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This paper presents studies and discussions of pottery-making practices during the Late period (ca. A.D. 900–1450) in Northwestern Argentina. It stems from an extensive archaeological research project carried out in the middle sector of the Abancán Valley, Province of Catamarca, Argentina. Pottery production during this period is evaluated through the study of technological choices and technical identity, as well as its relationship to the technical behaviors developed by potters. The analysis of a large sample of ceramic sherds, complete vessels, and overfired sherds indicates that the potters produced a very narrow repertoire of ceramic forms (bowls, urns, and ollas) using local raw materials and technology, the latter with a strong hold in the area. Pottery production during the Late period was carried out in household contexts, becoming increasingly intensified and concentrated with the appearance of inkas in the region. Additionally, some ideas are discussed concerning the technological choices of ancient potters during this period, and the implications for technological studies in archaeological ceramics.

En este trabajo las prácticas alfareras desarrolladas por los alfareros antiguos durante el período Tardío (ca. 900–1450 d.C.) en el noroeste argentino son estudiadas y discutidas a través de una investigación arqueológica extensa llevada a cabo en el sector medio del Valle de Abancán, Provincia de Catamarca, Argentina. La producción de alfarería para este periodo es evaluada a través de las nociones de elecciones tecnológicas e identidad técnica y su relación con el comportamiento técnico desarrollado por los alfareros. El análisis de una gran muestra de fragmentos cerámicos, vasijas completas y fragmentos con evidencias de sobrecocción permitió establecer que los alfareros produjeron un repertorio reducido de formas cerámicas (pucos, urnas y ollas) utilizando una tecnología conservativa y local a través del tiempo con características bien definidas, en donde mayoritariamente se utilizaron materias primas cerámicas locales. La producción de alfarería durante el periodo Tardío puede ser interpretada como una producción a escala doméstica con una creciente intensificación y concentración geográfica que se acentúa con la entrada de los inkas en la región. Adicionalmente, se presentan y discuten algunas ideas relacionadas con las elecciones tecnológicas realizadas por los alfareros durante este periodo y sus implicancias para los estudios arqueológicos de tecnología cerámica.


I agree with Arnold (1993, 2000, 2005) that the study of pottery production and its spatial and temporal organization should necessarily involve the study of how restrictive ecological and environ-
mental factors of craft production activity relate to broader models of cultural dynamics in which craft, economic, social, and reproductive practices are embedded in society. The archaeological record of pottery production therefore is multidimensional and can be explored through different scales of resolution. Thus the interpretations of past human behavior based only on compositional data, be it mineralogical or chemical, are far from simple interpretations of ceramic pastes; they cannot rest exclusively on direct comparisons between the chemical or mineralogical data obtained from ceramic pastes, nor the geological contexts of ceramic raw materials (Arnold 2000, 2005). As was pointed out by Arnold (2005), the link between ceramic compositional analyses (mineralogical or chemical) and the constituent ceramic raw materials (clays and tempers) is behaviorally complex and results from natural and cultural variables.

This paper examines the pottery-making practices developed by potters during the Late period (ca. A.D. 900–1450) in the middle sector of the Abaucán Valley (Dept. of Tinogasta, Province of Catamarca, Northwestern Argentine region) by identifying technological choices in ceramic manufacturing. One key theoretical concept to understanding such technological choices is the chaîne opératoire (operational sequence), originally developed by André Leroi-Gourhan (1943, 1945, 1964, 1965) and revisited by others such as Pierre Lemmonier in his “anthropology of technology” (Lemmonier 1986, 1992; see also Sallet 1993). A second goal here is to outline technical behaviors performed by potters in the past, in order to evaluate “technical identity” in pottery-making societies (Gosselain 1992, 1999; Gosselain and Livingstone-Smith 2005; see also Lemmonier 1992; Leroi-Gourhan 1964, 1965).

The first part of this paper presents the theoretical framework guiding this research, and pays special attention to key methodological concepts developed by Leroi-Gourhan (1943, 1945, 1964, 1965) emphasizing the technical behavior in pottery-making societies. The next two sections explain the context of the Late period in Northwestern Argentina and describe the Batungasta archaeological site as a ceramic production center. The fourth section briefly details the main characteristics of pottery production organization during the Late period at the Batungasta site. The fifth section presents and discusses the more important results from dimensional standardization and craft specialization studies focusing on ceramic manufacture during the Late period. The next section deals with the technical choices in paste and forming techniques made by potters in the past. Finally, the last section discusses the particular case of pottery tradition and craft development in the Late period at Abaucán Valley, building on the position that pottery-making practices are integral to, and an active part of, social practices, upon which a society builds its social identity.


The term chaîne opératoire was originally defined by André Leroi-Gourhan (1943, 1945, 1964, 1965); it defines the sequential nature of bodily actions as one goes about daily repetitive technological activities (see discussion in Desrosiers 1991; Dobres 2000; Edmonds 1990; Lemmonier 1992; Schlanger 1994). As originally proposed, the concept was strongly influenced by the ideas Mauss proposed in his seminal work Les techniques du corps; he saw technology as a “total social fact,” and focused his attention on understanding how bodily movements reflected, and at the same time were conditioned by, social tradition (Mauss 1934; see also Dobres 2000). In exploring the link between the physical and social body, Mauss explained that even the apparently natural body actions were, in fact, learned through primary socialization of the individual. Thus, material transformation of natural resources into cultural products through sequential physical actions, were choices—technological choices—made among alternatives that in their very enactment, and whether intended or not, expressed ethnic, gender, age, and personal identities (Mauss 1934; see Dobres [2000] and Schlanger [1998] for an excellent discussion of these topics). This means that, as part of technologies, sequential physical actions on matter are part of a cultural milieu, and they embody what Leroi-Gourhan (1964, 1965) called “social memories.”

As Dobres (2000) has pointed out, much of the recent use of the chaîne opératoire term refers only to the technical chain of sequential material operations by which natural resources are acquired and physically transformed into cultural com-
modities (e.g., Creswell 1983; Delaporte 1991; Sellet 1993). Two other concepts deserve our attention, namely “technical gestures” and “technical identity.” Technical gestures are the corporeal basis of the bodily engagement with the material and social conditions of their productive activities (Leroi-Gourhan 1964, 1965). Physical interaction with the material world is accomplished through technical gestures, and this transforms matter through action into cultural products that, in turn, leave physical marks that the archaeologist can identify. Most importantly, technical gestures are embodied, mediated, meaningful, and collective practices (Dobres 2000).

On the other hand, while not developed by Leroi-Gourhan, the concept of technical identity is a wider and more inclusive concept; it focuses on technical gestures and chaînes opératoires displayed by ancient technicians. I prefer to define and understand technical identity as a final expression of technical practices by ancient technicians (see Gosselain and Livingstone-Smith [2005] for discussion). Ancient technicians mediate their understanding of physical and social conditions through the lens of cultural reason and through the embodied knowledge and skill that derive from the habitus of technological practice (Bourdieu 2007; Mauss 1934). During their physical existence, people navigate social conventions regarding the right and wrong ways to make and use material objects, thus navigating a generative identity process.


In his ethnoarchaeological research, Dean Arnold (1971, 1975, 1985, 1991, 1993, 2000, 2005) proposed and developed several concepts in order to identify and explain the main causes of variability in ceramic paste composition, as well as the way in which such variability relates to the behavior of potters, and its role in the organization of ceramic production in a given society. One of the most useful concepts is the term “community of potters” (Arnold 2000, 2005:16–17). The notion of a “community of potters” refers to the social unit of production in which members interact more frequently than with members from other communities of potters. Due to their social interaction within a community, they also share common “decision making trees” concerning the different steps in the technological process of ceramic vessel manufacture, e.g., design structures, forms, and function (Arnold 1975, 1985, 1993). In this way, they generate a greater cohesion and a lower level of variability in pottery production within their own community (Arnold 1993:140–187, 2000, 2005). However, Arnold (2005) has observed high variability in the behaviors involved in the selection of ceramic raw materials and preparation of ceramic pastes; they are rather unstable and are broadly governed by a number of factors such as geology, individual perceptions of ceramic raw materials, religious beliefs, intended use of vessels, and techniques involved in the remainder of the manufacturing process.

Sillar (2000b), with a similar approach, observed very well defined forms in the production process of pottery in several communities in the South-Central Andes (Perú and Bolivia), where the production of pottery is surprisingly consistent in terms of technique and organization of production (local traditions). His approach is somewhat different from that of Arnold, in that he emphasized understanding “technical choices” (Lemmonier 1992, 1993; van der Leeuw 1993) made by potters in different stages of the pottery production process and their vital importance in the social reproduction of pottery communities (Sillar 1988, 2000a, 2000b).

Technical choices of potters during the stages of the pottery production process are visualized as cultural choices, in which a technological tradition is reproduced on a daily basis through the repetition of a series of technical acts, and partially maintained through time and space by the way the specific technologies are embedded into wider social and technical practices in the social life of these communities (Lemmonier 1993; Sillar 2000a).

Gosselain (1999) and Gosselain and Livingstone-Smith (2005) broadened the scope in their intercultural study, carried out in Sub-Saharan Africa with more than 1000 potters from many different countries, in which they explore the mechanisms of procurement and processing of ceramic raw materials. Through the study of the wider social aspects governing this craft activity, they attempted to understand the technical behavior of potters in a more dynamic and realistic way. One of the most important conclusions derived from this work is that the current patterns of selection and process-
ing of ceramic raw materials do not depend, nor are determined, by geographical distance to the sources, geology, or the use intended for the vessel, but instead by the way in which pottery practices configure themselves over time and space. In other words, the strategies of selection and processing of clays for ceramic manufacture involve broader economic, technical, social, and symbolic aspects of society (Gosselain and Livingstone-Smith 2005). Thus, tradition, techno-functional constraints, relationships with other scopes of social activities, and symbolic conceptions play an important role charting the underlying logic in these local practices and representations. The selection of “appropriate recipes” from a very wide range of adequate processing techniques and materials available to the potter, is based in the general and specific knowledge of individuals and the way they perceive themselves in society, in the local conceptions of techno-functional constraints, in the relation with activities other than pottery production, and in the specific symbolic meaning of materials and particular behaviors.

As Gosselain and Livingstone-Smith (2005:73–74) have pointed out:

potters do not act randomly, but navigate throughout a narrow channel of culturally defined and shared practices,” and “traditions may be considered as local definitions of what is possible and what is not within specific context, such definitions (or rules) being embodied by individuals through practice, tacitly shared and, most often, non-explicit.

This means that traditions are understood not as mere technical acts, but as culturally defined practices that are transmitted both vertically and horizontally within a society as well as within very narrow social limits (Barley 1994; Gosselain and Livingstone-Smith 2005; Wenger 1998).

Late period in Northwestern Argentina: Chieftdoms and Power

The Late period in Northwestern Argentina was traditionally characterized as a time of marked regional development, increased sociopolitical complexity, inequality, economic stratification, and internal conflicts (warfare) (González 1977; González and Pérez 1972; Ottonello and Lorandi 1987; Raffino 1983, 1991; Tarragó 2000). It was a time when regional chiefdoms arose in different geographical areas—identified with specific valleys—leading to centralized power, controlled labor forces, increased social inequality, craft specialization, and the beginning of large fortified archaeological sites strategically built on defensive locations2 (cf. Leoni and Acuto 2008; Nielsen 2007). The Belén and Santamaria cultures were characterized as Late period chiefdoms with an increased sociopolitical complexity, a strong emphasis in agricultural and pastoralist economy (evidenced by large stone masonry settlements and intensified agricultural infrastructure), and the existence of craft specialization mostly based in the archeological record of pottery production (González 1977; González and Pérez 1972; Ottonello and Lorandi 1987; Raffino 1983, 1991; Tarragó 2000; see also González 2004 for a discussion on metallurgical production). One the most important aspects of the Late period concerns the mortuary practices, namely the occurrence of funerary urns for infant burials, and in some exceptional cases also for adults (Berberian 1969; González 1977; González and Pérez 1972). Treatment of these burials involved a complex ritual mortuary practice, including several different patterns of fantastic decoration on the external surfaces of funerary urns (e.g., Nasti 2008; Sempé and García 2007; Wynweldt 2007). The sites are large clustered residential compounds in which households are the basic unit of spatial organization (Leoni and Acuto 2008). Some of these Late period sites include Inka architecture in a differentiated sector, for example Fuerte Quemado (middle Calchaquí Valley, Catamarca), Hualín (Hualín Valley, Catamarca), and La Paya (northern Calchaquí Valley, Salta) (Ambrosetti 1907–1908; González and Díaz 1992; Orgaz 2008; Raffino 1991). Although the Sanagasta culture was not originally defined as a chiefdom, it has large settlements with rooms made of mudbricks (tapia and adobes) and shares with Belén and Santamaria the presence of agricultural terraces and the common mortuary practice of burying infants in decorated funerary urns (González 1977; González and Pérez 1972).

Archaeologists have not solved the question regarding the relationship between Sanagasta groups and the Inkas, given that no evidence of Inka architecture and ceramics were found in
Sanagasta classical sites. On the other hand, Sempé (1980) defined the Abaucán culture as different from the Sanagasta in that it used a different type of funerary urns. At almost 2 m tall, these Abaucán urns are larger than Sanagasta urns and show very different ceramic morphology and decoration. In regard to the proto-historic groups preceding the Diaguitas (the native groups Spaniards encountered in the early sixteenth century), González and Pérez (1972), stated that the Sanagasta, Belén, and Santamaría cultures composed the core of the organized resistance against the Hispanic conquest.

**Batungasta: A Late period Ceramic Production Center**

The archaeological site of Batungasta is located in the middle portion of the Abaucán Valley (Dept. of Tinogasta, Province of Catamarca, Argentina), approximately 25 km northwest of the town of Tinogasta (Figure 1). It is in the area known as La Troya, approximately 50 m south of the La Troya River; one sector of the site was built on a sandy hillside and the other on an alluvial clay deposit. The site covers an area of approximately 2 km² and is evidenced by abundant surface architecture (of stone and mudbricks) and ceramic sherds. The site was studied by several researchers throughout a period spanning more than a century (Lafone Quevedo 1892; Lange 1892; Quiroga 1897; Weisser 1925), although the main contributions started in the 1970s (González and Sempé 1975; Raffino 1991, 1995; Raffino et al. 1982; Ratto, Orgaz, and Plá 2002; Sempé 1973, 1976, 1977a, 1977b, 1983a, 1983b). The site was frequently characterized as an Inka site (Sempé 1976, 1977a, 1977b), with a settlement pattern interpreted as indicative of an “administrative center” (Raffino 1991, 1995; Raffino et al. 1982) (Figure 2). Occupation of Batungasta began during the Late period, however, and lasted until the Hispanic conquest (Ratto, Orgaz, and Plá 2002; Ratto 2005; Sempé 1976, 1977a, 1977b). Recent research carried out by Ratto determined that the site was a ceramic production center, at least during the Late and Inka periods although probably beginning at earlier times (Caletti 2005; Feely 2003; Feely et al. 2010; Ratto, Orgaz, and Plá 2002, 2004; Ratto, Orgaz, de la Fuente and Plá 2002); the radiocarbon dates obtained in the western section of the site show that it was occupied during the Inka, Hispanic, and Colonial times (Ratto 2005: Table 3). The most direct evidence of ceramic production includes more than 50 ceramic kilns of different shapes in the northern and southern sections of the site (Caletti 2005; Feely et al. 2010; Ratto, Orgaz, and Plá 2002), as well as by-products, wasters, and high frequencies of overfired sherds (De La Fuente 2007) (Figure 3). Overfired sherds and wasters are considered direct evidence of pottery production. Wasters in pottery production include high frequencies of broken vessels associated with kilns, parts of vessels with evident deformation processes, and sherds showing different defects resulting from several firing atmospheres (Figure 3).

**Characteristics of Ceramic Production Organization at Batungasta**

We studied the organization and scale of ceramic production during the Late period by analyzing an extensive ceramic sample from a surface collection at Batungasta and its surroundings \( n = 15,937 \), along with a sample of ceramic vessels from archaeological collections \( n = 93 \) and ceramic material from stratigraphic excavations in various structures at Batungasta.

Results of this research are summarized below:

1. Recording of more than 50 ceramic kilns north and south of Batungasta supports the idea proposed by Ratto that Batungasta was a ceramic production center (Caletti 2005; Feely et al. 2010; Ratto, Orgaz, de la Fuente and Plá 2002; Ratto, Orgaz, and Plá 2002, 2004; Ratto et al. 2007) during prehispanic times (Figure 3).

2. High frequencies of overfired sherds and their spatial correlation with kilns reinforce the interpretation that ceramics were produced at the site (Figure 3) (De La Fuente 2007; Feely 2003).

3. Frequencies of diagnostic ceramic sherds indicate that ceramic production intensified during the Late period at Batungasta, especially for what were traditionally defined in the archaeological literature as Sanagasta, Abaucán, and Belén cultures (González 1955, 1963, 1977; González y Pérez 1972).

4. Morphological analysis carried out on the surface ceramic sample \( n = 15,937 \), refitting studies of ceramic vessels identified through sherds (n
Figure 1. Map of middle Abaucán Valley showing the location of Batungasta archaeological site.
= 148) and their comparison with ceramic vessels from different archaeological collections \((n = 93)\) suggest the following narrow spectrum of ceramic forms was present in the middle sector of Abaucán Valley during the Late period: funerary urns, bowls, and globular ollas (Table 1 and Figure 4) (De La Fuente 2007).

(5) Identification of the aforementioned ceramic forms has led to the construction of a tentative and preliminary ceramic typology for the Late period; it is characterized by ceramic forms such as bowls, globular ollas, and funerary urns. Bowls are assigned mostly to the Sanagasta and Abaucán cultures (Figure 5 and 6). Globular ollas often belong both to decorated and non-decorated Sanagasta types (Figure 7). Among the funerary urns, the most common are the Sanagasta infant funerary urns (Figure 8a–f), followed by nondecorated Sanagasta urns with conical bases (Figure 8g–i), and the Abaucán urns in lesser numbers (Figure 8j–m) (Boman 1927–1932; De La Fuente 2007).

**Dimensional Standardization and Craft Specialization in Pottery Production at Batungasta**

Analysis of dimensional variability during the Late period in ceramic vessels from archaeological collections \((n = 93)\) has made it possible to determine which variables offer the most adequate measures and indexes to study dimensional standardization, but this study highlights the need to use data for interpretations cautiously (De La Fuente 2007). Dimensional standardization in the manufacture of ceramic vessels in pre-state non-Western societies is quite complex, in spite of the vast corpus of mainly ethnoarchaeological data supporting the operationalization of this concept in the study of archaeological ceramics (Arnold 2000, 2005; Arnold and Nieves 1992; P. Arnold 1991; Benco 1987; Blackman et al. 1993; Blinman 1988; Blinman and Wilson 1992; Brumfiel and Earle 1987; Costin 1991; Crown 1995; Kvamme et al. 1996;
Figure 3. Fragments of overfired ceramics: a–c and e–i overfired sherd from Late period. The circular bubbles were formed by the generation of gases during firing at high temperatures.


Arnold (2000) has pointed out that cognitive structures and individual choices are important, but
in regard to ceramic paste analyses, the potters’ choices are broadly masked, both synchronically and diachronically, by a combination of natural and cultural variability. Natural variability is related to the availability of ceramic raw materials inherent in the local geology. Cultural variability refers to the technological behaviors of potters in the selection, modification, and mixing of clays for manufacturing ceramic vessels. The final product of potters is also affected by social and political factors.

Quantitative studies attempting to approach standardization in ceramic production typically have employed relatively simple measures of dispersion or variability such as standard deviation (s), sample variance (s²), and coefficient of variation (CV) (Benco 1987; Crown 1995; Longacre et al. 1988; Arnold and Nieves 1992; Hagstrum 1985; Sinopoli 1988; Stark 1992, 1995). The standard deviation and variance are useful for describing the absolute variation in a frequency distribution. The coefficient of variation expresses the standard deviation as a percentage of the mean (x), and is therefore useful for comparing proportional variation in data sets with markedly different means (Van Pool and Leonard 2011:55). In our study, we used the following dimensional variables for each ceramic category: (1) total vessel height, (2) rim height, (3) neck height, (4) height to the maximum diameter, (5) rim diameter, (6) neck diameter, (7) maximum diameter, (8) base diameter, (9) rim thickness, (10) neck thickness, (11) thickness 1 cm below rim, (12) body wall thickness, and (13) base thickness. Additionally, we studied the following most significant dimensional relations between variables: (1) maximum diameter / total vessel height, (2) maximum diameter / rim diameter, (3) rim diameter / total vessel height, and (4) total vessel height / height to maximum diameter. Finally, we compared coefficients of variation for each of the defined ceramic groups.

The results reveal the existence of reduction of dimensional variability in at least three ceramic categories: nondecorated funerary urns (n = 10), infant funerary urns (Type A: n = 16 and Type B: n = 7), and bowls (n = 18) (Figures 6 and 8; Tables 2, 3, 4, and 5) (De La Fuente 2007). Low values obtained for CV s in some variables such as vessel height, rim diameter, and maximum diameter indicate that the manufacture of these ceramic forms was strictly controlled by ancient potters in order to achieve a “dimensional standard” in vessels, thus reducing dimensional variability. This is what researchers have referred to as “dimensional standardization,” which was achieved by ancient potters through highly skilled manufacture routines; in other words, a chaîne opératoire involving a narrow spectrum of primary vessel forming techniques. The lowest CV values were obtained for the non decorated funerary urns (n = 10) (Table 5); this indicates that, at the dimensional level, this category appears more standardized than the others.

It is interesting to observe that the CV s obtained for total height, maximum diameter, and rim diameter show values that are much higher than those recorded in the few other cases in which this kind of study was carried out on archaeological assemblages (see Crown 1995:153–155, Tables 6.2 and 6.3; but cf. Allen 1992:144–154, Tables 6.1 and 6.2 and Longacre et al. 1988:105–111, Tables 3 and 4).

Generally, it is observed that coefficients of variation for all categories of small vessels (bowls and infant funerary urns) are higher than 10 percent, indicating a relative lack of standardization (see Table 2, 3, and 4). The figures for the large vessels (non decorated funerary urns) are generally lower than those for small vessels, and include coeffi-

<table>
<thead>
<tr>
<th>Ceramic forms</th>
<th>Sanagasta</th>
<th>Abaućan</th>
<th>Belén</th>
<th>Non Decorated</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bowls</td>
<td>20</td>
<td>17</td>
<td>5</td>
<td>9</td>
<td>51</td>
</tr>
<tr>
<td>Globular ollas</td>
<td>8</td>
<td>4</td>
<td>—</td>
<td>13</td>
<td>25</td>
</tr>
<tr>
<td>Funerary urns</td>
<td>10</td>
<td>3</td>
<td>4</td>
<td>9</td>
<td>26</td>
</tr>
<tr>
<td>Small globular ollas</td>
<td>7</td>
<td>—</td>
<td>—</td>
<td>9</td>
<td>16</td>
</tr>
<tr>
<td>Ollas</td>
<td>3</td>
<td>—</td>
<td>—</td>
<td>12</td>
<td>15</td>
</tr>
<tr>
<td>Plates</td>
<td>3</td>
<td>—</td>
<td>—</td>
<td>7</td>
<td>10</td>
</tr>
<tr>
<td>Inka vessels with feet</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Total</td>
<td>51</td>
<td>24</td>
<td>9</td>
<td>64</td>
<td>148</td>
</tr>
</tbody>
</table>
Figure 4. Different refitted ceramic forms: (a–b) non-decorated olla; (c) funerary urn with conical base; (d) non-decorated Sanagasta funerary urn; (e) non-decorated urn; (f–g) Sanagasta bowl; and (h) small olla.

cients of variation less than 10 percent (see Table 5), indicating that this category is more standardized than the small vessels. However, we must be cautious about this conclusion since most of the ceramic categories are very small in sample size. Coefficients of variation reported for vessels (bowls) from the Middle period ($n = 165$) in Northwestern Argentina are much lower than those obtained in the present study, mainly for variables such as vessel height (18 percent), rim diameter (18 percent), and base diameter (15 percent) (Balesta et al. 2009:86–90, Tables 2 and 3).

Figures 9 and 10 show relations within each of the analyzed vessel categories between those vari-
ables reported in the archeological literature as being more sensitive to dimensional standardization: (1) maximum diameter/total vessel height, (2) maximum diameter/height to maximum diameter, (3) rim diameter/total vessel height, and (4) height to maximum diameter/total vessel height. The plots indicate a strong relationship between the dimensional variables showing good discrimination for some of the analyzed ceramic categories, bowls and nondecorated urns (Figure 9) and bowls, nondecorated urns, and infant funerary urns—Type B—(Figure 10). The exploration of the CVs for the vessel height and maximum diameter variables indicate that nondecorated
funerary urns and infant funerary urns (Type B) offer the lowest values, thus showing more uniformity at the dimensional level within each category (Tables 4 and 5), whereas bowls and infant funerary urns (Type A) present more dimensional variation than was expected (Tables 2 and 3). A better discrimination for bowls, nondecorated funerary urns and infant funerary urns (Type B) is observed when we analyze the relations between rim diameter and total vessel height variables (Figure 10), but CVs obtained for infant funerary urns (Type A) are the highest for the whole sample (see Table 3). Why these dimensional differences between the ceramic categories,
especially infant funerary urns Type A and B, are so marked in our case study remains poorly understood, and they need further exploration.

Dimensional variation in the production of some ceramic forms (bowls, infant funerary urns, and nondecorated funerary urns) belonging to the Late period suggests the existence of a set of very uniform and deeply rooted practices of ceramic production (Tables 2, 3, 4, and 5; Figures 9 and 10). Consequently, we posit that well-established local perceptions and representations of social identities were expressed in pottery making practices (Lemmonier 1992; Sillar 2000b), perhaps strongly linked to aspects of identity and cosmogony embedded in wider social reproduction practices in place during the Late period (Gosselain 1999).
Figure 8. Different types of infant and adult funerary urns: (a–c) Sanagasta infant funerary urns Type B; (d–f) Sanagasta infant funerary urns Type A; (g–i) funerary urns with conical base; (j–m) Abaucán adult funerary urns.

Technical Choices in Paste and Forming Techniques

Ceramic technological studies carried out with a binocular microscope and by ceramic petrology suggest a consistent technology during the Late period (Figure 11), strongly marked by the use of local raw materials. There was a good fit between the data obtained with binocular microscope (Table 6) and ceramic petrology (Table 7); this allowed us to define 17 different inclusion types (Figure 12).
Table 2. Means (x), Standard Deviations (s), Variances (s²) and Coefficients of Variation (CV) for Bowls Sample (N = 18)

<table>
<thead>
<tr>
<th>Vessel height</th>
<th>Rim height</th>
<th>Height to maximum diameter</th>
<th>Rim diameter</th>
<th>Maximum diameter</th>
<th>Equator diameter</th>
<th>Base diameter</th>
<th>Thickness 1 cm below rim</th>
<th>Body thickness</th>
<th>Base thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>x</td>
<td>20.32</td>
<td>2.12</td>
<td>4.77</td>
<td>33.47</td>
<td>35.47</td>
<td>24.58</td>
<td>9.26</td>
<td>6.06</td>
<td>10.22</td>
</tr>
<tr>
<td>s</td>
<td>4.55</td>
<td>1</td>
<td>4.69</td>
<td>7.4</td>
<td>5.87</td>
<td>12.22</td>
<td>3.58</td>
<td>1.48</td>
<td>2.77</td>
</tr>
<tr>
<td>s²</td>
<td>20.67</td>
<td>1.01</td>
<td>22.06</td>
<td>54.79</td>
<td>34.45</td>
<td>149.39</td>
<td>12.85</td>
<td>2.20</td>
<td>3.8</td>
</tr>
<tr>
<td>CV</td>
<td>.22</td>
<td>.48</td>
<td>.99</td>
<td>.22</td>
<td>.16</td>
<td>.50</td>
<td>.38</td>
<td>.32</td>
<td>.33</td>
</tr>
</tbody>
</table>

*Note: Additional references for dimensions used in this study in Sinopoli (1991: 62); all dimensions in cm; thickness in mm.*

Table 3. Means (x), Standard Deviations (s), Variances (s²) and Coefficients of Variation (CV) for Infant Funerary Urns Sample (Type A) (N = 16)

<table>
<thead>
<tr>
<th>Vessel height</th>
<th>Rim height</th>
<th>Height to maximum diameter</th>
<th>Rim diameter</th>
<th>Maximum diameter</th>
<th>Equator diameter</th>
<th>Base diameter</th>
<th>Thickness 1 cm below rim</th>
<th>Body thickness</th>
<th>Base thickness</th>
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</thead>
<tbody>
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<td>10.1</td>
<td>5.43</td>
<td>6.86</td>
</tr>
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<td>.43</td>
<td>.23</td>
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<td>.41</td>
<td>.32</td>
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<td>.20</td>
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</tbody>
</table>

*Note: Additional references for dimensions used in this study in Sinopoli (1991: 62); all dimensions in cm; thickness in mm.*

Table 4. Means (x), Standard Deviations (s), Variances (s²) and Coefficients of Variation (CV) for Infant Funerary Urns Sample (Type B) (N = 7)

<table>
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<th>Height to maximum diameter</th>
<th>Rim diameter</th>
<th>Maximum diameter</th>
<th>Equator diameter</th>
<th>Base diameter</th>
<th>Thickness 1 cm below rim</th>
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*Note: Additional references for dimensions used in this study in Sinopoli (1991: 62); all dimensions in cm.*
Table 5. Means ($\bar{x}$), Standard Deviations ($s$), Variances ($s^2$) and Coefficients of Variation (CV) for Non Decorated Funerary Urns Sample ($N = 10$)

<table>
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<th>Maximum diameter</th>
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Note: Additional references for dimensions used in this study in Sinopoli (1991: 62); all dimensions in cm; thickness in mm.

Table 6. Descriptive Statistics for Temper Type Discriminated by Rims, Bases, Body Fragments and Handles ($N = 959$)

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<th></th>
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</tbody>
</table>

Note: All values are in percentages (%); references in Figure 13.
Figure 9. Relations between dimensional variables for different ceramic forms: total vessel height / maximum diameter and height to maximum diameter / maximum diameter.

Temper identification using the binocular microscope (20X–40X) was performed on 959 sherds. Statistical analysis was conducted based on 200 inclusions per sherd (Table 6). Identification of mineral inclusions follows methodological criteria proposed by Orton et al. (1993) and Ravines (1989). Ceramic petrology (40X–100X) was carried out on 125 ceramic thin sections (Table 7). Mineral inclusions and rock fragments were identified by qualitative analyses of the main mineral features under polarized light (Adams et al. 1984; Cox et al. 1988; MacKenzie and Adams ...)
Figure 10. Relations between dimensional variables for different ceramic forms: total vessel height / rim diameter and total vessel height / height to maximum diameter.

Quantitative analyses were carried out applying the 'total area' method, counting 200 inclusions per sherd (Middleton et al. 1985), and descriptions of the main characteristics of fabrics were done following Freestone (1995), Mathew et al. (1991), and Barraclough (1992). Volcanic glass, argillaceous inclusions, and grog were unequivocally identified with ceramic petrology using criteria for plane and cross-polarized light reported in the literature ( Cuomo Di Caprio and Vaughan 1993; Middleton et al. 1985; Whitbread 1986).

Table 7 again shows that felsic materials (Figure 13a–d) dominate the sample, except for the presence of a relatively significant amount of volcanic igneous rock fragments (10 percent) (Figure 13e–f) and volcanic glass (5 percent) (Figure 13 and 14). Figure 15 presents a multiple box-plot for quartz, plagioclase feldspar, and igneous rock fragments in the sample, distributed homogeneously in all ceramic forms, thus suggesting a technological
tendency seen in the sample previously analyzed with binocular microscope.

Overall, the ceramics were characterized mainly by the presence of local materials, which included felsic materials (quartz and feldspars) (Figure 12b–d), mica, biotite, calcite (Figure 12c), and different types of igneous and volcanic rock fragments [volcanites and andesites] and accessory minerals such as amphiboles and pyroxenes] (Figures 11, 12, and 13) (De La Fuente 2007).

This standardization observed in ceramic pastes of the Late period may indicate the use of conservative recipes on the part of ancient potters. When compared with earlier periods, the Late period ceramic technology differs in the appearance of cultural temper (grog) and volcanic glass in all analyzed ceramic forms (see also De La Fuente 1999, 2004, for similar results in Inka ceramics). However, grog (<1 percent) and volcanic glass (5 percent) percentages are very low compared to other tempers (Table 6 and 7). The low percentages of grog and volcanic glass suggest that this technological choice might represent a deliberate practice linked to wider social aspects rather than a functional choice; this should be further explored in Late and Inka periods (see Bengtsson et al. 2001; Pérez 2005, 2010; Pérez and Armasio 2009; Pérez and Patáné 2007; Schwartz 1991; Tarragó et al. 2002, for the presence of grog and volcanic glass in Late period Santamaría ceramics).

Primary and secondary ceramic forming techniques were studied at both macroscopic and microscopic levels of resolution, using X-ray radiography and ceramic petrology (De La Fuente 2011). Prehispanic ceramics in Northwestern Argentina were handmade and ancient potters used a narrow and very specific repertoire of primary forming techniques to shape the ceramic vessels during the Late period. Coiling was the most common primary forming technique used to shape the body of the vessels, followed by drawing in order to form the highest section of the bases, and then use of a non-conventional mold to produce concave bases in large vessels (De La Fuente 2011:Figure 5–11). Surprisingly, an unusual use of slabs was recorded by X-ray radiography in some bowls of the Sama-gasta culture. Of the secondary forming techniques, the only one that could be properly identified both at macroscopic and microscopic levels was scraping. Scraping was identified both in internal and external surfaces of various types of vessels. Additionally, there is some evidence of the use of paddle and anvil in the production of bowls, but most evidence was obliterated by scraping and turning during the manufacture process (De La Fuente 2011:Figures 7, 10, and 11).

Results obtained through the application of INAA to a sample of ceramics from the Late and Inka periods (n = 127) clearly indicate that ceramic artifacts were being locally produced in the vicinity of the Batungasta site, mainly using clays from a source identified in the area of La Troya River (see Plá and Ratto 2003, 2007; Ratto, Orgaz, De La Fuente, and Plá 2002; Ratto, Orgaz, and Plá 2002; Ratto et al. 2009). The later statement is based on the analyses of compositional data obtained through INAA by Ratto from the last 15 years in the Abucán Valley (see Plá and Ratto 2003, 2007; Ratto, Orgaz, De La Fuente, and Plá 2002; Ratto, Orgaz, and Plá 2002, 2004; Ratto et al. 2007, 2009).

The analysis of pottery production at Batungasta during the Late (ca. A.D. 900–1450) and Inka (ca. A.D. 1480–1532) periods indicates that—throughout time—it was highly concen-

| Table 7. Temper Type Distribution by Ceramic Petrology (N = 125) |
|-----------------|----------------|----------------|----------------|----------------|
|                | x              | y              | Min            | Max            |
| CQ             | 43.7           | 10.23          | 25.17          | 75.0           |
| PQ             | .68            | 1.62           | .4             | 11.0           |
| PF             | 12.44          | 6.84           | 1.0            | 27.66          |
| KF             | .11            | .43            | .4             | 4.0            |
| M              | 2.57           | 4.6            | .7             | 22.8           |
| B              | 10.59          | 9.17           | 2.6            | 46.99          |
| Ca             | 2.22           | 4.11           | .5             | 30.8           |
| IgFr (p)       | 5.3            | 4.62           | .5             | 24.8           |
| SedFr          | 1.57           | 2.89           | .5             | 20.0           |
| MtFr           | .21            | .47            | .47            | 2.62           |
| IgFr (v)       | 10.26          | 7.14           | .31            | 38.46          |
| Gr             | .2             | .37            | 1.0            | 4.0            |
| ArcInc         | .31            | 1.17           | .4             | 11.66          |
| VG             | 5.88           | 7.58           | .66            | 29.5           |
| An             | 1.26           | 3.62           | .5             | 19.0           |
| Pfr            | 1.85           | 2.18           | .4             | 8.65           |

References: CQ crystalline quartz, PQ poly crystalline quartz, PF plagioclase feldspar, KF potassium feldspar. M muscovite, B biotite, Ca calcite, IgFr (p) igneous rock fragment (plutonic), SedFr sedimentary rock fragment, MtFr metamorphic rock fragment, IgFr (v) igneous rock fragment (volcanic), Gr grog, ArcInc argillaceous inclusions, VG volcanic glass, An amphibole, Pfr Piroxene.

Note: all values in percentages (%).
trated (Costin 1991) in the middle sector of the Abaucán Valley. The distribution pattern suggests a high degree of artifactual mobility along all the Abaucán Valley, which reached as far as the Puná region of Chaschuil (Orgaz et al. 2007; Plá and Ratto 2003, 2007; Ratto, Orgaz, De La Fuente, and Plá 2002; Ratto, Orgaz, and Plá 2002, 2004; Ratto et al. 2007, 2009).

When observing standardization in ceramic pastes (see Tables 6 and 7, Figures 11–14), together with the existence of certain degrees of dimensional standardization in particular ceramic forms (Tables
2–5) and the control and re-use of ceramic raw materials through time (Ratto et al. 2004), we believe that during the Late period in the middle sector of the Abauçan Valley, there is evidence that pottery was primarily produced on a household basis by nonspecialist potters, although some forms like non-decorated funerary urns and bowls may have been produced by part-time specialists (Crown 1995).

Craft specialization in pottery production during the Late period is understood here as a broad concept involving not only the dimensional level, but also the recipes used by ancient potters for ceramic pastes,
the set of primary and secondary forming techniques to shape the vessels, the decoration patterns observed in the vessels, and the use of specific clay sources. This craft specialization could represent a consistent set of routine pottery-making practices during the Late period (De La Fuente 2007, 2011).

Towards a Model of Ceramic Production at Batungasta

Considering the information presented in this paper, we propose a model of pottery production at Batungasta for the Late period (ca. A.D. 900–1450) based
on the notion of a community of potters, wherein pottery production in the middle sector of Abaucán Valley (Dept. of Tinogasta, Province of Catamarca) was geographically concentrated at Batungasta and its surroundings. This pottery production was carried out in household contexts, and ceramic goods were distributed within the Abaucán Valley during the Late period (Ratto, Orgaz, De La Fuente, and Plá 2002; Ratto, Orgaz, and Plá 2002, 2004; Ratto et al. 2007).

Pottery production became more intensified and specialized over the course of the Late period, with very well-established workshops in residential contexts sharing a high degree of functional specialization and exploitation of ceramic resources (De La Fuente 2007; Plá and Ratto 2007). This specialization has a direct archaeological material correlate in the appearance of higher degrees of standardization at both the morphological and dimensional levels in the manufacture of vessels and of ceramic pastes used during this period (Arnold 2000; De La Fuente 2007, 2011).

As for ceramic pastes, during this period there is almost a continuum through time in which there are no significant changes in ceramic recipes used by ancient potters to produce ceramic vessels (De La Fuente 2007). Ceramic production was perhaps intensified and reoriented again during the Inka occupation of the Abaucán Valley (Orgaz et al. 2007; Ratto, Orgaz, and Plá 2002), to cater to the demands of a state bureaucracy after these new territories and populations were annexed (Orgaz et al. 2007; Williams 2000).

It is almost impossible to talk about "tradition" in archaeology without falling into interpretations shaped by the old cultural–historical paradigm. I believe, as I mentioned above, that traditions can be visualized as "culturally defined practices" through time within communities with very marked social limits (Gosselain and Livingstone-Smith 2005). This definition might apply to the archaeological record of pottery production at the Batungasta archaeological site during the Late period at Abaucán Valley, where we can propose the existence of a local "pottery tradition." This would imply a consistent set of practices or technical behaviors repeated by potters through time. Such tradition began early and blossomed during the Late period with ceramic manifestations known collectively as Sanagasta Culture; it involved different technical choices in several stages of pottery production such as: (1) a repeated use of local...
ceramic raw materials through time (both clays and tempers); (2) shaping of very specific ceramic forms (bowls, ollas, and funerary urns), most of them related to conception and death rites (i.e., infant funerary urns); (3) the existence of dimensional variation between each ceramic category analyzed, what might be read as some forms being more standardized than others; (4) use of a reduced repertoire of primary and secondary firing techniques; (5) extremely conservative decoration of vessels; and (6) use of a very well-defined set of techniques for ceramic firing in kilns (see Caletti 2005; De La Fuente 2007; also see an excellent discussion about this topic in Pool 2000).

Thus, studying the chaîne opératoire of ceramic manufacture during the Late period at Abaucán Valley is a useful conceptual framework from which to advance to other ideas related to technical identity as expressed in the way potters configure themselves as individuals participating in society. In this way, the addition of "grog" as temper to ceramic pastes in Sanagasta bowls and urns in very low percentages has no functional significance (De La Fuente 2007). Instead, the grinding and addition of grog as temper is considered a technological choice related to a broader reproductive social practice, probably associated with rites, myths, and prohibitions governing life (Barley 1994; also see Sillar 2000a, 2000b), an idea that should be further explored through additional technological studies of these kinds of vessels.

On the other hand, the addition of low concentrations of volcanic glass inclusions to Late period ceramics raises the question whether this practice was related to broader cultural practices mainly linked to the importance of volcanoes in the daily life in the Andes (see Paéz 2010; Paéz and Arnosio 2009 for a functional discussion dealing with this potting practice).

Finally, the concept of chaîne opératoire offers a useful tool to explain the natural processes and to structure those cultural processes occurring within society. What Barley (1994:138) referred to as the potting model "is only one of many options for a culture to think about itself."

Thus, it should not be surprising that the archaeological record shows that pottery took different configurations and patterns as a consequence of its role as a social product. Studying the chaîne opératoire in past pottery-making societies is a powerful and methodological tool to approach topics such as technical identity and technical behavior from a different perspective in order to better understand the role of pottery in the past. Archaeologists should be aware of the limitations imposed by traditional typological approaches, which sometimes limit interpretations to only pottery function.

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Notes

1. It is not the intention of this paper to enter in the discussion of agency theory—and the concept of practice—and its relation with technology. Several works by Dobres have remarkably developed this relationship in several ways (Dobres 1999, 2000, 2001, 2008).

2. Recently, this vision has been questioned and several topics such as sociopolitical complexity, inequality, the production and use of prestige goods; and the evidence of warfare are currently under reassessment considering the evidence present in the archaeological record of the Late period (González 2004; Leoni and Acuto 2008; Nielsen 2001, 2006, 2007).

3. This ceramic sample was selected from a larger sample ($n = 66,000$) collected through an intensive survey carried out to the north, south and east of the Batungasta archaeological site as part of the Batungasta Archaeological Rescue Project (Ratto, Orgaz, and Plá 2002, 2004; Ratto, Orgaz, de la Fuente and Plá 2002; Ratto et al. 2007).

4. The effect of sample size for small samples was corrected by the application of the formula $CV = (1 + 1/n)$, as recommended in VanPool and Leonard (2011:55–56).

5. It is not the goal of this paper to present in a detailed way the INAA data. The INAA analyses were done at Ezéita Atomic Centre, National Commission of Atomic Energy, Argentina. The analyses were done by Lic. Ritu Plá and Dr. Norma R. Ratto through different research projects, and have been extensively published elsewhere (Plá and Ratto 2003, 2007; Ratto, Orgaz, de la Fuente and Plá 2002; Ratto, Orgaz, and Plá 2002).

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