17 Ceramic Ecology

Most of the processual studies related to systems theory and focused on archaeological ceramics can be broadly included in a theoretical trend known as *Ceramic Ecology* (Matson, 1965a). In this perspective, the natural environment and, to a lesser extent, the functional contexts rather than the sociocultural factors are greatly emphasised. This position tries to understand and regulate the dynamic relationships existing between the ceramics as a cultural product and the natural environment as a way to transcend the objects themselves. From an ecological point of view, the adaptation of the pottery to the environment is the primary aspect in determining the physical features of the artefacts. Both the environment and the physical dimension of the objects condition the human behaviour developed to create the ceramics.

Many authors (e.g., Arnold, 1985, 1993; Kolb, 1988; Matson, 1965b, 1995; Rice, 1996; Rye, 1976, 1981) suggested from this cultural ecology viewpoint that the technological choices made by the potters could respond more to environmental issues, such as raw material availability and their quality, than to social factors. As recently clarified by D. Arnold (2011), the intention of this perspective is not to understand the relationship between pottery production and the environment in a mono-causal or deterministic sense. The main purposes consist in overcoming cultural determinism and highlighting those aspects of pottery production that, in opinion of most of the mentioned authors, clearly relate to environmental factors and were not considered when these perspectives became popular. Hence, it was considered that researchers had to take into account the crucial role that the environment plays in their interpretation of the relation existing between human behaviour and ceramics.

Ceramic ecology, in accordance with processualist thinking, agrees that from a cognitive perspective all human beings perceive the environment in the same way through their five senses. In this way, for example, many modern potters included in domestic productions (e.g., Arnold, 1971, 2000) are able to categorize their raw materials on the basis of variables such as colour, texture, presence of certain particles, plasticity, degree of salinity, etc. This perception allows potters to predict the suitability of the materials for pottery production and to select them accordingly. It is due to this sensorial perception that the basis for an epistemology of the human species can be established which sets a number of general connections between cognitive categories and the surrounding natural environment. These links can be glimpsed in the choices made by potters and, ultimately, in the vessels they manufacture. This common cognition involves, for instance, the raw materials used to make pottery, the idea of symmetry that structures the decorative patterns and defines the style of the vessels or the cognitive requirements that are necessary for firing the pottery.

It is accepted that the pottery has an additive component related to particular cultural patterns and that there are practices specific of each culture that go beyond purely cognitive knowledge. However, it must be also noted that this common human cognition is in fact the key factor that permits the development of pottery production

in many societies worldwide. In the case of pottery, this common cognition is possible thanks to the physicochemical properties of the materiality itself, such as clay plasticity.

In this sense, in this theoretical trend researchers are widely concerned about the behaviours that, from a participant observation and an etic perspective, allow them to establish cross-cultural connections that follow universal rules regarding human cognition and include materiality. Their interpretations are then performed from positions of presumed moral superiority, impartiality and objectivity that characterise positivist science. Thus, they emphasise that feedback relations exist between environment and culture that are isomorphic among societies. Although these connections could start from particular cultural causes, the fact is that they crystallise in the same way in different potter communities, thus acquiring a universal scope. It is in this feedback, which entails conscious and unconscious information flows, where the behaviour of the individuals takes place and where certain technological choices promoting change or stability in ceramics are developed.

Therefore, in this theoretical school, the particular rationale of each culture and the emic viewpoints or the "ideal behaviour" of the people studied are considered irrelevant in the analysis of ceramics. Therefore, the logic used by the individuals, for instance, to structure the design and decorative patterns in the vessels or for firing the pottery, is seen to be of little value to approach the past, since they do not respond to Middle Range Theories. These "ideal behaviours" are constructed categories which are related to what people say about what they do. However, they must not be thought of as the real reasons why people develop certain behaviours. Hence, in order to provide scientific validity, these behavioural patterns require further verification from an etic perspective.

The definition of Middle Range Theories is the ultimate goal of this line of thought. According to its premises, these theories provide a scientific value to pottery studies allowing the interpretation of the archaeological record and the past through ethnoarchaeological analogies. In addition, such ideas have been often combined with other evolutionary and economist perspectives and, in a few cases (e.g., Arnold, 1983), with structuralist viewpoints.

Finally, a cultural version of this approach has also been proposed, where the relationship between environment and culture is not seen as uniquely unidirectional. Therefore, culture is argued to interrelate with the natural environment. This latter position has led to new ecological trends that aim at approaching the way human beings physically and conceptually change and influence the biotic and abiotic resources available in the environment (Arnold, 1993; Banning, 2005; Dobres and Hoffman, 1994; Lavan, 2007; Van der Leeuw, 1984).

In short, ceramic ecology has tried to establish a significant correlation between parameters involved in pottery production or consumption processes and the environmental system. In this sense, diverse topics have been commonly addressed such as raw material procurement, spatial management of resources, environmental sustainability and seasonality.

17.1 Raw Material Procurement

The study of soils in the natural environment from the perspective of soil science and human geography has been undertaken with archaeological purposes since the 1960's. Pedological studies allow archaeologists to approach the composition and the local or regional variability of soils, as well as to infer the potential uses they could have had in specific archaeological contexts. The application of this trend had also some impact on ethnographic studies. Thus, ethnopedological approaches (e.g., Arnold, 1971, 1985; Wilshusen and Stone, 1990) aim at deepening in the interactions and the knowledge that humans establish with certain mineral resources.

As aforementioned, this perspective considers that there is a complex interaction in all societies between environment and the cultural perception that determines the way resources are exploited as well as the social organisation of production. Thus, depending on the natural possibilities, different resources can be selected in a particular region according to a series of social and biological needs. In this sense, the materiality involved in social practices is considered to be greatly influenced by the raw materials available in the environment (Kingery, 1984; Rice, 1984b). Clay resources available in the landscape are usually varied and rarely restricted to a single deposit. In this way, the variations observed in the composition of the pottery indirectly reflect the unequal distribution of the geological resources and the management of the raw materials present in a given environment (Arnold, 2000; Buxeda *et al.*, 2003).

17.1.1 Properties of Raw Materials

While sedimentary clay deposits apparently have the same basic properties (e.g., plasticity and ability for hydration), they are actually formed by lithologic components that can vary greatly from one deposit to another and, to a lesser extent, within the same source. These variations in the composition also determine fluctuations in the mechanical and physicochemical properties of the materials. These particular properties of soils may influence, on the one hand, a preferential selection of the natural resources based on their behaviour according to certain technical needs which are related to the manufacturing process and the use of artefacts. On the other, the properties of the raw materials available in the environment determine the way in which potters carry out production as well as the introduction of certain technical actions. In this sense, according to their experience, potters can use or refuse any particular clay, but they can also modify its behaviour and properties through experimenting and mixing the soil with other materials (Arnold, 2000; Cooper, 2002; Cuomo Di Caprio, 1985; Hein *et al.*, 2004; Mahmoudi *et al.*, 2008; Rice, 1984a; Van As, 1984).

The previous assumptions make clear that the knowledge of how and why people produce and use pottery requires to address the study of ceramics themselves, but also the analysis of their raw materials. Enquiries associated with the properties of clays can be inferred from the characterisation of their mineralogical, chemical and textural composition, as well as through their geological distribution (Carretero *et al.*, 2002; Chávez and Johns, 1995), as a complementary step to the study of the end products (Martín-Martín *et al.*, 2006). Through the combination of different archaeometric methods and techniques applied to the analysis of clay raw materials the complex interactions existing between technical, functional and ecological factors that are involved in the material culture can be inferred (Arnold, 2000; Blackman, 1992; Howard, 1982; Rice, 1984b; Roux and Courty, 1999; Van As, 1984).

In consequence, much technical and experimental research has been undertaken in the field of ceramology[18] in order to fully understand the physicochemical properties of clay materials. In these works, the analysis of certain variables and processes considered highly relevant in the ceramic production, such as the plasticity of the materials or the changes they experience during dehydration has been prioritised. The ultimate goal of these studies is to approach the specific behaviour of different types of clay in the several stages involved in the pottery manufacturing process, such as paste preparation, modelling, drying and firing. Although some of these studies examine the characteristics of raw materials associated with traditional or preindustrial pottery productions, the vast majority conduct in-depth approaches of the raw materials highlighting their functional application to the current ceramic industry.

As noted by Gibson and Woods (1990), there are some constraints that should be considered when extrapolating the reality of modern pottery to handmade ceramics of the past. Thus, prehistoric pottery is often coarse-textured and fired at low temperatures, while current ceramics have very fine pastes, thin walls and are fired at high temperatures. Anyway, although there are significant technical dissimilarities, the ceramological approaches are also interesting for studies of prehistoric pottery. In this sense, research undertaken in the field of modern ceramic production has provided knowledge regarding certain technological processes and facilitated the implementation of current and sophisticated methodologies to better understand the technology of prehistoric pottery.

In any case, some archaeological studies also perform, in addition to the identification and characterisation of local clays, experimental research with the aim of approaching the physicochemical properties and the behaviour of the raw materials available in the past. Thus, some key parameters (e.g., plasticity or thermal behaviour) which are involved in the various phases of the *chaîne opératoire* are

18 There are many applied studies focused on this ceramological approach (e.g., Bernal *et al.*, 2003; Carretero *et al.*, 2002; Chávez and Johns, 1995; Delgado *et al.*, 2007; Duitama *et al.*, 2004; Ferrari and Gualtieri, 2006; Jordan *et al.*, 2008; Lacasa *et al.*, 2000; Mahmoudi *et al.*, 2008; Maritan *et al.*, 2006; Martín-Martín *et al.*, 2006; Murad and Wagner, 1996; Souza *et al.*, 2005; Strazzera *et al.*, 1997; Toledo *et al.*, 2004).

recorded to evaluate the relationship existing between certain raw materials and the production of specific ceramic assemblages (Albero, 2011a; Capel *et al.*, 2006; Carter, 2002; Fernández Navarro, 2008; García Heras *et al.*, 2001; García Rosselló and Albero, 2011; Key and Gaskin, 2000; Maritan *et al.*, 2005a, 2005b; Núñez *et al.*, 2002; Vaughn and Neff, 2004). In this sense, P. Rice (1987) published an analytical protocol that provides useful information about the properties of clay raw materials that is quite accessible and affordable.

17.1.2 Provenance of Raw Materials

The provenance of the raw materials used in pottery production has been the most popular topic of ceramic ecology through ethnoarchaeological studies involving many societies, mainly from Africa and South America. From an economic viewpoint, these studies stated that in both domestic and specialised productions the resources commonly used in pottery production (e.g., clay, temper and fuel), especially those that required large quantities such as the clay base, usually come from the areas close to production sites. Thus, it is suggested that the distance at which the raw materials are collected respond to cross-cultural patterns related to proximity and the minimal effort principle (Arnold, 1985)[19].

These models were developed considering the transport of raw materials on foot, since it is perhaps the most common system used by many pre-industrial societies (Van der Leeuw, 1984) and was also applied for the procurement of mud building materials (Vaughn and Neff, 2004). Everything suggests that the availability of raw materials and their proximity are significant elements for potters. In spite of this fact, the use of mineral resources coming from waste materials, for instance from building material, is rarely considered. These materials could have been present in production areas and, albeit marginally, be opportunistically used to temper the pottery, thus explaining the occasional presence of peculiar tempers in the pots.

Furthermore, these models were partially corrected in recent works (Arnold, 2005, 2006) and were considered in probabilistic terms rather than as absolute assumptions. Thus, in 96% of the cases studied the preferential range of exploitation of raw materials is found to be usually located within less than 4 km from the production site. Moreover, in 49% of the cases the resources come from less than 1 km away. In this sense, potters are argued to share economic criteria linked to the "minimal

19 While D. Arnold is the researcher who better systematised this perspective, there are many archaeological and ethnographic studies that, to a lesser extent, also confirm this statement (e.g., Albero and Mateu, 2012; Beck and Neupert, 2009; Capelli *et al.*, 2006; Cooper, 2002; DeBoer, 1984; Druc, 1996; Gallegos and Armijo, 2008; García Rosselló, 2008; Krause, 1984; Livingstone-Smith, 2000, 2007; Longacre, 1999; Martineau *et al.*, 2007; Matson, 1989; Mercader *et al.*, 2000; Moshe and Adan-Bayewitz, 1999; Sillar, 1997; Skibo, 1992; Spataro, 2004; Varela, 1990; Vaughn and Neff, 2004).

effort" principle regarding the amount of energy invested. Therefore, it is evident the existence of energetic constraints, since once exceeded this range of distance in raw material procurement the pottery production is quite unviable in economic terms. In short, these premises can be considered in the study of the management of clay resources for the production of ancient pottery and other artefacts.

The residual percentage which is not included in this range of proximity is usually related to the procurement of particular raw materials which are rarely used in pottery production or have a casual use, such as pigments and resins. Moreover, resources acquired from greater distances do not necessarily contradict efficient behaviours in economic terms. In this sense, the use of beasts of burden, carts or any other means of transport different from the body itself must be considered as a way to enlarge the energy available to obtain raw materials by means of these same theoretical premises (Arnold, 2011).

In contrast with "minimal effort" principles, there are other cases where clays are procured from greater distances following the movements people do along their territory. These movements are performed on the basis of family ties or carrying out other activities such as agriculture or trade or to search for raw materials for other crafts. In these cases, it is possible to collect small amounts of resources that are more limited in the territory during the trip.

In this sense, ceramic ecology justifies the economic viewpoint arguing that in these situations energy is not solely invested in the procurement of raw materials, but also in the performance of other activities. So, the energy exclusively devoted to acquiring materials is considerably reduced. Although there may be exceptions to this economic pattern, they are unlikely. When inefficient behaviours take place, it is argued that they are not usually long-term, especially if the production intensifies. If this happens, it is necessary to incorporate new energy sources in the production, such as more efficient means of transport (Arnold, 2011). In this sense, it is considered that the daily and massive use of resources located at long distance requires certain social settings and infrastructures in order to maintain a close interaction with external agents that enable the procurement and movement of the raw materials (DeBoer, 1984; García Rosselló, 2008; Rice, 1984a).

According to the previous statements, many archaeological studies[20] in recent decades conducted intense field surveys in landscapes associated with certain

20 For instance: Aguayo *et al.* (1992), Albero (2011a), Albero and García Rosselló (2011), Albero and Mateu (2012), Beck and Neupert (2009), Bollong *et al.* (1993), Brodà *et al.* (2009), Capel (1983, 1986), Drebushchak *et al.* (2005), García Rosselló and Albero (2011), Gherdán *et al.* (2007), Gómez *et al.* (2002), Howard (1982), Jorge *et al.* (2009), Key and Gaskin (2000), Klein *et al.* (2004), Kóvacs *et al.* (2009), Kretier *et al.* (2007), Mainman (1982), Maritan *et al.* (2005a), Moshe and Adan-Bayewitz (1999), Morris (1982), Padial *et al.* (1998), Papadopoulou *et al.* (2006), Peacock (1969), Rice (1984b), Sauer and Gassner (2009), Shoval *et al.* (2006), Starnini and Szakmány (2009), Stoltman (2001), Szákmany and Starnini (2007), Taubald (2009), Tite (2008), Varela (1990) and Whitbread (2003).

archaeological sites or potter communities. These surveys, which are often developed considering also geological criteria (Duitama *et al.*, 2004; Szákmany and Starnini, 2007), aim at identifying clay-bearing outcrops, knowing their proximity to the production centres, and, finally, selecting samples for undertaking their archaeometric characterization. In this kind of research, the composition of the clays obtained from archaeological contexts or from the neighbouring landscape is characterised and, subsequently, compared with the features of the ceramic materials. The intention is to conduct a more accurate approach to the material record and the behaviours which rule over the selection of specific raw materials.

The landscapes included in these studies are not identical to those existing in the past. However, given the time scale of geological processes, the clay sources currently available are considered to be also present in the recent past, especially if they are located close to archaeological sites. In any case, it is emphasised that the analysis of the resources potentially available in the environment should be considered in relative rather than absolute terms (Rice, 1984b). Notwithstanding a number of exceptions, it can be difficult to relate archaeological materials to certain resources geographically located because the environment is constantly changing and, therefore, some outcrops which were potentially available for pottery production in the past may not be present today. Moreover, clay resources can be significantly dispersed in the geography; therefore, most of them may remain unknown to the researchers. This fact demonstrates the limited applicability of this "minimal effort" perspective in the interpretation of archaeological ceramics. In addition, it should be considered that there is usually some degree of uncertainty when approaching the provenance of ceramics through compositional analysis.

Recently, D. Arnold (2011) recognized that what he hoped to achieve with his studies was to establish a number of empirical categories in order to define which pottery productions can be classified as "local" and which ones as "imported". The final goal was to favour the interpretation of raw materials management in archaeological contexts. This position stemmed from the fact that most of the studies which focused on the provenance of pottery addressed the origin of the vessels through macro-scalar perspectives and in a supra-regional level without precisely defining these terms.

Broadly speaking, a pottery is considered locally produced when there is a certain geological compatibility with the closest resources. In this way, the mineralogical, textural or chemical composition of the ceramics should be well correlated with the features of the clay deposits located in the environment nearest to archaeological sites. In some studies (e.g., Spataro, 2002) both raw materials obtained at less than 15 km from the production centre and resources that are less than half a day away are considered as local. In contrast, the analysis by D. Arnold (1985, 2005, 2006), based on ethnographic case studies, suggests that we can usually consider local resources the raw materials obtained at less than 4 km.

A regional provenance can be established for the pottery when its composition is not conclusively linked with resources placed in the local environment but matches well with the geological traits of other sources of the region. Finally, products whose compositional attributes are not consistent with the geomorphology of a geographically well-defined area or a specific territory can be considered imported. In the latter cases, a number of potential sources of origin can be pointed at depending on the distance of the resources present and the main trade routes used by the societies that produced and consumed the ceramics.

While the studies conducted by D. Arnold permit us to reach a consensus about what should be considered a local production, the application of such broad categories about the provenance of the pottery does not lead to a thorough understanding of the practices involved in the management of raw materials in the past. Thus, the vast majority of domestic pottery production strategies, even those in which the ceramics are distributed more than 100 km away from their place of origin (e.g., Calvo *et al.,* 2013), relate to local productions. The same happens with specialised pottery productions (e.g., Albero and Puerta, 2011). In both cases the raw materials are collected in the closest surrounding area. Consequently, provenance analyses performed at a micro-regional level are quite unusual (Rice, 1984b) and the macro-scalar models regarding raw material management just provide anecdotal and obvious information. Therefore, the application of micro-regional scales would be more appropriate to address properly other concerns involved in the procurement of raw materials that are more significant for the study of pottery technology and production contexts (*vide infra*).

17.2 Settlement and Subsistence Base

Resources are differentially distributed along aterritory and may vary in quantity and quality as well as in their location in time and space (DeBoer, 1984; Vaughn and Neff, 2004). This unequal distribution of abiotic and biotic resources is materialised in areas where the raw materials have a specific composition that better suits certain uses, such as the application to agricultural activities, pottery production or building. Thus, cultural ecology highlights that this imbalanced distribution of resources in the natural environment determines the placement of the settlement as well as the subsistence base characterising the society. A holistic perspective involving the whole natural environment surrounding archaeological sites is, therefore, essential to understand settlement patterns and the way the space is used according to certain subsistence strategies. These relations are crucial to approach, for instance, change and stability in pottery production.

The environmental diversity present in the territory determines which activities are performed. Thus, several communities were documented – for instance in Tabasco in Mexico (Gallegos and Armijo, 2008), Kofyar in Nigeria (Wilshusen and Stone, 1990)

or Ancash in Peru (Druc, 1996) – where land use is determined by soil variability in the landscape. While sandy soils are easily drained and therefore useful for agriculture, clay soils, due to their properties, have drainage problems. In this way, examples of the prevalence of specific activities based on the quality of the soils are found in Quinua (Peru) and Guatemala, where the presence of poor soils for agriculture justify a more intense dedication of the population to pottery production (Arnold, 2011).

The availability of certain raw materials and types of soil in the territory also determines the generation of conflicts between different subsistence activities. For example, resources which are essential for the development of pottery production might be claimed instead for agricultural activities. These problems increase when food production intensifies – for instance, due to population growth – and requires more land. In these cases, the worst soils are often set aside for pottery production while the more productive ones are used for agricultural purposes. In short, as some ethnoarchaeological studies (Rice, 1984a, b; Wilshusen and Stone, 1990) demonstrate, agricultural productivity, which is very sensitive to demographic changes, can influence the management of mineral resources in the whole territory.

The continuous extraction of clay in surface outcrops can cause multiple and severe perforations in the sediments which increase the exposure of the soil surface to erosion (e.g., rainfall) with the subsequent loss of nutrients. This process provokes the destruction and alteration of potential areas of cultivation, thus permanently reducing the subsistence carrying capacity of human groups. The effects of this process are especially critical when nutrient-rich soils are quite scarce. In response to this unsustainable environmental situation, some societies with an agricultural economic base regulate explicit prohibitions regarding clay procurement from agriculture fields. These prohibitions are developed even if the alternative deposits available to produce ceramics are of poorer quality and involve a more dispersed exploitation of the sources along the territory, thus increasing the variability of the ceramic record (Arnold, 2000; García Rosselló, 2008).

Also the procurement of fuel for firing pottery represents one of the main costs involved in the production process. In this sense, vegetable fuels such as the ones typically used in pottery production may be a limited resource in the territory and, therefore, come in competition with different productive activities (Arnold, 1999; Cuomo Di Caprio, 1985; Gibson and Woods, 1990; Matson, 1989; Morales, 2005; Sillar and Tite, 2000).

As already mentioned, the types of soils present in the natural environment occupied by ancient societies play an important role in the way the space was managed. In this way, in many societies there is a close spatial connection between certain human settlements and particular mineral resources, such as clays (Cordova *et al.*, 2005; Matson, 1989). Thus, the formation of certain archaeological records obeys specific relations between environment and people (Schiffer and Skibo, 1987). These issues can be ultimately addressed through the study of the settlement pattern

of ancient societies in relation to the distribution of the different kinds of sediments located in the territory (Rice, 1984b; Sofaer, 2006).

In this sense, the proximity to particular clay resources may influence the way in which potters settle in the landscape. An ethnographic example is documented in Pòrtol (Mallorca, Spain), where the closeness to high quality clay resources for manufacturing cooking pottery conditioned the settlement of a community of potters in the seventeenth century (Albero and Puerta, 2011). Another case would be the abandonment of certain Hopi villages due to, at least partially, long distances at which the potters had to collect their raw materials (Arnold, 2011).

Furthermore, the influence of the environment in the many dimensions of pottery and space management is exemplified in the analysis made by D. Arnold (1983) of the relations existing between the decorative patterns of the vessels and the use of space in Quinua (Peru). He stated that vessel designs and their function express structural principles related to the conceptualisation, organisation and use of the natural and social environment. In this village, the several ecological zones – based on the distribution of irrigated areas – are physically arranged and structured through horizontal patterns, just as happens in pottery decorations.

According to Arnold, to discern such complex relations (e.g., between environment, resources, productive activities, settlement patterns, etc.) is complicated in archaeology as the quality of all the soils existing in the past can be difficult to know. Moreover, it is often problematic to know which other activities were performed by the potters and other individuals in the territory. In any case, this trend considers that the natural environment and its resources could have determined the settlement pattern of ancient societies as well as their most important subsistence activities. In any case, it should be considered that the settlement pattern itself also determines the way resources are exploited in the territory. For example, a concentrated, sedentary and stable occupation of the space may favour the use of specific resources, thus reducing the variability of the raw materials used in pottery production. In contrast, mobile settlement patterns usually entail the exploitation of a wider range of sources (Arnold, 2000).

17.3 Seasonality and Climate Conditions

Many ethnographic studies, such as the ones carried out with Bantu (Krause, 1984) or Kalinga (Skibo, 1992) potters, highlight that pottery production undertaken in domestic contexts are usually part-time, for instance after the harvest season or when there are favourable weather conditions. In this way, from an ecological viewpoint, weather and seasons are considered to constrain or stimulate pottery production. Thus, the physical characteristics of clays and fuels, the duration of the rainy season, the degree of humidity throughout the year and, in general, the climate conditions determine when pottery can be manufactured. All these factors determine if a full-

time specialised production is economically viable or only a seasonal and occasional production can be achieved (Arnold, 1975, 1985, 2011).

On the one hand, potters can adjust their production to the environment and weather conditions. For instance, certain climatic factors (i.e., wind, rain, etc.) can have a negative influence on firing customs, especially when the potter uses open-structures such as bonfires in which many of the variables involved in the process cannot be controlled. Therefore, an adequate strategy to solve these climatic constraints consists in performing the pottery firing only under the appropriate weather conditions. In this sense, potters have to know the apt time and place for firing the vessels, which implies some knowledge of meteorology. An example of this common wisdom is observed in Tabasco (Mexico), where pottery firing is exclusively undertaken when the moon is full and there is a bright sunshine (Gallegos and Armijo, 2008).

On the other hand, pottery manufacturing can be developed under adverse climatic conditions through small-scale and low intense production. Moreover, environmental limitations can be also counteracted by certain technological choices that minimise weather's negative effects (Arnold, 2011). In this sense, the use of certain techniques and structures (e.g., kilns and drying areas) as well as materials (e.g., specific tempers), can be interpreted as an adaptation to overcome adverse weather conditions that can significantly affect the ceramic production. While the warmer seasons are the ones more suitable to develop pottery production, this activity should not be necessarily restricted to certain times of the year. Thus, in domestic productions such as the one currently developed in Cuzco in Peru (Sillar, 1997) and San Nicolás in the Philippines (Longacre, 1999) pottery manufacturing is more intense in the dry season, when there is no rain and consequently a low humidity in the atmosphere. However, ceramics can also be produced occasionally during the rainy season. In other cases, as among the Newari in Nepal (Arnold, 1985), a wide range of vessels is produced at a specific time of the year and later stored until required for use or its production can be resumed.

The seasonal cycles determine, in turn, subsystems such as the economy in which, as already seen, certain activities (e.g., agriculture) are developed that influence the organisation of pottery production. In Yucatan, for instance, pottery production is undertaken along the year according to other productive activities, thus they do not compete for the same resources (Arnold, 1985). Often, as we observed in north-east Ghana, the pottery is produced in the dry season coinciding with the gathering of the harvest, since it is considered the most suitable time to perform this activity.

In this sense, pottery production must be adapted to the amount and kind of fuel available as well as to the seasons in which it is manufactured. Sometimes the fuel is also stored until needed. These aspects may favour the use of certain types of firing structures, thus influencing the features of the end products (Pool, 2000; Sillar, 2000). Moreover, in periods of fuel scarcity the use of waste materials generated by agriculture (e.g., from pruning) or industry (e.g., car tires) is not uncommon (Sillar,

2000). We observed this strategy in pottery workshops from Fez (Morocco), an area in which wood fuel is scarce and where some potters have opted to use waste from olive materials, once the oil has been pressed, to perform long pottery firings which allow reaching temperatures up to 1200ºC.

Access to the clays is also a parameter that should be considered in the study of raw material procurement, since it may influence the choice or rejection of a specific source of clay, even if it is of good quality (Arnold, 2000; Cooper, 2002; Wieder and Adan-Bayewitz, 1999). Thus, as seen in potter communities from Niger (Gosselain, 2008), the production takes place in the dry season according to a seasonal organisation of the activities, but also because clays are more accessible and pastes dry better.

Some authors (Rice, 1984a) suggest that the availability of the resources is one of the parameters that explain why the raw materials used in pottery production may change across time and space. Thus, ethnographic studies, such as the one about the Shipibo-Conibo (DeBoer, 1984), demonstrate that there is a preferential exploitation of certain resources depending on natural cycles that alter their accessibility along time. It must be considered that the clay outcrops do not necessarily need to be permanent in space, since natural factors may influence their availability. In this sense, while some clay deposits are easily accessible the whole year round others may be covered by courses of water at certain seasons. These clays are suitable for pottery production but cannot be identified and remain inaccessible because the physical characteristics of the environment prevent their exploitation.

Moreover, although many clay deposits which are close to watercourses or wetlands may be available, they can be excessively wet most of the year. The high moisture content of these raw materials may affect the manufacturing process since excessively wet clays must be dried before using them to make vessels. This aspect ultimately affects the organisation of production and the consumption patterns because more time is needed to perform pottery production. Such environmental factors determine when the manufacturing process can be developed, so it can be intensified at certain times of the year. Anyway, overcoming these climatic constraints involves controlling parameters such as temperature and humidity, something which is achieved through drying and firing processes (Arnold 2011; García Rosselló, 2008).

The presence of high moisture content in the clays may favour certain technological choices, such as the addition of dry organic matter, which can decrease drying time and reduce the time spent in pottery production (Schiffer and Skibo, 1987). In these cases, a correlation between the amount of organic temper added and the moisture content of the clay and air humidity can be suggested. So, moisture content can explain the variability existing in the amount of organic temper observed in certain fabrics.

Furthermore, the coarser texture and higher porosity that provides the use of tempers to the paste, besides being ideal to fire hand-made ceramics in open-firings, also ensures the proper drying of the pottery, even in seasons or places with high

relative humidity. Thus, the production can be developed throughout the year. Anyway, despite these technical solutions, there are other factors such as cold or freezing that adversely affect and constrain pottery production. However, they do not necessarily prevent the potter's activity (Djordjevic, 2003; Gibson and Woods, 1990; Krause, 1984).

It must be also considered that during certain times of the year a higher erosive action takes place favouring the formation of landslides and cuts in the sides of the slopes, thus exposing and making some clay outcrops available. Such natural processes can affect the configuration of the clay deposits and are important for explaining the use or abandonment of certain clay sources (Arnold, 2000; Rice, 1984b).

Finally, the space where pottery production takes place can be also selected on the basis of climatic conditions. In this way, the adequate place to make pottery should not be exposed to wind or sun. In this sense, drying the vessels outside domestic structures can avoid risks related to the movement of people or animals but, in contrast, can cause other damages due to a higher exposure of the vessels to undesirable weather conditions. Moreover, the movement of the pottery along the many working areas also increases the probabilities of failure and, therefore, the subsequent need to produce more vessels (Arnold, 1999; Cruz, 1996; DeBoer, 1984; Mills, 1989).

17.4 Scope of Ceramic Ecology

Ceramic ecology, in its origins, played an important role in pottery studies. Thus, this trend permitted researchers to overcome culture-historical viewpoints which had mainly focused on the typological classification of pottery with the sole purpose of establishing its relative chronology and spatial distribution. The final goal of the culture-historical studies had been to establish and sequencially arrange certain archaeological records with the aim of defining societies into distinct ethnic and cultural groups and interpret them in evolutionary terms.

Both ceramic ecology and functionalism have tried to give this materiality a meaning by relating it to a series of stable social dynamics and trying to explain the change in pottery production through arguments not exclusively diffusionist. Furthermore, both perspectives have encouraged significant methodological development in archaeological studies. As seen in Chapter 1, among these improvements the use of multiple archeometric analytical techniques which allow deeper characterisations of the pottery fabrics and the properties of the artefacts is especially noteworthy. Thus, thanks to these methods, other questions involving the relationship between materiality and people can finally be addressed.

The consideration of the spaces occupied by settlements and the distribution of clay resources in the territory provides a useful framework for the understanding

of raw material procurement strategies in ancient societies (Key and Gaskin, 2000). Thus, it may be interesting to record spatially the availability of raw materials that have different properties and try to establish whether or not they were exploited and the reasons explaining their use. In this sense, the analysis of the efforts devoted to collect and prepare the clay can be useful for addressing further reasons far from concepts of technical and economic efficiency which could have participated in the selection and management of raw materials (Martineau *et al.,* 2007). This kind of perspective, once properly contextualised, may be helpful in a number of ways, from explaining the relationship between potters and the natural environment, to locating areas of provenance for the vessels, to finally, making assumptions about the motivations and rationale of the individuals involved.

While the generalisation of this kind of approach in archaeology is evident in the large number of studies mentioned, there is still much research focused on the composition of archaeological ceramics which pays little attention to the potential variability of local raw materials. Thus, many studies often tend to ignore some relevant aspects such as the location and accessibility of the different clays, among other key factors, that may be involved in the procurement of raw materials (Stark *et al.,* 2000). Furthermore, the spatial identification of the clay sources exploited in the past can be used, in the absence of other more consistent material evidence (e.g., workshops, kilns or waste areas), to establish hypotheses about the potential location of production areas within the territory.

To summarize, in order to make a proper classification of pottery and fomulate certain inferences about their technology, it is advisable to approach the characteristics of the environment and raw materials. This ecological view allows comparisons between ceramics and the clay sources available in the territory and, through experimental and analytical studies, to explore the way clays were managed. Eventually, we can assess which changes took place in the use of raw materials throughout time and space according to the creation of specific pastes that may respond to technical, functional and sociocultural factors (Bonzon, 2003; Martineau *et al.,* 2007). Therefore, it should be admitted that in the study of pottery technology it is convenient to consider also the distribution of the raw materials in the landscape (Tite, 2008), among other environmental parameters.

17.5 Criticism to Ceramic Ecology

Despite the strengths of ceramic ecology already mentioned, it should be also stated that this perspective understands the environment as a deterministic and universal element, thus promoting reductionist explanations. The natural context, the distribution and properties of the raw materials available in conjunction with climatic conditions and seasonality, determine the presence or absence of pottery production in a given society, its intensity, scale and degree of specialisation. These perspectives

have led to normative propositions which propose general laws regarding, for instance, the negative correlations between agricultural potential and the amount of pottery production (Arnold, 1978) or assumptions like the one that concludes that the anthropic pressure exerted on the natural environment must be less because a lower firing temperature means a lower fuel consumption (Waldren, 1982). Without attempting to confirm or falsify these claims with countless examples, the fact is that they may be true in many cases but may not be in others.

Thus, the natural spatial variability of soils should be considered as just one of the parameters involved in the creation of material culture, as there are other cultural variables that largely influence the way the several mineral resources available are exploited. The social organisation of production can greatly affect how resources are procured and this activity can be performed with the aim of enhancing the integration of individuals in society. It can be accepted that resources are differentially selected in a specific region according to the possibilities of the natural environment, specific physical properties and certain biological needs, but also depending on complex historical factors and social needs. Thus, ceramic ecology excludes explanations which involve the significant cultural variability documented in the way raw materials are exploited.

Many ethnographic (e.g., Albero and Puerta, 2011; Barley, 1994; González Ruibal, 2005; Gosselain, 1992a, 1994, 2008; Gosselain and Livingstone-Smith, 2005; Gosselain *et al.*, 1996; Sillar, 1997) and ethnoarchaeometric studies (e.g., Arnold, 2000; Cruz, 1996; Livingstone-Smith, 2000; Mercader *et al.*, 2000; Neupert, 2000; Pool, 2000; Stark *et al.*, 2000) demonstrate that although resources may be collected in accordance with environmental, economic or functional factors there are also relevant social, cultural, symbolic, ideological or political parameters. All these parameters which are related to the social organisation of production, the perception of clay sources and the role of pottery within society have to be, then, fully considered to properly understand and explain the reasons why certain forms of resource management are preferred over others. In this sense, the use and abandonment of clay sources can be a powerful cultural marker. Similarly, synchronic differences in the use of resources may reflect a situation of social dialectics. Moreover, socio-political factors, for instance those related to partnerships or land tenure, may dictate, even in written records, which resources should be used and the way they have to be managed.

Therefore, most of these studies highlight how the historical and social context greatly affects, along with the other variables already mentioned, the use of clay deposits and pottery production. In short, these approaches confirm that other kind of aspects interact with the materiality and that only considering all the factors involved we will be able to deepen our understanding of the complex phenomena underlying the management of clay sources in space and time. Thus, the final stage must consist in assimilating such management strategies in their own social context (Koriakova, 2006; Laviano and Muntoni, 2003; Levi and Sonnino, 2003; Martineau *et al.*, 2007).

In response to such arguments, D. Arnold (2011) points out that the fact that many potters do not justify the procurement of their raw materials by proximity and minimum effort criteria but by tradition, land tenure, social ties or religion does not contradict or diminish the validity of the model proposed and established by means of etic perspectives. Actually, in his opinion, these emic perspectives enrich our understanding regarding specific cultural aspects involved in the exploitation of raw materials. However, although these perspectives promote a holistic viewpoint of the processes, cultural assumptions are considered of little scientific value, since they do not lead to universal laws.

The same problem applies to the timing of production. Although environmental aspects such as seasonality are essential to understand this aspect, social and symbolic factors should also be considered. Thus, variations in the tempo of pottery production have a structuring role in many traditional societies, since the activities involved in manufacturing the vessels also symbolises different times in the year and the life cycles of people. For instance, in the Dowayo ethnic group (Cameroon) pottery production is closely related to the human life cycle (birth, adulthood and death) and an annual cycle in which important events such as funerals, rites of passage, circumcision, etc., are temporarily organised (Barley, 1994). Also in the area of Negros in the Philippines, the highest pottery production coincides with the celebration of festivals that involve the whole community and in which ceramic artefacts are required to be exhibited (Van der Leeuw, 1984).

Summing up, the epistemological goals of ceramic ecology have led to wide and superficial generalizations regarding pottery production as well as the establishment of universal behavioural patterns. Consequently, their principles do not explain the technological variability and cultural specificities observed in potter communities. The criticisms made regarding this school should be framed within those generally used for processualism and systems theory. These involve, among others, the presupposed objectivity and impartiality of their perspectives, the use of analogies and essentialist viewpoints, little attention to cultural contexts in the explanations, interpretation restricted to macro-scale or high level-theory, the prevalence of western and modern conceptions and categories, etc. (see, for instance, Hodder, 1991; Jones, 2002).

In relation to the role of the environment in pottery production processes, Hodder (1991) criticizes the lack of contextual information and the consequent impossibility to establish from an emic perspective the strong ties existing between abstract structures and content of meanings underlying the materiality. Moreover, D. Arnold (2011) accepts, in a recent reflection of his own research work, the fact that the ethnoarchaeological studies he has been developing in Peru, Mexico and Guatemala have limited value in transcultural terms. This is due to the close linkage existing between the data collected and the specific cultural contexts under study.

Finally, nature and materiality are understood in static and stable terms in these evolutionary theoretical trends. Moreover, this unchangeable character is also applied to the way humans perceive both elements, thus allowing the same perception of the environment and materiality regardless of time and space (Jones, 2002). Hence, it should be considered, in the first place, that the perception of reality and materiality is always historical, contingent and relational, since it can be included in many possible categorisations depending on the way in which perception is undertaken and sensory experience is understood (Ingold, 2012). In this sense, perception of reality may range, for instance, between mono-sensory and multi-sensory approaches (MacGregor, 1999). This contingency is reflected, for instance, in the different perceptual criteria that different potter communities use to classify the clays they use (e.g., Arnold, 1971; Wilshulsen and Stone, 1990). In addition, the existence of potters such as the ones in Quinua in Peru (Arnold, 2000), who are neither able to predict the quality of the clay by means of mineralogical parameters nor conceptualise it evenly through the perception of its physical properties should also be noted. In these cases, D. Arnold justifies the lack of adequacy to universal standards arguing that the intra-deposit variability often existing in clay sources precludes the development of common perceptive criteria regarding raw materials.

Hence, it is convenient to approach the issues developed in this section from a symmetrical position between culture and nature in which one cannot be understood as opposed to the other (Latour, 1993) and in which both are contingent. This viewpoint involves accepting that nature is not constant and unchanging but, in contrast, has to be understood from multiple cultural perspectives. In this sense, the idea of a static, constant and deterministic nature characteristic of the ceramic ecology proposal is not neutral. It is intensely rooted on a western and modern conception of the environment that has been established by certain individuals through specific cultural settings, philosophical principles and scientific basis.