for what it was intended.

3. Examples

Some examples may illustrate the multiple uses of site formation analysis in archaeology. I conducted a library database search of anthropological and earth science literature published since 1984 using the key words “formation processes.” This search generated a list of hundreds of entries, most of them using the English definition of the words “formation processes” (e.g., titles of articles such as: “Different Formation Processes of the Moon, the Earth and Meteorites,” “Analysis of Reformation and Formation Processes in the course of Karst Development”, and “Formation Processes of Gallstones: with special reference to Cholesterol Gallstones”). These examples aside, about 40 of the entries used formation processes in a manner specific to archaeology and illustrate the multiple uses of the term.

Michael Barton and Geoffrey Clark entitled a chapter “Cultural and Natural Formation Processes in Late Quaternary Cave and Rockshelter Sites of Western Europe and the Near East” (Barton and Clark, 1993). The publication summarizes how material is incorporated into rockshelters, separating the transport agents (or processes) into those that are natural and those that are cultural. The list is informative and of interest to anyone attempting to infer cultural events taking place in a rockshelter. The authors, however, did not differentiate the cultural formation processes that are behaviors involving the use and manufacture of artifacts, and those that are responsible for altering the pattern of artifacts after deposition. The authors instead provided an excellent synthesis of the various kinds of cultural and natural transport agents affecting rockshelters.

Stein (1996) summarized research in an article titled “Geoarchaeology and Archaeostratigraphy: view from a Northwest Coast Shell Midden” that explained the origin of a stratigraphic sequence observed frequently in shell midden sites on the Northwest coast. Two layers (shell midden with light colored matrix overlying shell midden with dark-colored matrix) had been interpreted as the

result of two different cultural activities representing different cultural components in each site. Stein's research suggested that the color of the matrix is related to the differential water content held within the organic matter and clay minerals. More water is held in the lower layer because a 1m rise in sea level has effectively "raised" the water table of sites near the shore to the point where lower portions of sites are affected. The upper layer is too porous to hold water percolating from the surface, and only the water pulled upward through capillary action hydrates the matrix and produces the dark color. She identified a natural formation process that altered the site to produce a pattern where none had existed previously. The natural pattern has been misinterpreted as cultural. This is a classic example of identifying natural formation processes that affects behavioral interpretations.

In the article "Pollen-Record Formation Processes, Interdisciplinary Archaeology, and Land Use by Mill Workers and Managers: The Boott Mills Corporation, Lowell, Massachusetts 1836–1942" Gerald Kelso (1993) discussed the pollen record in terms of how pollen is naturally deposited on the surface of the site and moved into the subsurface through translocation associated with soil development. Kelso also discussed how cultural site formation processes distort this natural pollen "formation" pattern. These cultural events produce other patterns that are characteristic of broad classes of human behavior and not of natural pollen rain. The pollen was transported by natural processes but was moved post depositionally by cultural processes. This research differentiates between natural and cultural processes, but with a twist. The target event is natural and the cultural processes are those that are altering it. Again, however, this use of formation processes is an excellent study of how the earth's deposits can be altered by a variety of processes. As in the previous examples, this article does not include the theoretical concern associated with formation studies.

Charles Miksicek wrote a synthesis entitled "Formation Processes of the Archaeobotanical Record" (Miksicek, 1987). After reviewing many topics related to plants as part of archaeology (e.g., preservation environments of plants, methods of extraction, and uses of plants), the cultural transformations of the archaeobotanical record were described. These "transformations" were in turn used to predict how plant remains could be used to infer one kind of discard (refuse), and when a charred plant remain was *de facto*, primary, or secondary refuse (terms introduced by Schiffer [1972] as part of his model to describe different kinds of behaviors). Miksicek describe how archaeobotanical objects are transported and altered within the archaeological record, but he went further than other archaeologists toward theoretical concerns and inferring behaviors that might be "laws" applicable to human actions across time and space.

Masakazu Tani (1995) presented "Beyond the Identification of Formation Processes: Behavioral Inference Based on Traces Left by Cultural Formation Processes," in which he clearly addresses behaviors that affect the life history of artifacts in the hopes of defining behavioral laws. Tani's publication flows directly from the original theoretical goals of Schiffer. Tani targeted only cultural depositional processes—those involving refuse disposal. He articulates the depositional formation processes, the refuse deposits, and the theoretical compo-

nents within behavioral archaeology. He attempts to infer site functions and changes in occupation over time. This study follows faithfully the research advocated by Schiffer toward the goal of understanding behavior through material culture. Tani recognized that the transformational processes had to be considered before the behaviors could be inferred.

These examples demonstrate a range of research conducted under the rubric formation processes. Most researchers use site formation processes to study the creation or alteration of the archaeological record. Many of them focus on geoarchaeological studies of how artifact patterns are destroyed and rearranged after deposition. But other archaeologists use cultural formation processes as synonymous with the search for material culture's use, procurement, or other behavioral inferences. How many archaeologists realize that the term formation process really contains all these connotations?

4. Conclusion

The analysis of formation processes, as defined by Schiffer in the early 1970s and 1980s, required that archaeologists take the giant step beyond just interpreting the histories of artifacts. In addition to the artifacts, archaeologists had to focus on the deposit as a whole and interpret its depositional history. That is a difficult thing to ask of archaeologists, especially ones who were interested essentially in the systemic context (the behavior behind the artifact) that Schiffer originally proposed. The systemic context, however, cannot be determined until the formation processes (transformations) are identified. The artifact patterns that allow us to interpret behavior are altered, obliterated, and sometimes replaced with new patterns, created by processes that are in no way related to the behavior of interest. Whether we like it or not, we must study these processes.

The most appropriate unit for studying these formation processes is the deposit, not the individual artifact. The deposit requires that the archaeological record be thought of in terms less dichotomous than cultural and natural, but rather as one depositional event. Many attributes traditionally used by earth scientists are appropriate to study this event and can be effectively incorporated into archaeology. For example, studies of grain size distributions (Stein and Teltser, 1989), micromorphology (Courty et al., 1989), and sequence stratigraphic methods (Laville et al., 1980; Farrand, 1975, 1993) have all made significant contributions. Archaeologists are not necessarily familiar with these earth science methods, because they are not taught traditionally as part of archaeology. More important, these methods did not become important until archaeologists became interested in questions involving artifact patterns rather than strictly their chronology. Once that step was taken, the new approaches became the appropriate ones.

Geoarchaeology gained popularity in archaeology about the same time as did formational studies. This coincidence is perhaps related. Archaeologists have often concerned themselves with the regional environment, the burial of their sites, or the preservation conditions of organic remains (concerns identified as

part of geoarchaeology). The concern blossomed, however, when processes were identified that could affect the patterns of artifacts. Artifacts are the central concern of archaeology and their interpretation is the focus of the discipline. Geoarchaeologists could really assist in the identifications of these processes, and such contributions became crucial.

The discipline of archaeology now recognizes that formational processes are integral, and most excavations include a watchful eye toward identifying transformational events that could distort artifact patterns. Not everyone, however, is equally equipped to identify these processes or to make the correct measurements of deposit-based attributes, archaeologists and earth scientists alike. The archaeological community must make an effort to provide students with training in the methods necessary to succeed in identifying formation processes correctly.

One step that will lead us closer to this goal is to recognize that the phrase formation processes means different things to different people. To behavioral archaeologists it includes the search for behavioral laws; to geoarchaeologists it means the search for processes of formation associated with the archaeological context. These are not mutually exclusive goals, just connotations that could cause confusion.

ACKNOWLEDGMENTS. The author thanks Michael Schiffer for many years of conversation about formation processes, and Patrice Teltser for acting as translator between the two of us. This manuscript was greatly improved by the comments of Michael Schiffer, Debora Kligmann, Vance Holliday, Paul Goldberg, and Reid Ferring, the indexing of Christopher Lockwood, and the bibliographic assistance of Jennie Deo.

6. References

- Bar-Yosef, O., 1993, Site Formation Processes from a Levantine Viewpoint. In *Formation Processes in Archaeological Context*, edited by P. Goldberg, D. T. Nash, and M. D. Petraglia, pp. 11–32. Monographs in World Archaeology No. 17, Prehistory Press, Madison, WI.
- Barton, C. M. and Clark, G. A., 1993, Cultural and Natural Formation Processes in Late Quaternary Cave and Rockshelter Sites of Western Europe and the Near East. In *Formation Processes in Archaeological Context*, edited by P. Goldberg, D. T. Nash, and M. D. Petraglia, pp. 33–60. Monographs in World Archaeology No. 17, Prehistory Press, Madison, WI.
- Binford, L. R., 1962, Archaeology as Anthropology. *American Antiquity* 28:217–225.
- Binford, L. R., 1964, A Consideration of Archaeological Research Design. *American Antiquity* 29:425–441.
- Binford, S. R. and Binford, L. R., 1968, *New Perspectives in Archeology*. 2nd ed., Aldine-Atherton, Chicago.
- Birkeland, P. W., 1984, *Soils and Geomorphology*. Oxford University Press, New York.
- Birkeland, P. W., 1999, *Soils and Geomorphology*, 3rd ed.. Oxford University Press, Oxford, U.K.
- Bocek, B., 1986, Rodent Ecology and Burrowing Behavior: Predicted Effects on Archaeological Site Formation. *American Antiquity* 51:589–603.
- Bordes, F., 1961, Mousterian Cultures in France. *Science* 134:803–810.
- Bordes, F., 1972, *A Tale of Two Caves*. Harper & Row, New York.
- Browman, D. L. and Givens, D. R., 1996, Stratigraphic Excavation: The First “New Archaeology” *American Anthropologist*. 98:80–95.

- Butzer, K., 1960, Archeology and Geology in Ancient Egypt. *Science* 132:1617–1624.
- Butzer, K., 1964, *Environment and Archaeology: An Introduction to Pleistocene Geography*. Aldine, Chicago.
- Butzer, K., 1965, Acheulian Occupation Site at Torralba and Ambrona, Spain: Their Geology. *Science* 150:1718–1722.
- Butzer, K., 1971, *Environment and Archaeology: An Ecological Approach to Prehistory*, Aldine-Atherton, Chicago.
- Butzer, K., 1973, Geology of Nelson Bay Cave, Robberg, South Africa. *South African Archaeological Bulletin* 28:97–110.
- Butzer, K., 1976, *Early Hydraulic Civilization in Egypt*. University of Chicago Press, Chicago.
- Butzer, K., 1977, *Geomorphology of the Lower Illinois Valley as a Spatial–Temporal Context for the Koster Archaic Site*. Illinois State Museum, Reports of Investigations No. 34, Springfield, Illinois.
- Butzer, K., 1978, Changing Holocene Environments at the Koster Site: A Geoarchaeological Perspective. *American Antiquity* 43:408–413.
- Butzer, K., 1981, Cave Sediments, Upper Pleistocene Stratigraphy and Mousterian Facies in Cantabrian Spain. *Journal of Archaeological Science* 8:133–182.
- Butzer, K., 1982, *Archaeology as Human Ecology*. Cambridge University Press, Cambridge, UK.
- Clarke, D. L., 1968, *Analytical Archaeology*. Methuen, London.
- Cornwall, I. W., 1958, *Soils for the Archaeologist*, Phoenix House, London.
- Courty, M. A., Goldberg, P., and Macphail, R., 1989, *Soils and Micromorphology in Archaeology*. Cambridge University Press, New York.
- Davidson, D. A., and Shackley, M. L., 1976, *Geoarchaeology*. Westview Press, Boulder, CO.
- Dunnell, R. C., 1986, Five Decades of American Archaeology. In *American Archaeology: Past and Future*, edited by D. J. Meltzer, D. D. Fowler, and J. A. Sabloff, pp. 23–49. Smithsonian Institution Press, Washington, DC.
- Erlandson, J. M., 1984, A Case Study in Faunalturbation: Delineating the Effects of the Burrowing Pocket Gopher on the Distribution of Archaeological Materials. *American Antiquity* 49:785–790.
- Farrand, W. R., 1975, Sediment Analysis of a Prehistoric Rockshelter: The Abri Pataud. *Quaternary Research* 5:1–26.
- Farrand, W. R., 1993, Discontinuity in the Stratigraphic Record: Snapshots from Franchthi Cave. In *Formation Processes in Archaeological Context*, edited by P. Goldberg, D. T. Nash, and M. D. Petraglia, pp. 85–96. Monographs in World Archaeology No. 17, Prehistory Press, Madison, WI.
- Frison, G. C., 1974, *The Casper Site: A Hell Gap Bison Kill on the High Plains*, Academic Press, San Diego.
- Gifford, D., and Behrensmeyer, A. K., 1977, Observed Formation and Burial of a Recent Human Occupation Site in Kenya. *Quaternary Research* 8:245–266.
- Gladfelter, B. G., 1977, Geoarchaeology: the Geomorphologist and Archaeology. *American Antiquity* 42:519–538.
- Gladfelter, B. G., 1981, Developments and Directions in Geoarchaeology. *Advances in Archaeological Method and Theory* 4:344–364.
- Goldberg, P., Nash, D. T., and Petraglia, M. D., 1993, *Formation Processes in Archaeological Context*. Monographs in World Archaeology No. 17, Prehistory Press, Madison, WI.
- Hassan, F. A., 1978, Sediments in Archaeology: Methods and Implications for Paleoenvironmental and Cultural Analysis. *Journal of Field Archaeology* 5:197–213.
- Haynes, C. V., Jr., 1964, The Geologists's Role in Pleistocene Paleocology and Archaeology. In *The Reconstruction of Past Environments*, edited by J. J. Hester and J. Schoenwetter, pp. 61–64. Publication of the Fort Burgwin Research Center, No. 3, Taos, N.M.
- Haynes, C. V., Jr., 1971, Time, Environment, and Early Man. *Arctic Anthropology* 8:3–14.
- Isaac, G. L., 1967, Towards the Interpretation of Occupation Debris: Some Experiments and Observations. *Kroeber Anthropological Society Papers* 37:31–57.
- Johnson, D. L., 1989, Subsurface Stone Lines, Stone Zones, Artifact–Manuport Layers, and Biomantles Produced by Bioturbation via Pocket Gophers (*Thomomys bottae*). *American Antiquity* 54:370–389.
- Kelso, G. K., 1993, Pollen-Record Formation Processes, Interdisciplinary Archaeology, and Land Use by Mill Workers and Managers: The Boott Mills Corporation, Lowell, Massachusetts, 1836–1942. *Historical Archaeology* 27:70–94.
- Krumbein, W. C., and Sloss, L. L., 1963, *Stratigraphy and Sedimentation*. W. H. Freeman, San Francisco.

- Laville, H., Rigaud, J.-P., and Sackett, J., 1980, *Rock Shelters of the Perigord: Geological Stratigraphy and Archaeological Succession*. Academic Press, New York.
- Limbrey, S., 1975, *Soil Science and Archaeology*, Academic Press, London.
- Miksicek, C. H., 1987, Formation Processes of the Archaeobotanical Record. *Advances in Archaeological Method and Theory* 10:211–247.
- Nash, D. T., and Petraglia, M. D., 1987, *Natural Formation Processes and the Archaeological Record*. BAR International Series 352, London.
- Pettijohn, F. J., 1957, *Sedimentary Rocks*, 2nd ed. Harper & Bros., New York.
- Phillips, P., Ford, J. A., and Griffin, J. B., 1951, *Archaeological Survey in the Lower Mississippi Valley, 1940–1947*. Papers of the Peabody Museum of Archeology and Ethnology No. 25, Harvard University, Cambridge.
- Pyddoke, E., 1961, *Stratification for the Archaeologist*. Phoenix House, London.
- Rapp, G., Jr., 1975, The Archaeological Field Staff: The Geologist. *Journal of Field Archaeology* 2:229–237.
- Rathje, W. L., 1974, The Garbage Project: A New Way of Looking at the Problems of Archaeology. *Archaeology* 27:236–241.
- Rathje, W. L., 1979, Modern Material Culture Studies. *Advances in Archaeological Method and Theory* 2:1–37.
- Reading, H. G., and Levell, B. K., 1996, Controls on the Sedimentary Rock Record. In *Sedimentary Environments: Processes, Facies and Stratigraphy*, 3rd ed., edited by H. G. Reading, pp. 5–36. Blackwell Science, Cambridge.
- Reid, J. J., 1985, Formation Processes for the Practical Prehistorian. In *Structure and Process in Southeastern Archaeology*, edited by R. S. Dickens, Jr., and H. T. Ward, pp. 11–13. University of Alabama Press, University, Alabama.
- Reid, J. J., Schiffer, M. B., and Rathje, W. L., 1977, Behavioral Archaeology: Four Strategies. *American Anthropologist* 77:864–869.
- Renfrew, C., 1976, Archaeology and the Earth Sciences. In *Geoarchaeology: Earth Science and the Past*, edited by D. A. Davidson and M. L. Shackley, pp. 1–5. Westview Press, Boulder, Colorado.
- Rick, J. W., 1976, Downslope Movement and Archaeological Intrasite Spatial Analysis. *American Antiquity* 41:133–144.
- Salvador, A., 1994, *International Stratigraphic Guide: A Guide to Stratigraphic Classification, Terminology, and Procedure*, 2nd ed. The Geological Society of America, Boulder, Colorado.
- Schiffer, M. B., 1972, Archaeological Context and Systemic Context. *American Antiquity* 37:156–165.
- Schiffer, M. B., 1975, Archaeology as Behavioral Science. *American Anthropology* 77:836–848.
- Schiffer, M. B., 1976, *Behavioral Archaeology*. Academic Press, New York.
- Schiffer, M. B., 1983, Toward the Identification of Formation Processes. *American Antiquity* 48:675–706.
- Schiffer, M. B., 1987, *Formation Processes of the Archaeological Record*. University of New Mexico Press, Albuquerque.
- Schiffer, M. B., 1995, *Behavioral Archaeology: First Principles*, University of Utah Press, Salt Lake City.
- Schiffer, M. B., and Rathje, W. L., 1973, Efficient Exploitation of the Archeological Record: Penetrating Problems. In *Research and Theory in Current Archeology*, edited by C. L. Redman, pp. 169–179. Wiley, New York.
- Selley, R. C., 1988, *Applied Sedimentology*, Academic Press, San Diego.
- Shackley, M. L., 1975, *Archaeological Sediments*. Wiley, New York.
- Stein, J. K., 1983, Earthworm Activity: A Source of Potential Disturbance of Archaeological Sediments. *American Antiquity* 48:277–289.
- Stein, J. K., 1987, Deposits for Archaeologists. In *Advances in Archaeological Method and Theory*, Volume 11, edited by M. B. Schiffer, pp. 337–393. Academic Press, Orlando, Florida.
- Stein, J. K., 1990, Archaeological Stratigraphy. In *Archaeological Geology of North America*, edited by N. P. Lasca and J. Donahue, pp. 513–523. Geological Society of America, Centennial Special Volume 4, Boulder, Colorado.
- Stein, J. K., 1992, Interpreting Stratification of a Shell Midden. In *Deciphering a Shell Midden*, edited by J. K. Stein, pp. 71–93. Academic Press, San Diego.
- Stein, J. K., 1996, Geoarchaeology and Archaeostratigraphy: View from a Northwest Coast Shell Midden. In *Case Studies in Environmental Archaeology*, edited by E. J. Reitz, L. A. Newson and S. J. Scudder, pp. 35–54. Plenum Press, New York.

- Stein, J. K. and Teltser, P. A., 1989, Size Distributions of Artifact Classes: Combining Macro- and Micro-Fractions. *Geoarchaeology* 4:1–30.
- Stockton, E., 1973, Shaw's Creek Shelter: Human Displacement of Artifacts and its Significance. *Mankind* 9:112–117.
- Straus, L. G., 1993, Hidden Assets and Liabilities: Exploring Archaeology from the Earth. In *Formation Processes in Archaeological Context*, edited by P. Goldberg, D. T. Nash, and M. D. Petraglia, pp. 1–10. Monographs in World Archaeology No. 17, Prehistory Press, Madison, Wisconsin.
- Tani, M., 1995, Beyond the Identification of Formation Processes: Behavioral Inference Based on Traces Left by Cultural Formation Processes. *Journal of Archaeological Method and Theory* 2:231–252.
- Taylor, W. W., 1948, *A Study of Archaeology*. American Anthropological Association, Memoir 69, Washington DC.
- Thomas, D. H., 1971, On Distinguishing Natural from Cultural Bone in Archaeological Sites. *American Antiquity* 36:366–371.
- Villa, P., 1982, Conjoinable Pieces and Site Formation Processes. *American Antiquity* 47:276–290.
- Villa, P., and Courtin, J., 1983, The Interpretation of Stratified Sites: A View from the Underground. *Journal of Archaeological Science* 10:267–281.
- Watson, P. J., 1986, Archaeological Interpretation, 1985. In *American Archaeology Past and Future: A Celebration of the Society for American Archaeology 1935–1985*, edited by D. J. Meltzer, D. D. Fowler, and J. A. Sabloff, pp. 439–457. Smithsonian Institution Press, Washington, DC.
- Watson, P. J., LeBlanc, S. A., and Redman, C. L., 1971, *Explanation in Archaeology: An Explicitly Scientific Approach*. Columbia University Press, New York.
- Wheat, J. B., 1967, A Paleo-Indian Bison Kill. *Scientific American* 216:43–52.
- Wheat, J. B., 1972, The Olsen–Chubbuck Site: A Paleo-Indian Bison Kill. Society for American Archaeology Memoir 26, Washington, DC.
- Willey, G. R., and Sabloff, J. A., 1993, *A History of American Archaeology*, 3rd ed. W. H. Freeman, New York.
- Wood, W. R., and Johnson, D. L., 1978, A Survey of Disturbance Processes in Archaeological Site Formation. In *Advances in Archaeological Method and Theory*, Volume 1, edited by M. B. Schiffer, pp. 315–381. Academic Press, Orlando, Florida.
- Wylie, A., 1989, The Interpretive Dilemma. In *Critical Traditions in Contemporary Archaeology: Essays in the Philosophy, History and Socio-Politics of Archaeology*, edited by V. Pinsky and A. Wylie, pp. 18–27. Cambridge University Press, Cambridge.