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Introduction

Since the invention of fired clay vessels about 10,000 B.C., pottery has become one of the most abundant artifacts left behind by ancient humans. While written records are restricted to a relatively small number of societies in the last 6,000 years and largely represent the work of political, social, and/or religious elites, ceramics provide information about how ordinary people actually lived, not just the literate. Ceramic artifacts are thus the products of the actual behavior of ancient peoples, and inferences of the past based on pottery can extend understanding of ancient societies beyond the verbal accounts of the learned, the wealthy, the privileged and the influential.

What do the ancient ceramics tell archaeologists about the societies that made them? Traditionally, archaeologists have used ceramics for formulating chronologies, for tracing political and economic relationships and for reconstructing ancient lifeways (see Sinopoli 1991 for a review). Ceramics, however, do not speak for themselves, but like all data, they must be interpreted (e.g. Anderson 1984).

In recent years, the study of contemporary, pre-industrial ceramic production has become an important tool for interpreting ancient ceramics. Archaeologists have long recognized the value of using contemporary societies to understand ancient ones where the two were linked in a direct historical way. But, more recently, they have asked fundamental questions about the relationships of artifacts and society and have turned to the study of the material culture in the ethnographic present. With few exceptions, however, answers to their questions were not found in the ethnographic literature. Archaeologists thus began studying contemporary societies themselves and this approach became known as "ethnoarchaeology," a term first used by Jesse W. Fewkes in 1900.[1]

While anthropologists have described pottery making among traditional societies for decades, ethnoarchaeology addresses questions that are specific to archaeology: How are artifacts and behavior related? Is social organization reflected in ceramic design? Can the different use-lives of pots affect interpretations of ancient pottery? How do patterns of discard and site-formation affect the interpretations of ancient ceramics? Since its beginnings in the 1960s, this "ethnography" of ceramic production, use and discard[2] has grown tremendously with research focusing on those parts of the world where pre-industrial potters still remain.[3]

Despite the enthusiasm for ethnoarchaeology, some archaeologists have cautioned their colleagues about utilizing ethnographic data to interpret the past. Hodder (1982a, 1982b) has warned against using contemporary societies

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uncritically to reconstruct ancient societies, while others have argued that the present differs so fundamentally from the past that ethnoarchaeology has limited use in archaeological interpretation (e.g. Rice 1987: 466–468). For those who argue that ancient and modern societies share similar cultural processes, Gould (1980, 1983) retorts that uniformitarian principles are inappropriate to interpret the past. He believes that ethnographic data should only be used to choose between competing inferences. Still others, however, argue that ethnographic work among contemporary peoples is essential for the development of a middle range theory relating material culture to its behavioral causes.[4] They argue that it is not the ethnoarchaeological *data* which should be applied to the past. Rather, they believe that a *theory* should be derived from the ethnoarchaeological data and then be used to interpret the artifacts of ancient societies.

If ethnoarchaeological data are so relevant to archaeological interpretation, how should one approach the study of a contemporary material culture? How should one study ceramic production, for example, in order to provide a useful theory for interpreting ancient ceramics? Certainly, great differences exist between the modern and ancient potters, but similarities exist as well. If ethnoarchaeology is to be used effectively in archaeological interpretation, it is essential to focus on the similarities in order to develop a theory for making inferences from ancient ceramics. A previous work (Arnold 1985) argued that there are widespread processual similarities in pre-industrial ceramic production between the present and the past and that these similarities consist of common adaptive processes that link ceramics, the environment and society. Describing these adaptive processes provides the foundation for developing a cross-cultural theory of ceramic production which can be used both in the present and in antiquity. Without such a cross-cultural approach to theory formulation, the application of ethnoarchaeological studies to archaeology is hopelessly tied to direct historical analogies and ethnographic homologies or mired in a slough of relativistic cautionary tales.

This book takes the ecological approach of an earlier work (Arnold 1985) one step further by using an ecological perspective to describe ceramic production in a single community. The purpose of the book is to elucidate the relationships linking ceramics, culture and the environment in one society at a single point of time. At the end of the book, these relationships are then applied to ancient ceramic production in the same region. This approach to the past is not based on homologies with modern ceramic production, or direct historical continuity, but rather on the adaptive processes that are common both to ancient and modern societies. Such processes occur in the Ayacucho Valley and in a variety of societies around the world (see Arnold 1985). The book is thus part of a continuing attempt to work out a theory relating contemporary ceramics to culture and the environment in a way that can be applied to ceramic production in antiquity.

Conceptual approach of the book

If archaeology has learned anything from the philosophy of science, it is the importance of theory formulation prior to the presentation of data. No matter how

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"objective" data may seem, these data are already theory-laden having been collected with certain *a priori* conceptual frameworks in mind (Hanson 1958; Kuhn 1962). No scientific undertaking is liberated from the personal, paradigmatic, theoretical, and interpretive presuppositions that affect data selection, collection and interpretation. The task of scientific investigators, then, is not to eliminate all bias in scientific description, but rather to be sure that one's interpretive, paradigmatic and theoretical biases are explicit. The personal background, interpretation and experience affecting this study have already been carefully described in the preface of this book. So, attention will turn now to its paradigmatic and theoretical underpinnings.

One of the most fruitful paradigms for developing a theory of ceramic production comes from cultural ecology. Originally pioneered by Julian Steward (1955) and now encompassed by cultural materialism,[5] cultural ecology seeks to generalize about cultural similarities and differences by analyzing the relationships of a culture's environment to its technology and social organization. A cultural ecological approach takes the position that the environment permits a range of choices that human beings can use for survival. By understanding the relationship of the environment and the technology of a society, it is possible to understand those forces that have selected the technological patterns that are necessary for a culture's survival. In some cultures, there may be a wide range of possible choices, whereas in others, the range of choices may be very small. In any case, cultural ecology is concerned with adaptation and the contribution that a culture's environment makes to its technology, social organization and beliefs. The ecological approach thus gives methodological priority to working out the relationships of the environment and the "exploitative or productive technology" (Steward 1955: 40), or, as Steward says, "the material culture of a society."[6]

Since ceramics are one kind of material culture and are part of the "exploitative technology," the study of ceramics fits well within the paradigm of cultural ecology. Applying this paradigm to ceramics means that one should first analyze the relationships of ceramics with the environment. Once such relationships are understood, one can then examine how ceramic production articulates with the rest of the technological subsystem of a culture and then with its social structural and ideological subsystems. By studying ceramic production as an adaptive phenomenon and seeing its relationship to the environment and to the society, it is possible to develop theoretical explanations that can be tested against the data from other societies and then be applied to the past as well. This approach thus creates cross-cultural explanatory generalizations which can help explain ceramic production in the past as well as in the present.

The attempt to develop such a theory is often attacked by those who argue: "My data from the BugaBuga (or the Fulano site) does not support this explanation, therefore it is false." Few archaeologists would want to argue, as this objection implies, that adaptive processes are so relativistic that they change from society to society and from one point in time to the next. Scientific explanations are probabilities. In the physical sciences, the probabilities of such explanations accounting

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for natural phenomena are much higher than in the social sciences, but they are still probabilities. "Law-like generalizations" of human behavior that approach the probabilities of the physical sciences are not possible. Explanatory theories of patterns, events and processes are never certainties and there are always data that do not fit the pattern. In the science of humanity, the probabilities of an explanation occurring are never 100 percent certain, seldom occur in more than 60 percent of the cases and in some cases may occur less than 50 percent of the time. No explanation fits all cases. But, to reject all theorizing because it does not account for all cases is to embrace a highly relativistic view of the past in which there are never any cross-cultural patterns of regularity. To the contrary, patterns of convergence and divergence in cultural evolution suggest that such general adaptive processes do exist.

An ecological approach to ceramic production

Ceramics can be approached by several methodologies at several levels of analysis. This work uses a cultural ecological paradigm and methodology to understand contemporary ceramic production. The application of cultural ecology to ceramics was first suggested by F. R. Matson who wanted to redirect ceramic studies away from the specifics of pots and potsherds towards the humans who made them. Matson thus coined the term "ceramic ecology" to express this concern and defined it as "one facet of cultural ecology . . . which attempts to relate the raw materials and technologies that the local potter has available to the functions in his culture of the products he fashions" (Matson 1965a; 1965b: 203).

The concern with "raw materials," "technologies," and "products" in Matson's definition, however, implies a heavy emphasis on ceramics as objects with limited recognition of the relationships that exist between ceramic production and society, on the one hand, and between ceramics and the environment, on the other. The preoccupation with ceramics as "objects" is understandable given the concrete and tangible data of archaeology, but if archaeologists want to infer patterns and processes of ancient societies, they must move beyond the ceramics themselves and focus on their relationships to the sociocultural system as a whole. *Relationships* should be the subject matter of ecology – whether ceramic or cultural. If one embraces an ecological approach to ceramic production, one would expect a wider range of relationships between ceramics, society, and the environment than just the "functions" of the ceramic product in the society that Matson suggested. Nevertheless, the concern with "relationships" in Matson's "ceramic ecology" was pioneering and does imply a broader relational paradigm even though it was not explicit. Matson's "ceramic ecology" thus represents an important conceptual change in the way that archaeologists have viewed ceramics. Understood more broadly, then, an ecological approach to ceramic production should focus on the relationships of the ceramics, *their production, use and discard* with the rest of the sociocultural system and the broader ecosystem.[7]

Since the formulation of "ceramic ecology" in 1965, Matson's ideas have inspired a number of studies[8] and the development of several volumes.[9] Kolb[10] broadened

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Matson's ecological viewpoint and provided a conceptual and methodological guide for ceramic analysis using an ecological approach. Arnold (1985) refined the ceramic ecological perspective to include a systems paradigm and provided cross-cultural data for a number of widespread relationships between ceramic production and the sociocultural system, on the one hand, and the environment, on the other.

The application of cultural ecology to ceramics thus reflects a paradigm which emphasizes the relationships of ceramics to the environment and to the sociocultural system. This focus assumes that culture can be usefully described as an open subsystem of the larger ecosystem and that all parts of it, including material culture, have relationships with other parts such that changes in one part produce changes in others (see Sharp 1952). This view of culture goes back to functionalism in anthropology, but is conceptually rooted in the organismic model of society from nineteenth-century social thought.

Applied to archaeology, the use of the systems paradigm means that there is a relationship of material culture to the intangible aspects of culture, and that the archaeologist can potentially infer ancient behavior of a society by studying the material culture of that society. Giving assent to this notion, however, does not mean that material culture can tell archaeologists everything they want to know about a society. Nor does invoking it mean that *all* of the aspects of a society are reflected in the material culture. Indeed, ceramics probably encode far less social and environmental information than archaeologists would like to believe they do. Rather, the point of using a systemic paradigm is far more basic. In a system, ceramics, like all parts of culture, have relationships with other parts of culture. But, the crucial component of this paradigm concerns the focus of research: the relationships between ceramics and social and environmental phenomena should be the focus of study rather than the ceramics themselves.

The systemic view of culture thus provides an important theoretical framework congruent with an ecological approach. The point is a simple one. Ecology focuses on interrelationships, but in order to study these relationships, an ecological approach to ceramics must assume that relationships exist between ceramics and the environment, on the one hand, and between the ceramics and the rest of culture, on the other. In an ecological approach, ceramics are not studied for their own sake. Rather, it is the linkages of the ceramics with social behavior and environmental conditions which should be the focus of research.

Unfortunately, these relationships cannot be inferred from the ceramics themselves. They cannot be discovered by analyzing the ceramics using scientific techniques like trace element or mineralogical analyses. Rather, these relationships must be brought to the process of interpretation from a theoretical understanding of the relationship of ceramics to environment and society in a broad range of societies. There is nothing inherent in the ceramics that can provide this information. Archaeologists thus have a problem; they must infer these relationships with little help from the analysis of the ceramics themselves. It is thus the task of the ethnoarchaeologist to discover those relationships between ceramics, the environment, and the society

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which actually exist and those which do not, and to test assumptions in the interpretation of ancient ceramics using ethnographic data.

In addition to the congruency of a systems view of culture with an ecological approach, a systems paradigm is also congruent with a set of formal properties which is characteristic of systems. This congruency enables cross-cultural comparison of the relationships between ceramics, environment and culture. Systems have a wide variety of characteristics which are isomorphic (that is share the same basic form) and these can be applied to any number of disciplines. All systems (whether living or non-living), for example, can be viewed as being characterized by goal-directed behavior and the processes of control and communication (Boulanger 1969). The first of these characteristics, goal-directed behavior, consists of the desired end-point of the system. This goal, however, does not need to be a conscious, human-directed goal, but may be a mechanical, inanimate goal. Human cultural systems, however, have the goal of survival which may be mediated by the preservation of the internal order of the society, and the production and transfer of information, matter and energy which foster that survival. Ceramic production is an alternative subsistence technique where the links to obtaining food are more complex than subsistence agriculture in which the technology provides food directly to a family. Potters must produce pottery successfully if they want to survive and obtain food for survival. A second characteristic shared by all systems consists of the processes of control and communication that permit the system to achieve its goal. These processes collect information about the difference between the desired goal and the actual performance of the system and then work to reduce that difference.[11] These processes are called feedback mechanisms and are viewed as mutual causal relationships in which the output of the system affects the input.

There are two types of feedback mechanisms: regulatory (or negative) feedback and deviation amplifying (or positive) feedback. Regulatory or deviation counteracting feedback promotes equilibrium and counteracts deviations from stable situations over long periods of time. This process of control prevents divergence from a prescribed set of boundaries. Deviation amplifying feedback, on the other hand, promotes or amplifies deviations as the result of some external input into the system (called "kicks") which the system cannot regulate. This mechanism causes the system to expand and reach stability at new, more complex levels (Maruyama 1963) when the inputs causing the expansion eventually become regulated and create new parameters for the system. Deviation amplifying mechanisms are thus the means by which the system gains new information and cause disequilibrium and change within it. In some situations, feedback may be both change-inhibiting (deviation counteracting) and change-inducing (deviation amplifying).[12]

The isomorphous relationships between ceramic production, the environment and the sociocultural system thus consist of basic feedback mechanisms which stimulate (deviation amplifying) and/or limit (deviation counteracting) ceramic production in a culture-environmental system. An earlier work (Arnold 1985) argued that these mechanisms are based on certain chemical and physical phenomena that underlie the nature of pottery itself, are adaptive processes and are

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tied to some of the fundamental processes involved in ceramic production. They are broadly classed into categories which include resources, weather and climate, degree of sedentariness, scheduling, demand, people-land relationships and innovations (Arnold 1985). They possess isomorphous (but not identical) relationships found in a broad range of societies throughout the world. The mechanisms thus have relevance to many different societies and can be applied to diverse societies in the present and the past as either stimulating or hindering the initial development of the craft and its growth and development into a full-time specialty. It is thus possible to partially explain the development and maintenance of both modern and ancient ceramic production using this approach without recourse to a simple kind of ethnographic analogy which requires a direct historical approach to the past or the use of ethnographic homologies.

Is the use of systems terminology just an attempt to obfuscate the obvious with unnecessary jargon? Or, does it say something deeper about the relationships of pottery, environment and society? The use of systems terminology constantly reminds archaeologists that culture and society are systems with varied interconnections. Because the western scientific tradition utilizes an analytical paradigm which breaks phenomena apart into their constituent units, one needs to be reminded that the essential character of ancient social and cultural inference is understanding the links between ceramics and their social, cultural and environmental context. Unfortunately, traditional anthropology does not provide a terminology that emphasizes the systemic interrelationships of culture. One learns detailed categories of technology, subsistence, social structure and religion, but relationships between these categories are not clearly laid out nor understood. In archaeology, one learns the details of ceramic paste, shape and decoration and how to classify such features into types, but the relationships of these entities to the rest of the sociocultural system are based more on traditional archaeological beliefs about the relationships of ceramics and society than on empirical knowledge of such relationships.

A scientific approach is analytical and scientists (especially social scientists) become experts in classifying phenomena into categories and coining new words for entities that do not fit traditional ones. One does not learn about the causal links, nor about the relationships between entities, but rather, one focuses on the entities themselves. One can take a society apart, but can one put it back together again? Can one reconstruct the relationships between parts of culture that one has so painstakingly analyzed, defined and categorized?

Nothing is more illustrative of this dilemma than a childhood memory. During a visit to my grandmother, I discovered some discarded alarm clocks. After taking them home, I disassembled them and enjoyed the thrill of handling shiny brass sprocket wheels and hearing the "twang" of recoiling springs. When I got the clocks apart, however, I could not reassemble them. I do not remember why I thought that I should *want* to put them back together, but perhaps in childish naïvete I thought that I could repair them. I do remember, however, that this same experience was repeated many times with other clocks, and with discarded auto parts from the

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repair shop across the street. I never could reassemble anything and in frustration, I always ended up throwing the clock and its parts away. Curiously, I do remember that although I took many, many clocks apart, I learned nothing about how they actually worked! Only now, I realize that in my childhood zeal to be analytical, I paid no attention to the relationship of the parts to one another as I took them apart. I never tried to understand how the parts of the clock fit together during disassembly. The point of this story is simple. One can analyze phenomena and never understand how the parts interrelate and how the system actually works.

This study is an allegory for the relationships between ceramics and society. We have focused so much on analyzing ceramics that we have failed to pay attention to the relationship of the ceramics with the rest of culture. In fact, we are so good at the analysis of ceramics that we are now able to describe their constituents in parts per billion. Such trace element analysis is, of course, indispensable, but we fail to recognize that the force of our analytical tradition and that of the language that we use to describe ceramics reflect a way of thinking that makes the discovery of relationships of ceramics, environment and culture difficult.

We need to understand how ceramics are related to the environment and society. The use of systems terminology reminds us that we need to think differently about ceramics and their relationships with the culture we seek to understand. Systems terminology is a constant reminder that archaeologists must develop "systems thinking" about ceramics if they are to use ceramics successfully to interpret the past. Understanding the relationships between phenomena is important, not just the analysis of the phenomenon itself.

Systems terminology also reminds us that the factors (feedback mechanisms) that affect the systems are multicausal. In describing the system, one must first be analytical and identify the units of the system and then describe the relationship between them. In an attempt to be clear, the relationships may seem to be monocausal. The relationship between climate and ceramic production, for example, may appear to suggest that rainfall prevents ceramic production in all cases and always hinders the development of full-time ceramic specialization. This misinterpretation, of course, is the result of analytical, monocausal thinking that is a part of our western tradition. The use of systems terminology, on the other hand, constantly reminds us that any feedback mechanism is only one of several interacting causative factors that affect ceramic production.

The use of systems terminology has been interpreted by some to mean that cultures are closed, stable systems that have reached equilibrium. On the contrary, cultures are constantly changing. While all cultures must have deviation counteracting mechanisms that keep the society from falling apart, they probably do not keep the culture in equilibrium. Deviations and cultural evolution will still occur even in the most isolated hunting and gathering societies. Furthermore, such feedback mechanisms are not immutable. They can change as the system gains information. Nevertheless, they provide a basis for cross-cultural comparison because they are rooted in the dynamic formal properties of the system's

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interrelationships rather than in its static units. These properties thus permit comparison of ceramic production in different cultures in similar ways.

Finally, systems terminology facilitates a way of thinking that permits latitude in the effects of the inputs to the system. Feedback processes, for example, are not a mechanistic, presence/absence, "if this, always that" kind of relationship. A single feedback mechanism is a process which may have a different effect on a system depending on the conditions under which it operates. The kinds of causes and subsequent effects are not fixed; they occur in a continuum, not just as presence/absence. Systems terminology thus reminds us that the societies of archaeological and anthropological study are fluid and changing, affected by multiple interrelated causative factors.

The complex nature of feedback mechanisms is more comprehensive and generalizable than studying the ceramic phenomenon itself. Feedback mechanisms provide a way to understand the processes of change, for example, in a more comprehensive way than by simply looking at the ceramics themselves. One can describe change by cataloguing its effects at different points in time, or one can explain such change conceptually. Explaining change is facilitated by using systems terminology because it attempts to uncover the underlying processes which cause the change. Such explanations increase the utility of the explanations of the relationships of ceramics, society and the environment by making them more universally applicable as processes which affect the evolution of ceramic specialization.

The unit of analysis

The interrelationships of ceramic production that occur within the ecosystem do not exist in isolation, but occur within the population of potters. The pottery-producing population is the interface between the ceramics and the larger society, on the one hand, and between the ceramics and the environment, on the other. Potters adapt to the environment through ceramic production and also modify this environment by expending energy to obtain the raw materials that are necessary to produce pottery. The pots then serve as channels of matter and energy which flow from the environment to humans in order to meet their nutritional and caloric needs. Ceramics also serve channels of ideological or social structural information between members of the society (Arnold 1985: 127).

Focusing on the population of potters as the locus of the relationships between ceramics, environment and culture is important for three reasons. First, the knowledge of, or information about, production resides within the population of potters and they behaviorally *produce* the ceramics. If any aspect of the society manifests itself in the ceramics, then it is transferred to the pottery in some way by means of the population of potters. Furthermore, pottery is the product of human agents and if any meaning exists in the pottery, it is the result of human action. Unless the relationship of the pottery to that action can be understood, interpretations of the past based on ceramic evidence are limited. Second, in harmony with ecological and evolutionary theory, the processes of ecological interaction and change operate primarily on the population, not on individuals.[13] The unit of adaptation is a

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population of living organisms and any relationships with the environment occur within that population. The population is thus the interface between the ecosystem, on the one hand, and ceramics, on the other. If one wants to relate ceramics to cultural and environmental systems, on the one hand, and to cultural and evolutionary change, on the other, one must understand the population of potters (rather than just the pots). Third, since cultures are viewed as having the properties of systems, focus on the population of potters is congruent with a systems viewpoint. Using the population as the unit of analysis thus avoids having to reconstruct a system of relationships from what is essentially a static phenomenon, that is ceramics. To use the allegory presented earlier, the dynamics of ancient society cannot be inferred from the statics of disembodied ceramics just as the workings of a functioning clock cannot be reconstructed from its disassembled parts. This problem is nicely embodied in the term "ceramic ecology" which appears to be conceptually contradictory because it links the static material culture (ceramics) with a dynamic, relational perspective (ecology). Nevertheless, it is for precisely this reason that "ceramic ecology" is an essential term for an ecological approach to ceramics because it expresses the paradox that every archaeologist faces in linking static material culture (ceramics in this case) with the dynamics of its contextual systems (society and the environment).[14] If ceramics cannot be viewed in dynamic terms and cannot be used to infer characteristics of the ancient society, there is not much point in using ceramics in archaeological interpretation. They are simply the objects that archaeologists find and have no social significance.

The point is that ceramics need to be understood with reference to a dynamic system if one is to make inferences about an ancient society from its ceramics. The study of the pots themselves will not provide these relationships no matter how many scientific analyses are used nor the number and kind of typologies used to classify them. Only by understanding ceramics as a part of a living system can archaeology begin to understand the relationship of pottery to society in the past. The unit of analysis in an ecological approach to ceramics should thus be the population of ceramic producers rather than the products of that population: pots.

With the importance of the population of potters established as the unit of analysis, it needs to be defined more precisely. The concept of the population used in ecological and evolutionary studies has important analogs with the population of potters. One of these analogs concerns the information in the population. One of the characteristics of a biological population is that it can interbreed and this feature has the effect of mixing and reshuffling genetic information within a common gene pool. Populations of potters also possess an analogous pool of technological information (or knowledge) which is shared through social interaction and learning. Just as genetic information is mixed and reshuffled through interbreeding, technological and decorative information is mixed and shared through social interaction whether it is done deliberately through verbal means or passively through visual means. The population of potters is thus a social group (rather than a biological one) whose numbers have regular social contact with one another. This group should be large enough to have some social interaction, and yet small enough to have this interaction

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