ANTHROPOLOGIE • LI/2 • pp. 195–211 • 2013

INA MILOGLAV

A MODEL OF CERAMIC PRODUCTION, SPECIALIZATION AND STANDARDIZATION OF CERAMIC ASSEMBLAGES ON THE BASIS OF TWO SITES OF THE VUČEDOL CULTURE IN EASTERN CROATIA

ABSTRACT: The paper presents an overview of the results of the standardization of ceramic material and the parameters by which the specialization and organization of production, placed within the socio-economic framework of a particular community, can be confirmed. The conditioning of the standardization, as well as various societal needs leading to the organization of production, is viewed in the wider context of the functioning of the Vučedol community at the very end of the Eneolithic and it includes organization of the settlement as well as socio-economic processes. Various definitions and interpretations of specialization, together with many ways of reconstructing organized production, make up the theoretical framework regarding the choice of methodology. The established Standardization Hypothesis states that "more uniformity is due to a higher rate of production". On the basis of this hypothesis, by using the coefficient of variation, ceramic assemblages from two sites of the Vučedol culture in eastern Croatia were tested. The results have shown a certain level of standardization in a certain type of vessel, which was most commonly used in everyday life. These results are corroborated by the results of mineralogical-petrographical analyses and X-Ray Diffraction method as well as by the typology of ceramic vessels itself. Based on the results, the proposed model of ceramic production within Vučedol society is defined. It assumes organization at the level of household industry and it relates to production that is still taking place within the household, but most of which is oriented towards needs existing outside the household, i.e., to trade and exchange beyond household consumption.

KEY WORDS: Vučedol culture – Organization of production – Standardization – Specialization

Received 28 February 2013; accepted 19 June 2013.

INTRODUCTION

Ceramic vessels, as well as other handmade artifacts, reveal a social context of man in the past, his behavior and activities as well as the social, economic and political conditioning of those activities. They are our connection to times past and represent a moment in time. That moment encapsulates the answers to crucial questions about the functioning and organization of a society and it slowly reveals the social dimension of human activity. Hence the ceramic vessels should constitute a framework for exploring human behavior in the past and not only for identifying chronological guidelines.

Pottery, like all other artifacts that are a part of human activity, is produced and used in a social context (Sinopoli 1991: 119). People have made pottery vessels, used them, distributed them, broken and discarded them in an archaeological record and within the context of their daily lives (Skibo 1999: 1). Archaeologists find the vessels in one of those five contexts. It is our "methodological task" to identify this context during excavation, so that we may gather as much data as

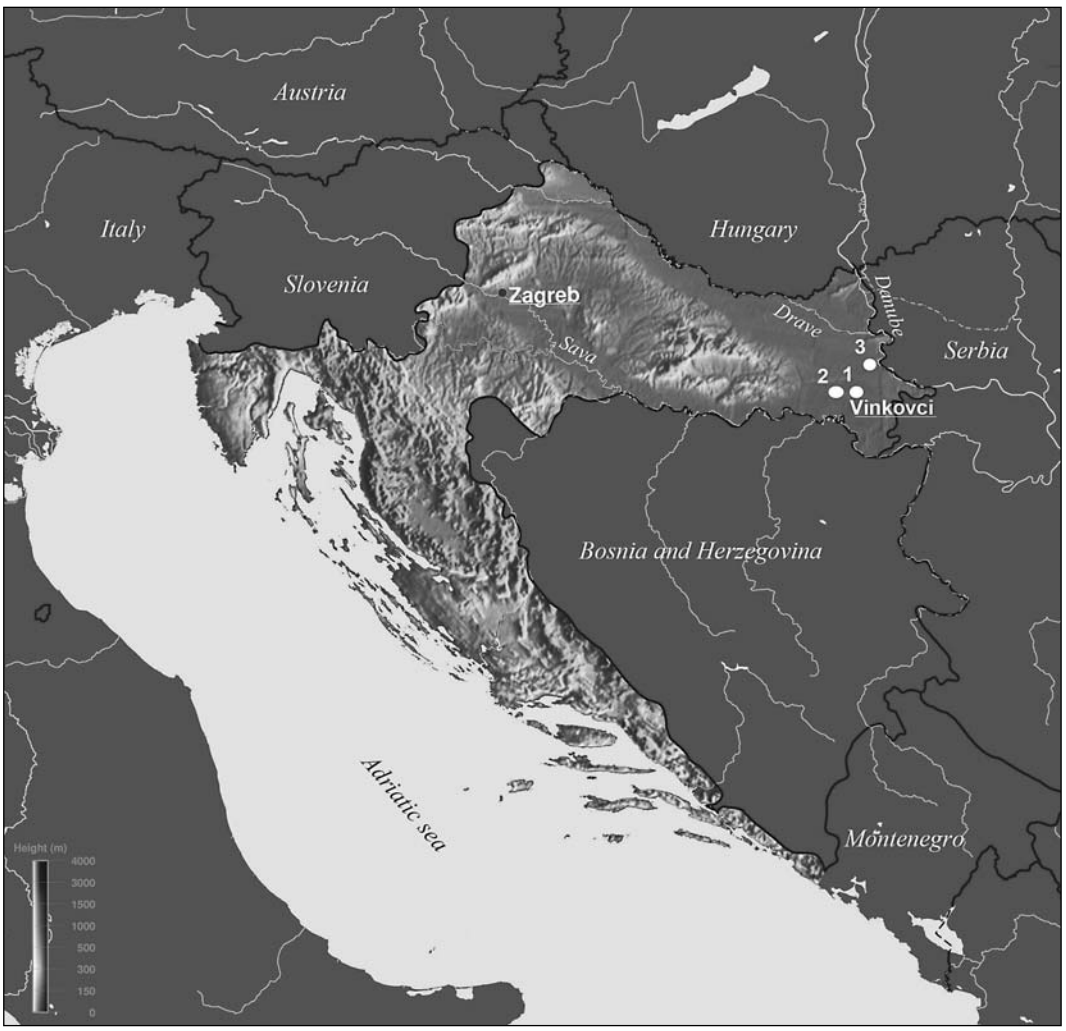

FIGURE 1. Map showing Vučedol sites. 1, Ervenica, in Vinkovci; 2, Damića gradina, in Stari Mikanovci; 3, Vučedol, near Vukovar.

needed to help us interpret the lifecycle of a vessel within the framework of its social, economic and political conditioning.

This paper presents the research results of processing the ceramic material from two Vučedol sites in eastern Croatia (Slavonia) – Ervenica, in Vinkovci and Damića gradina (Damića Fort), in Stari Mikanovci (*Figure 1:1, 1:2*).

In an effort to interpret the lifecycle of a ceramic vessel in as much detail as possible – from choice of material, through shaping and treatment of the surface, to its use and final discarding in the archaeological environment – I have tried to place the ceramic material in the context in which it was produced, distributed and consumed. This approach calls for multidisciplinarity. Hence, the methodology included: 1) classification and sorting of ceramic material, which results in the creation of a typology of ceramic assemblages on both sites; 2) descriptive statistics, produced by the SPSS program (Statistical Package for Social Sciences); 3) standardization testing, undertaken using the coefficient of variation, which is a standard statistic in studies of variation and therefore the best measure of standardization; 4) a technological segment substantiated by mineralogical-petrographical analyses and X-Ray Diffraction method; 5) the functional component of the ceramic vessels, supplemented with chemical analyses of organic residues in the vessel walls by gas chromatography-mass spectrometry (GC-MS); 6) a clearer picture of agricultural and commercial activities, as well as the nutritional habits of the Vučedol population, obtained by archaeobotanical analysis and osteological analysis of animal bones; 7) the absolute dating of both sites with 14C analysis.

The results presented in this paper relate to definition of the production process, craft specialization and standardization of ceramic assemblages, which, in its full contribution to the archaeological process, started developing in the 1980s (for a review, see, Tite 1999).

SOCIO-ECONOMIC, POLITICAL AND ENVIRONMENTAL FRAMEWORK OF THE VUČEDOL CULTURE

Most authors fully agree that the first point in defining and identifying organized production and specialization is the creation of a framework necessary for their development (Costin 1991, Rice 1981). This framework includes socio-economic, political and environmental factors that affect the development and functioning of a certain economic community. Answers to these questions are crucial for determining the traces of organized specialization.

Generally speaking, our knowledge of socio-economic and political conditions during the Eneolithic is very limited. It suffices to illustrate this with the example that, within the territory of Croatia, 63 Vučedol sites have been recorded, of which only 13 (19.1%) have been systematically investigated (Balen 2010). Through the chosen methods of analysis of ceramic material presented here, this work will attempt to respond, at least in part, to some of the key questions of the functioning of Vučedol society at the very end of the Eneolithic.

The Eneolithic

The Eneolithic, or Copper Age, as a temporal framework for the development of the Vučedol culture, is perhaps least determined by the usage and manufacture of copper objects. Copper as a raw material was already known in some Neolithic cultures and traces of the exploitation of copper ore can be confirmed in the period of the late Neolithic. A perhaps more relevant fact is that the Eneolithic as a period is marked by a time when society in southeastern Europe underwent dramatic changes in its socio-economic organization; changes that would embody a social framework for the transition into the political organization that emerges in the Bronze Age (Parkinson 2004: 335). These changes would have an equal impact on the economic and social aspects of life, new trends in settling and residential architecture, as well as on spiritual life. The Copper Age of southeastern Europe is generally considered a period of the establishment of the earliest social systems with hierarchic structure (Bankoff, Winter 1990: 175). The settlements which are the subject matter of this paper belong at the very end of this long transitional period.

The Vučedol culture

In these circumstances, the Vučedol culture had settled the area of eastern Slavonia and Syrmia where it had mainly taken over the positions previously settled by the Kostolac culture. Viewed topographically, the Vučedol culture settles naturally elevated prominent positions, located in the vicinity of rivers or smaller streams. Such positions represent a very logical choice, important from the strategic and communicatory point of view. Fortification of established settlements depended primarily on the natural configuration of the soil and on landscape features. The large number of fortified settlements suggests that the Vučedol population yearned for a more peaceful and continuous life in one

place, as well as the tendency to settle at previously inhabited and deserted positions which could easily be fortified.

The continuity of settling in one location is perhaps best documented, in archaeological terms, by the repairing of house foundations and the existence of several construction horizons in the same settlement, as is the case with the eponymous site of Vučedol (Dimitrijević 1979, Forenbaher 1995) and both sites analyzed in this paper – Vinkovci (Dimitrijević 1979) and Stari Mikanovci (Iskra-Janošić 1984, Miloglav 2012a). The repairing of house foundations in the same place has been a regular occurrence on the classical tell settlements of the Near East and southeastern Europe since the earliest times and it is usually interpreted as the need of Neolithic and Eneolithic households to establish symbolic continuity with respect to some household from the past (Stevanović 1997, Tringham 2000, Tripković 2009, Whittle 1996). Due to the raster of the settlement, the lack of space and limited surface, the houses are squeezed together at small distances and their repair is more frequent.

One technological novelty in the late Eneolithic was the emergence of two-piece moulds, which meant that one prototype could be used for making more moulds simultaneously (Durman 1983: 23–31). The vast quantity of copper axes and moulds that were found in hoards or as individual finds (Vinkovci, Vučedol, Sarvaš), as well as the evidence of metallurgic activity, which can be traced at sites from the earliest periods of the Vučedol culture, testify to the great role that metallurgy played in Vučedol society. In economic terms, the specialization of crafts emerges in societies which possess a certain level of complexity (Forenbaher 1999), which is definitely confirmed within the developed Vučedol society. Although specialized metallurgic activity is not the subject of this paper, it is important to stress its existence and relevance within the overall economic framework of the Vučedol culture.

The economic strategy of the Vučedol population, which included plant cultivation, herding, hunting and metallurgy, had, as a consequence, a social stratification where a few high-ranking individuals in the community raised themselves above the others.

The traces of social stratification are most vividly manifested in the burials and in some indicators pertaining to the concept of living and the organization of the settlement. The evidence of social hierarchy can very well be traced at the eponymous site of Vučedol, near Vukovar, in eastern Croatia (*Figure 1:3*). Although this site is not encompassed by the results of the processing of ceramic material presented in this paper, it is important to emphasize its relevance and socio-political organization, because it is the central and biggest archaeological site of the Vučedol culture in this area. The Vučedol site most accurately reflects the time, the economic and socio-political conditions and the mode in which Vučedol society was functioning at the very end of the Eneolithic. By its very size and spatial organization, it is a settlement that differs from others of its time. The settlement was spread over four elevated plateaus, among which the site of Gradac takes a very special place as the most prominent part of the settlement. Traces of social differentiation and the assumption that it was the seat of the social elite of the Vučedol settlement, can be confirmed at that site. The burial of a man and a woman with a large quantity of fine, decorated pottery at the Gradac site points to the burial of high-status individuals. Traces of metallurgic activity can be directly tracked in the feature "Megaron of a copper founder", the dimensions of which (15.5×9.5 m) considerably exceed those of other "common" houses in the settlement (approx. 8×6 m). Five copper smelting furnaces were found within and around this feature (Schmidt 1945: 21–28).

The settlement of Vučedol is the evidence of a stratified society which can be succinctly characterized by a few important facts, as has been suggested by Forenbaher (1994: 320): 1) Vučedol is by far the largest settlement of its period within the area delimited by classic Vučedol pottery; 2) its estimated population is surprisingly high for a prehistoric agricultural village; 3) there is a distinct part of the site, Gradac, which occupies the central and most prominent position; 4) structures standing on Gradac were much larger than any of the "ordinary" houses uncovered elsewhere; 5) evidence of certain activities that would have been of particular importance for the elite, such as copper smelting, appears to be restricted to Gradac; and 6) prominent individuals were sometimes (but not always) buried within that central area.

SPECIALIZATION OF CRAFTS AND ORGANIZATION OF PRODUCTION

There are many papers on the topic of the organization of specialization and an increasing amount of research focused on models of production, standardization and specialization (Arnold 1985, Costin 1991, 2005, Costin, Hagstrum 1995, Hagstrum 1985, Orton *et al.* 1993, Rice 1977, 1981, 1996, Roux 2003,

Sinopoli 1988). Most authors agree on one point – the organization of production can be identified and defined in several ways. However, it is important to emphasize that the proposed models of the organization of production must be flexible to a certain extent, because they cannot be linearly applied to all societies.

Specialization, in terms of its archaeological context and the organization of production, has many different definitions and interpretations. Among the more precise is that provided by Rice (1981: 200), in which specialization is defined as "regularized behavior and material variety in extractive and productive activities". For Costin (1991) specialization is a relative, not an absolute, state, characterized by a distinction of level which refers to the ratio of producers to consumers and the type of specialization. Specialization can be organized in many ways – from specialization at the individual level to community specialization, from a small-scale household-based production unit to large-scale organized workshops.

According to Costin, production is "transformation of raw materials and/or components into usable objects", while specialization is "a way to organize that production". Perhaps one of the most often-quoted models is that presented by Earl (see, Costin 1991): a model of attached and independent specialization. He distinguishes between the production of special, high-value goods, consumed and controlled by the elite and the production of utilitarian goods for wider distribution without a control system. This definition was soon accepted by numerous authors (e.g., Costin 1991, Hagstrum 1985, Sinopoli 1988). Speaking of specialization, Rice (1989: 110) makes a distinction between individual specialization and community-level specialization, as well as between the specialization of a particular form and the particular function of the vessel.

As has already been emphasized and partly illustrated, there are many types and definitions of specialization, since specialization is not a one-dimensional phenomenon, but depends on many different factors: first and foremost, social, economic, political and environmental conditions. Economic specialization can be defined as an investment of labour and capital, as opposed to the production of a particular good or service, in the sense that the producer produces more of that commodity and less of others than he/she can consume. Specialized production is thus the production of surplus for exchange (Blackman *et al.* 1993: 60-61). When speaking of specialization as a part of the economic organization, Costin (2005: 1065) characterizes it "as a form of economic relations where not all consumers of a particular good are its producers".

It is also important to emphasize that all economic systems have three components: production, distribution and consumption. Jointly, distribution and consumption inform us about the economic, social and political context of production (Costin 1991). At this point we should make a distinction between manufacture and production of pottery. According to Rice (1996: 173), manufacture is the making of the vessel, while production implies the social and economic organizational context of pottery manufacture.

Distribution is connected with the exchange model and, to a certain extent, the organization of production will depend on it. The last link in the chain is consumption, in other words the need for the final product. In the archaeological context, it is precisely the component of consumption that is most difficult to identify and – in terms of interpretation – it thus becomes the weakest link in the economic systems of prehistoric societies.

Demand and supply

Demand and supply are important components of every study of organized production. In classic economic systems, these are the basic economic principles and the main basis of the market economy. Generally, demand refers to how much of a product or service is desired by users and what price they are willing to pay for a certain product or service. Supply represents how much the market can offer. However, in the archaeological context we come across economies which are neither market economies nor capitalistic economies; hence these terms are applied to social and political factors which affect the need for a certain product.

Demand, or terms of consumption, cannot always be clearly recognized in the archaeological context. It relates to the questions: for whom are the goods produced, for what need, and in what context? One of the components of demand is the use or function of a product and it relates to the usage of a certain product and its function in everyday life, in rituals or in social life (Costin 2005: 1047). Defining demand includes three analytical techniques: a) identification of the context in which the products are found; b) morphological analysis of the pottery in order to identify its practical function (including residue analysis, use-wear and use alteration analysis and analysis of raw material) and c) quantitative and qualitative methods to estimate the amount of material made and used (Costin 2005: 1048). These are all the attributes which can be recognized as characteristics of the production system.

Direct and indirect evidence

In speaking of ceramic production, it is important to emphasize that it can be organized in many ways (Costin 1991, Costin, Hagstrum 1995, Rice 1981). One of the more frequently cited models is, perhaps, that presented by van der Leeuw (1977), according to which the intensity of production would be divided into six different levels. Costin (1991) presents eight levels of the organization of production on the basis of four parameters: the context of production, the concentration of production facilities, the level of production and the intensity of production.

Generally, archaeologists agree that reconstruction of organized production is possible on the basis of direct or indirect evidence. Direct evidence is the place of ceramic production, ceramic kilns, firing pits, tools, waste, pigments, moulds etc. Indirect evidence is that data where, in the archaeological context, we are not able to locate the places of production and the ceramic product itself becomes the proof of specialized production. There are several factors that are taken into account when it comes to indirect evidence. First of all, there is the identification of a large number of more or less standardized products, skill and efficiency in the pottery. Indirect evidence of skill is most frequently measured through technological attributes of the final products. There are several proposals on how to measure skill and they include gestures used to decorate a vessel (Hagstrum 1985) and control of movement (Costin, Hagstrum 1995). However, some ethnoarchaeological research suggests that the potter's skill and repertoire may vary with age and that skill in producing larger pots increases with age (Kramer 1985). Indirect evidence rarely provides the identification of the context, scale and intensity of production.

Standardization of products

Standardization of ceramic material is usually used in analyzing the organization of production (Arnold 2000, Blackman *et al.* 1993, Kvamme *et al.* 1996, Rice 1989, Stark 1991). Perhaps the best definition of standardization is that put forth by P. Rice (1996: 178-179), who defines it as reduction in variability of ceramic vessels. Standardization actually measures the number of production groups in relative terms and is usually considered an integral part of specialization and this is the case for two reasons. The first reason is that specialized systems have fewer producers, i.e., less individual variability; and the second one is that specialists practice their craft more frequently through training and practice and also develop routine gestures (Costin 1991: 33–35, Costin 2005: 1067).

Generally speaking, it can be said that the level of standardization affects the level of production which can be organized in several ways. It encompasses several components which jointly create the production system.

One of the models was put forward by Costin (2005), and it aims to encompass: the people (specialists) who make the products, the resources of production (raw material, tools, skills, knowledge), organizational and social relationships of production (relationship between producer and consumer), objects, distribution (mechanisms by which the objects are transferred to consumers) and consumers. The first component of this production system would encompass people, i.e., specialists making standardized vessels as the result of their knowledge, skills and experience. In this respect it is usually emphasized that one should differentiate between intentional and mechanical attributes. The first set of attributes affect the functionality of the pot and include technological, morphological and stylistic attributes. These attributes are less revealing when it comes to the organization of production. Mechanical attributes are those actions which the ceramic worker unintentionally performs when making the pot. Bearing in mind that they are unconscious, these actions can be revealing about the organization of production and they include choice of clay and variability in metric measurements, such as small aberrations in the morphology of the vessel. Mechanical attributes are affected by level of skill, knowledge, experience and work habits (Costin, Hagstrum 1995, Costin 2005).

Hypothesis of standardization

The *hypothesis of standardization* (Blackman *et al.* 1993, Costin, Hagstrum 1995, Costin 2005, Rice 1981) suggests that a higher level of production is the reason for the greater uniformity of ceramic vessels. The level of production is connected with economic specialization, which encompasses many ways as to how to organize the production of products. Specialized ceramic production must be defined in the archaeological context through standardization of raw material and technique (Rice 1981), form and dimension (Sinopoli 1988) and decoration (Hagstrum 1985). Although the decoration is considered to be an intentional attribute inscribed by the ceramic worker with purpose (Costin, Hagstrum 1995, Hagstrum 1985), most measurements of standardization of ceramic material avoid this variable.

Most authors agree that, for the purpose of measuring standardization, it is best to compare two different ceramic assemblages, because they would allow tracking

the level of standardization (Blackman *et al.* 1993, Costin, Hagstrum 1995, Rice 1981, Roux 2003). When undertaking the standardization test, the most common measures are metrical values, the technology of making and the chemical composition of the clay. However, it should be emphasized that, when establishing standardization, which will serve for interpretation of specialization and organization of production, several things should be borne in mind: 1) the attributes analyzed reflect the organization of production and not the unintentional gestures conditioned by social, economic or political reasons (Costin 1991); 2) one or more analytic units need to be compared (sites, assemblages, regions, phases or types); 3) when interpreting, special attention should be dedicated to potential subjectivity; for this reason it is best to use various statistical tests or methods; 4) the size of the sample is very important for the representativeness of the data; 5) when measuring and comparing, it is very important to take data from the same typological group, in order to avoid aberration of metrical values; 6) utilitarian objects must be separated from prestigious objects, those that depart from the usual repertoire in their dimensions and decorations; 7) cumulative blurring should be borne in mind when interpreting the scale of production.

Although standardization, specialization and the organization of production are generally more easily recognized and tested in ethnoarchaeological research, many archaeological studies have recognized a certain level of these activities on sites belonging to the earliest prehistoric communities (Colombo, Boschian 2009, Tiberi 2007, Truffeli 1994, Vuković 2011).

Standardization tests, as has already been mentioned, are conducted mostly within ethnoarchaeological research (Arnold 1985, 2000, Kramer 1995, Kvamme *et al.* 1996, Roux 2003, Stark 1991) that helps us interpret archaeological theses, while on the other hand using information which cannot be obtained in the archaeological context. This includes most metrical measurements (e.g., the height of the vessel or maximum diameter), information on distribution, consumption and production, as well as ceramic products of one craftsman or from one production series. Also, it should be noted that, in the archaeological context, it is very difficult to gather information obtained through ethnoarchaeological research and the value of the coefficient of variation would be much higher. One of the reasons is the so-called cumulative blurring which emerges when all ceramic products from one settlement – that is, vessels made by several craftsmen and belonging to several production series – are being measured (Blackman *et al.* 1993). This problem is fairly common in archaeology because most of the material does not originate from clearly closed units, as was the case with the site on Damića gradina. Some research has shown that the coefficient of variation is far smaller if vessels made by a single craftsman are analyzed (Roux 2003). In the archaeological context it is fairly rare to find direct evidence which identifies the vessels of one workshop, as in the case of the potter's mark on the Late Eneolithic pottery of Arslantepe (period VII) (Truffeli 1994).

MATERIAL AND METHODS

Material

The total number of processed sherds was 7593 (5780 from Damića gradina and 1813 from Ervenica). The analyzed sites are located in eastern Slavonia, one in the centre of Vinkovci and the other in the centre of Stari Mikanovci. The site at Ulica M. Gupca 14 in Ervenica in Vinkovci (*Figure 1:1*) was researched in 2007 (Krznarić Škrivanko 2008) and it represents a part of a large Vučedol settlement located on two naturally elevated positions, which were divided only by the confluence of the Ervenica stream and the River Bosut. The centre of this settlement was at the location of the Hotel Slavonija, which was probably the centre of the settlement in a social and economic sense (Miloglav 2007). The stratigraphy of the site Hotel Slavonija (as well as some positions in Ervenica, which is part of the same settlement) revealed traces of Starčevo, Vučedol and Vinkovci occupation, as well as a distinct horizon with finds of the Lasinja-Salcuta and Bodrogkeresztúr cultures. Occupation during the Celtic-La Tène and Roman periods is also confirmed in this area (Dimitrijević 1979, Dizdar 2001). Owing mostly to rescue archaeological excavations, 12,000 m^2 of this large Vučedol settlement have been uncovered so far. By size, it is the second-largest settlement, immediately after the Vučedol site, which also testifies to the relevance of the metallurgy and the metallurgic activity in this settlement (Durman 1984, Miloglav 2007, 2012a).

The second site analyzed is Damića gradina in Stari Mikanovci (*Figure 1:2*), where, in 1980, due to the construction of an elementary school (Iskra Janošić 1984), a major rescue excavation was undertaken. This multi-layered tell site was occupied during the Sopot, Baden, Vučedol, Vinkovci and Bosut cultures, as well as Celtic-La Tène periods (Dizdar 2001, Iskra Janošić 1984, Miloglav 2012a).

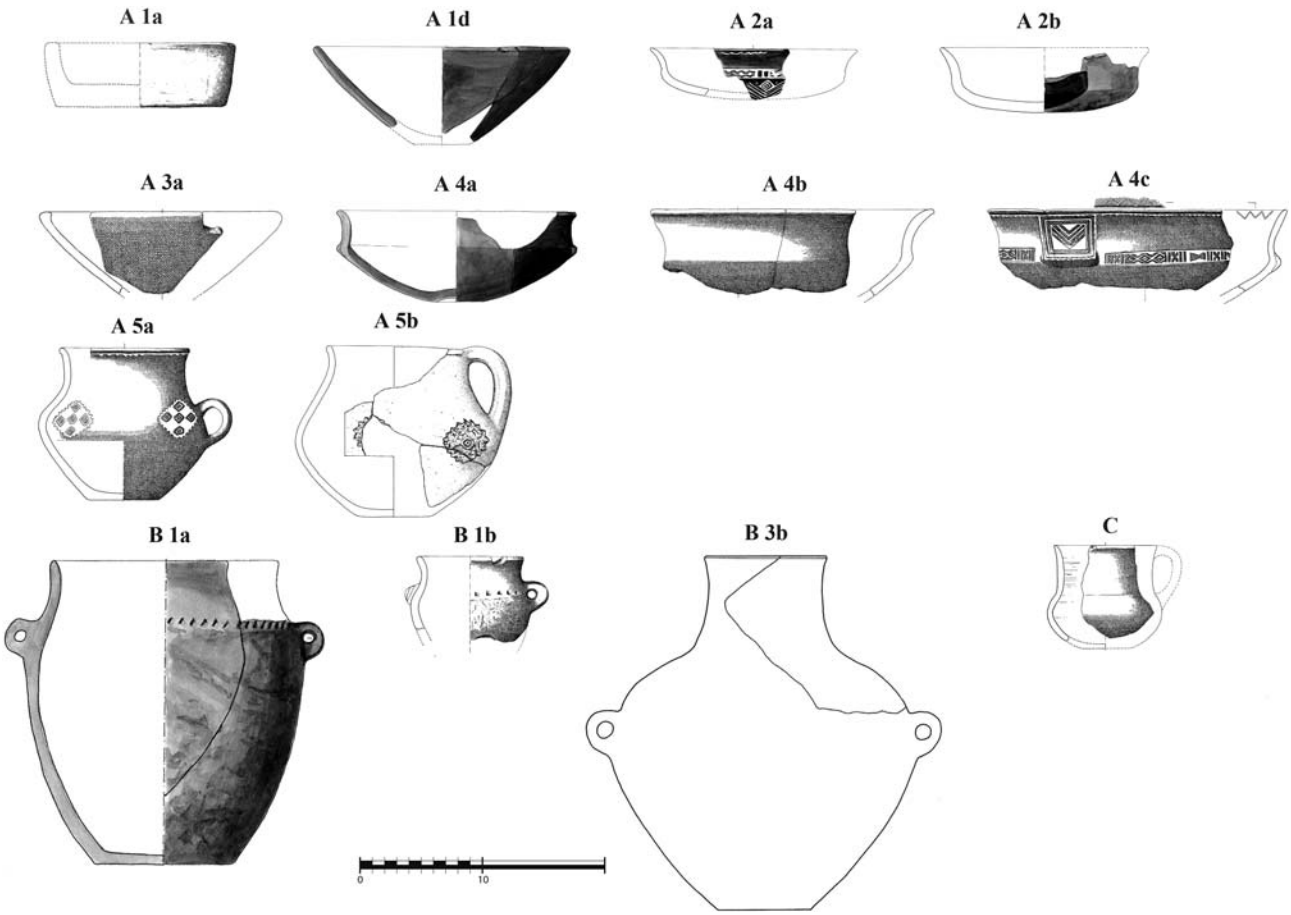

FIGURE 2. Typological table of types analyzed for standardization testing by coefficient of variation (CV).

Both sites are very good examples of continuity of settling from the Neolithic, as well as life during the Vučedol culture through several generations. That can be stratigraphically confirmed by means of the repair of house foundations in the same place. Chronologically, both settlements are absolutely and relatively dated to the late classical stage of the Vučedol culture (2630–2470 BC) (Miloglav 2012a).

Methods

Assemblages from both sites were divided into seven functional classes: A, bowl; B, pot; C, cup; D, jug; E, strainer; F, bottle; G, lid (*Figure 2*). The classes were then subdivided into broad groupings and variants based on the proportions and shape of the vessel and other selected variables (Miloglav 2012a). Measurements of the ceramics include height of vessel, radius of rim, radius of base, thickness of wall and width of handle. These are interrelated variables that allow measurement of the size and shape of ceramic vessels. The shape of the vessel was classified and described by four characteristic points on the vessel contour (Shepard 1985). This makes classification more objective, as the division into subgroups and variants is less susceptible to errors on the part of the person creating the typology. In an attempt to test the standardization of ceramic material on both sites, the measurements were undertaken using those variables that reveal most about ceramic products and that were available and numerically relevant (Miloglav 2012b). Apart from metrical variables, the analysis of clay and tempering material obtained from 17 samples by mineralogical-petrographical analysis and the method of X-Ray Diffraction was also taken into account. For the purposes of interpretation of functional forms, the analysis of lipids in the walls of the vessel was undertaken by the gas chromatography-mass spectrometry method (GC-MS) (Miloglav 2012a).

Measures of standardization

The standardization of ceramic material from both analyzed sites was measured by coefficient of variation (CV), which is used for measuring a cluster of data in terms of its dispersion. When calculating the coefficient of variation, it is necessary to divide the standard deviation of a certain group by its mean value and the calculation is expressed as a percentage (Shennan 2001).

When measuring the coefficient of variation, the measurement excludes extreme values (the lowest and the highest) and a maximum of three measurements by certain type. This approach is not unusual and it is applied mainly for two reasons. The first reason is the need to distinguish utilitarian objects from exclusive ones made for special purposes, which depart from other material in terms of their shape and decoration. The second reason is to reduce the subjectivity of and potential mistakes made during typological classification, especially when it comes to the size of the vessel (Blackman *et al.* 1993). For these reasons, measurements with extreme values which are not excluded from statistical processes provide false and unreliable data. Precisely because of the deviation of metrical values, it is also important that measurement and comparison are based on data from the same typological group. Although there are certain tests that include metrical parameters on the whole sample (without creating typological groups), these are rare and they demand a greater amount of statistical testing (Hirshman *et al.* 2010).

For the purposes of testing the level of standardization on material from both sites, measures of the rim radius and the thickness of the wall of the body of the vessel were taken. The thickness of the walls, although an important variable for the very function of the vessel, is rather unsuitable for comparison among certain types, since the fragmentation of ceramic vessels generally means taking measures on different parts of the vessel. When determining measures for the thickness of the walls, special attention was paid that they were always taken from the same parts of the vessel. For certain types, measures of the radius of the base and the height of the vessel were also taken, while for types where there were few or no relevant parameters, the comparisons and measurements were not undertaken (Miloglav 2012b).

Statistical analyses

Descriptive statistics is produced by the SPSS program (Statistical Package for Social Sciences). The Mann-Whitney *U* test is used to test differences between medians of rim radius in two independent groups (type A 2 and type A 4), i.e., whether these two types are classified correctly into two different typological groups. The Mann-Whitney *U* test is non-parametric statistical technique and it is used to analyze differences between the medians of two datasets, when the dependent variable is either ordinal or interval/ratio, but not normally distributed. The normality is tested by Shapiro-Wilk test. If *P*-value of the test is below 0.05, the data significantly deviate from a normal distribution.

RESULTS

Looking at the processed ceramic material, even at the lowest level of visual perception there is a visible resemblance of ceramic assemblages from both sites, seen within specific typological forms (bowl, pot, cup, jug). The simplest comparison of measured variables within typological groups has revealed that the metrical data either corresponds or else deviates by very small metrical values.

Even during material processing, a great resemblance among bowls of type A 4 was spotted. This type is divided into five variants, where variants A 4a, A 4b and A 4c exhibit minimal morphological deviations (*Figure 2*). Coefficient of variation for these bowls is extremely low and it shows the greatest level of standardization. For the radius of the rim on both sites, it varies between 11.6% and 12.8% and for the thickness of the wall from 10.8% to 13.8% (*Table 1*).

The high level of standardization identified in the bowls of type A 4 is not that surprising, especially when we know that bowls constitute the most numerous form on both sites in quantitative terms. Type A 4 is the best-represented type of bowl on both our sites, constituting 40.3% of all bowls at Ervenica and 28.8% of all bowls at Damića gradina. It has already been emphasized that the function of the vessel represents one of the analytical techniques for the interpretation of demand. By its function, bowls of type A 4 were used for serving and eating food which had not been thermally processed. Several important factors point to this fact. Apart from the very morphology of the bowl, this type of bowl does not contain traces of oxidation on its outer side nor traces that would point to the thermal shocks typical of bowls that are exposed to continuous warming up and cooling. Furthermore, GC-MS analysis uncovered traces of wax, which was applied to the interior and exterior surface of the vessel as a waterproof coating, preventing the liquid

TABLE 1. Comparative table of coefficient of variation (CV) measured on all types from Ervenica and Damića gradina.

	Rim radius / RR (cm)								
	Ervenica				Damića gradina				
Type	*N*	Mean	SD	CV (%)	*N*	Mean	SD	CV (%)	*P*-value
A 1d	4	11.9	1.4	12.0	7	13.7	2.7	19.8	0.181
A 2	6	8.6	2.2	25.2	30	9.1	2.0	21.4	0.248
A 3a	10	12.6	2.2	17.6	33	13.6	2.0	14.5	0.215
A 4a	14	12.0	1.5	12.6	14	11.3	1.4	11.9	0.268
A 4b	3	15.5	1.8	11.6	3	13.5	1.7	12.6	0.275
A 4c	6	14.3	1.7	11.6	28	13.1	1.7	12.8	0.063
A 5	8	5.6	0.8	14.2	24	6.1	1.4	22.8	0.379
B 1a	13	9.3	2.3	24.4	49	10.7	2.9	26.8	<0.043
B 1b	4	5.8	0.6	11.1	32	7.2	1.3	17.3	0.059
B 3b	7	7.3	1.3	17.6	11	6.5	1.4	21.7	0.203
C	4	4.1	0.3	8.0	3	3.8	0.5	12.3	0.857
	Wall thickness / WT (mm)								
	Ervenica				Damića gradina				
Type	*N*	Mean	SD	CV (%)	*N*	Mean	SD	CV (%)	*P*-value
A 1a	5	12.1	1.9	15.8	9	13.1	2.8	21.0	0.549
A 1d	8	8.1	1.4	17.0	18	8.1	1.2	14.6	0.912
A 2	27	6.9	1.2	17.2	88	6.4	1.1	16.7	0.159
A 3a	25	7.3	1.0	13.4	78	7.9	1.0	12.5	<0.006
A 4a	36	7.0	0.9	13.0	28	6.8	0.9	13.5	0.561
A 4b	7	6.8	0.8	11.0	9	7.3	1.0	13.8	0.469
A 4c	22	7.2	0.8	10.8	90	7.1	0.9	12.2	0.194
A 5	22	6.3	0.9	14.0	75	6.4	1.1	16.6	0.914
B 1a	23	7.3	1.0	14.1	87	8.9	1.4	15.2	0.000
B 1b	8	6.5	0.9	13.3	56	6.9	1.2	18.0	0.440
B 3b	7	9.3	2.5	27.1	15	8.4	1.4	16.7	0.341

N, number of sherds; SD, standard deviation; CV, coefficient of variation.
P-value represent statistical significance of the differences between medians of two independent groups (types on both sites), calculated using Mann-Whitney *U* test.

content from seeping out (Miloglav 2012a). The reason for the greater level of standardization on this type of bowl is probably its intensive use in everyday life, which means faster wearing out, deformation and breaking – resulting in more frequent production and greater experience in its making. The traces of mending on ceramic bowls, which include perforations on both sides of a fracture, are most frequent exactly on the bowls of type A 4, which represents additional confirmation of intensive use and wearing out of these bowls. A large quantity of products implies the acquisition of better experience in their making, i.e., a manner of routine making. The results of some ethnoarchaeological research (Eerkens, Bettinger 2001) point to a possible confirmation of this thesis.

As opposed to type A 4, type A 2 does not show a prominent level of standardization (21.4% and 25.2% for the radius of the rim), the reason for this being the fact that it varies considerably in height and radius of rim (*Table 1*). Although apparently similar, these two types

TABLE 2. Comparative table of rim radius between types A 2 and A 4 on both sites.

	Rim radius / RR (cm)						
	A 2			A 4			
	N	Mean	SD	*N*	Mean	SD	*P*-value
Ervenica	6	8.6	2.2	27	13.0	2.2	0.001
Damića gradina	30	9.1	2.0	49	12.5	2.0	0.000

N, number of sherds; SD, standard deviation.
P-value represent statistical significance of the differences between medians of rim radius on two independent groups (type A 2 and A 4) calculated using Mann-Whitney *U* test.

of bowl are rather different morphologically, in both shape and dimensions. Type A 2 is smaller, it has a rounded or *omphalos* base and S-profiled shape. Type A 4 is much higher, with biconical shape and flattened base (*Figure 2*). The Mann-Whitney *U* test was conducted, to reject the possibility of making potential mistakes during typological classification regarding types A 2 and A 4 (*Figure 2*). At the $\alpha = 0.05$ level of significance there is enough evidence to conclude that there is a difference in the median of two compared groups (*Table 2*). Because the *P*-value of 0.001 and 0.000 is smaller than 0.05 we can reject null hypothesis and conclude that there is a difference in the median of rim radius of two types (A 2 and A 4). Based on that, we can also conclude that those two types do not belong to the same typological group. Small variations in the morphology of bowls of type A 4 disclose that this type of vessel was used mostly for utilitarian purposes, while type A 2 was obviously made for some special purposes and in that respect the morphology of the vessel varies considerably.

It should be emphasized again, when measuring coefficient of variation it is very important that metric comparisons take size classes into account, e.g., to reduce the subjectivity and potential mistakes made in the course of typological classification. This problem is visible on the bowls type A 1 (*Figure 2*). Type A 1 is divided into four variants, precisely on the basis of height, thickness of the wall and radius of a rim, so it is not realistic to expect the level of standardization measured on the basis of all variants of this type of the bowl. Coefficient of variation, measured for rim radius on all variants of type A 1, on Ervenica amounts to 35.9%, while at Damića gradina it amounts to 43.8%, which is rather high. However, when the metrical measures are directed to the same shapes within the typological classification, the percentage of CV is being fairly reduced and it points to the certain level of standardization. Thus at the Damića gradina for type A 1d CV for radius of rim amounts to 19.8% and on Ervenica it is even lower, 12.0% (*Table 1*).

A relatively large CV is identified in the pots, specifically of type B 1a and B 3b (*Table 1, Figure 2*) while somewhat smaller variability is present in the smaller pots of type B 1b. A large CV for pots would point to their less intensive production, while another reason for this might be the size of the vessel, since mistakes in processing increase linearly with the size of the bowl (Roux 2003). Perhaps this might be confirmed precisely on pots of type B 1a and B 1b, since they represent the same functional forms, the separation of which into different subgroups within the same functional type is connected with the height of the vessel (Type B 1a is considerably taller). The reason why the pots are less uniform probably lies in the lower level of production, which is reflected in the level of standardization.

The results of Mann-Whitney *U* tests on *Table 1* showed no statistically significant differences between medians of rim radius and wall thickness by comparison between same types on both analyzed sites, except type B 1a. The *P*-value for this type is less then 0.05, which means that there is a significant difference between medians of rim radius and wall thickness compared between the types on both sites. This type, as it was mentioned above, also does not show any significant standardization.

It is very interesting to look at the graph presenting median relationships of rim radius for both sites on all analyzed types (*Figure 3*). The values that overlap to the greatest extent are found on the said bowls of type A 4, while other values can be linearly traced on both ceramic assemblages. Values obtained by measuring coefficient of variation also decrease or increase equally on both

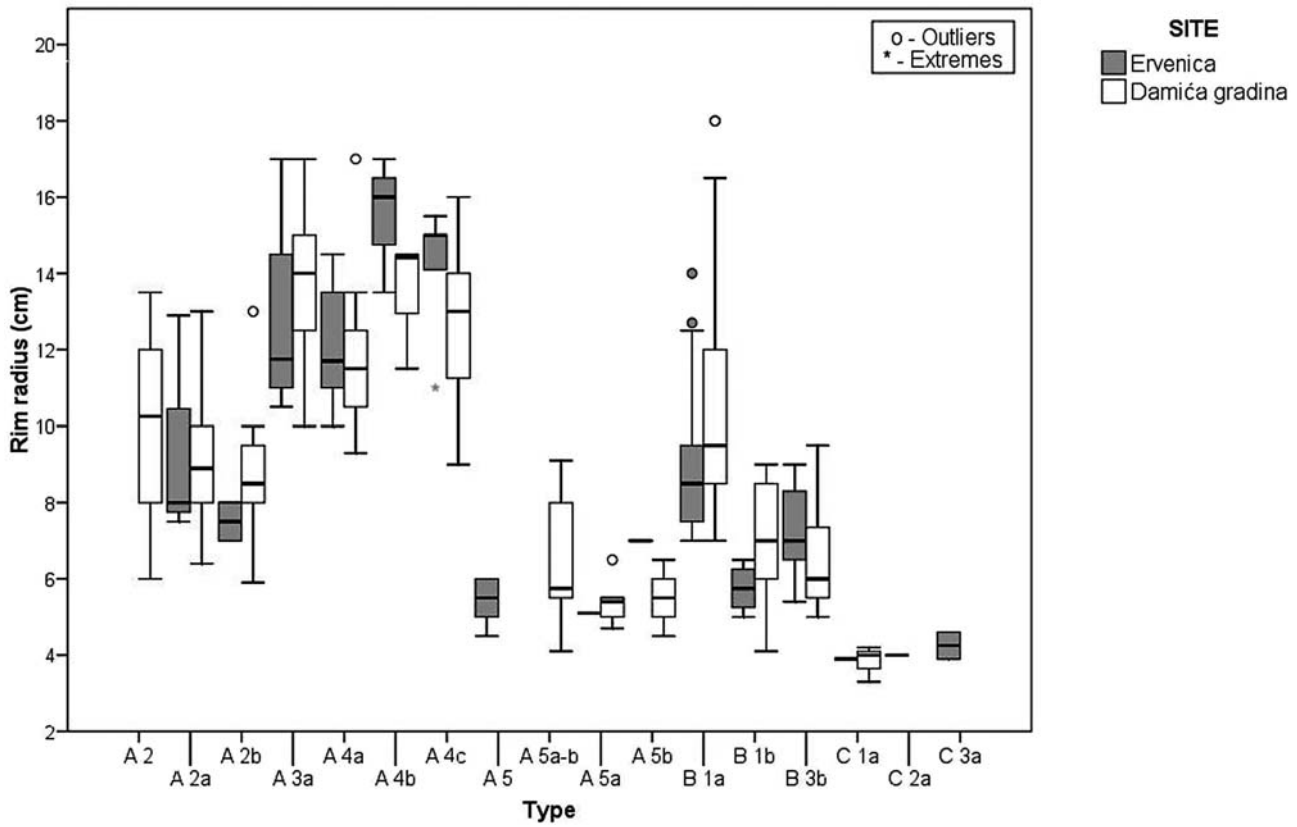

FIGURE 3. Box-and-whisker plot showing median relationships for rim radius (cm) dataset from two analyzed sites (Ervenica and Damića gradina). Horizontal lines within the boxes show median values, boxes represent 25–75% data ranges (lower and upper quartile), whiskers show minimum and maximum values, outliers are represented with circles and extreme values with asterisk.

sites, regarding the same type (*Table 1*). These measurements certainly serve as confirmation of standardization that depended on the intensity of certain ceramic forms which are almost equally represented at Ervenica and at Damića gradina.

DISCUSSION

The overview presented of the socio-economic and political framework in which Vučedol society was functioning makes it easier to explain and interpret the way in which ceramic production was organized and the level of its specialization. Generally, there are several key issues that represent the basis of every study and research of specialized production and these are related to spatial and socio-economic conditions. In our case, there is a visible stratification of the society and domination by the settlement at the Vučedol site, in the sense of its size when compared to other, neighbouring settlements. One of the estimations pertaining to the overall population presents the impressive number of 1100–1500 inhabitants (Forenbaher 1994) for only two locations on the Vučedol site (Streim's Vineyard and Cornfield), covering an area of 2.85 ha. Although the Vučedol site is not the theme of this work, it is essential to stress its importance with respect to the general picture of the functioning of Vučedol society. It is very likely that the site of the Hotel Slavonija in Vinkovci had very similar socio-political organization in its settlement.

Looking at the technological segment, when preparing the clay mixture for making the vessel, almost the same attention was dedicated to vessels for everyday use as to those serving some other purpose. All ceramic fragments indicate a markedly fine-grain texture of the clay mixture. This is shown by mineralogical-petrographical analysis and XRD analysis of ceramic material on both sites. All the pottery was made by

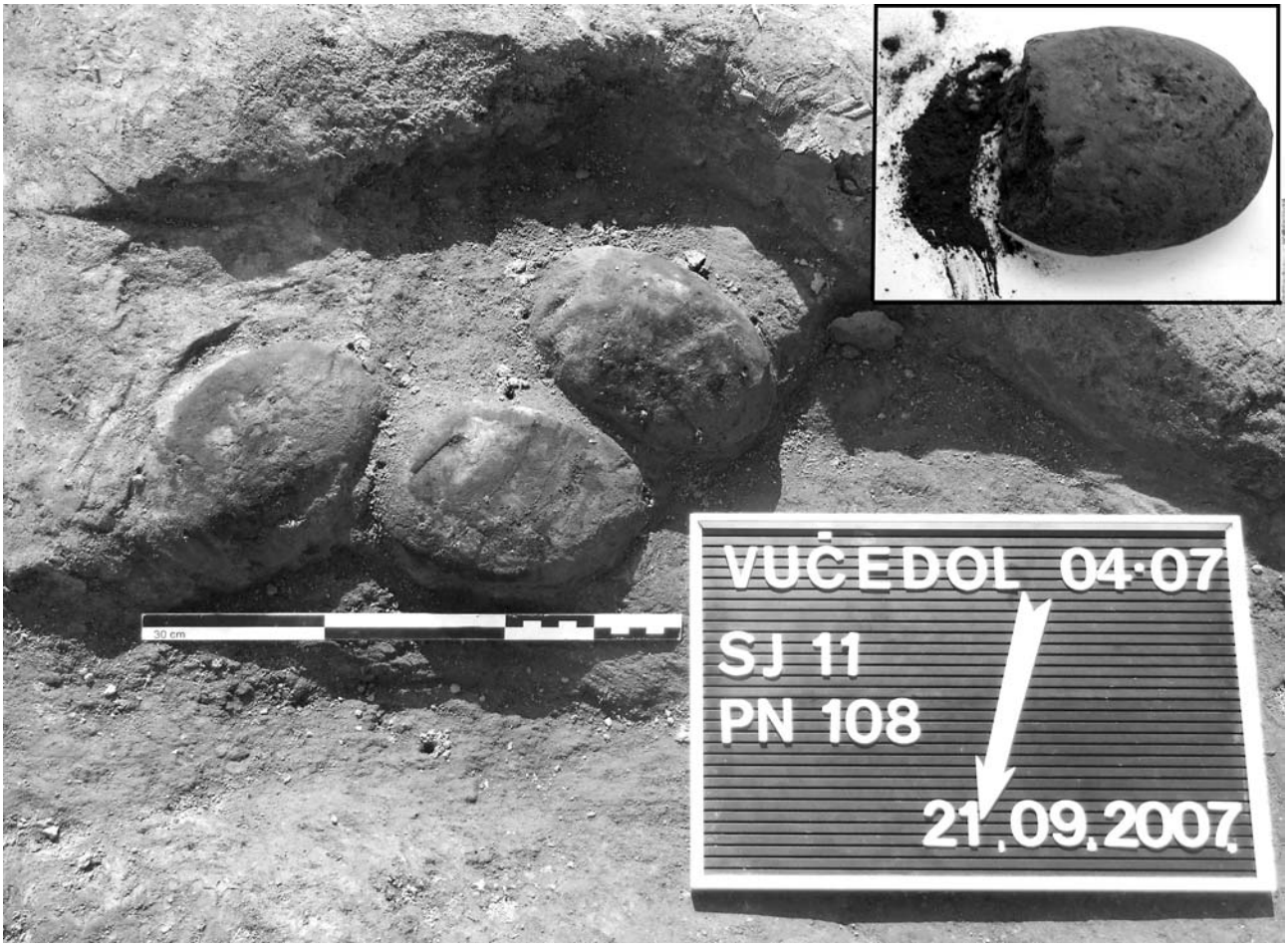

FIGURE 4. Lumps of hematite found on the Vučedol site (Streim's Vineyard).

reduction firing at high temperature, which results in its increased hardness and resistance to all kinds of deformation and fracturing. The matrix abounds in homogeneously arranged, small-grained sub-angular-to-angular quartz, as well as in leafy minerals belonging to the class of mica. In this case, the unimodal distribution of quartz and mica within the matrix, as well as the angularity of the quartz, suggest that minerals represent a natural component of the raw material, and that their source was relatively close to the location of the material used for preparing the clay mixture. In principle, the longer the grains were transported, the more rounded they are (Velde, Druc 1999). Based on the above analysis, it can be concluded that ceramic production took place locally at the level of both sites, since clay was dug up either from the close surroundings or, most likely, within the settlement (Miloglav 2012a).

Since, at both the Ervenica and the Damića gradina sites, no areas suggesting the places of production have been identified, it was the ceramic material itself that served as indirect evidence of specialization and organized production. However, certain general characteristics of the Vučedol sites should be pointed out regarding the production of pottery. In contrast with the cultures that preceded it, within the Vučedol culture not a single ceramic kiln has been found, so it is obvious that the firing of ceramics was taking place on an open fire, in the hearth or pit. The organization of Vučedol sites implies densely packed houses with passages between them often less than a metre wide (Forenbaher 1994). Therefore, it is likely that the surroundings of a house were often cleaned to remove rubbish and waste in order to be passable. For this reason it is rather difficult to find and identify direct evidence of the places of production

TABLE 3. Coefficient of variation (CV) results from pit SU 47/48 on the Ervenica site.

	Ervenica – pit SU 47/48									
	Rim radius / RR (cm)					Wall thickness / WT (mm)				
Type	*N*	Mean	SD	CV (%)	*P*-value	*N*	Mean	SD	CV (%)	*P*-value
A 4a	4	13.3	2.2	16.6	0.842	12	6.8	0.9	13.1	0.09
A 4	6	13.9	1.9	13.9	0.783	17	6.8	0.8	11.7	0.12

N, number of sherds; SD, standard deviation; CV, coefficient of variation.
P-value represents normal distribution of the data calculated by Shapiro-Wilk test.

by archaeological excavation. The large number of pits which have been found in the close vicinity of a house suggests that those pits served multiple purposes – as clay pits for house building and making ceramic vessels, as storage places for food, as well as firing pits. At some point these pits became waste deposits, while some of the pits also served for burials. Perhaps the only piece of indirect evidence that would point to a place of production is the one comprising three big lumps of hematite, which was used for red decoration (incrustation) of pots (*Figure 4*). The lumps are found in the close vicinity of a house on the Vučedol site (Streim's Vineyard). Although they represent evidence which suggests a place of production on the Vučedol site and not on the sites analyzed in this paper, it is important to emphasize their relevance in the sense of identifying places of production which do not include firing pits/kilns, tools or unworked clay.

On the basis of up-to-date research, it can be concluded that standardization reflects more intensive production and production organization that it stems from the economic and social framework of the community and that it has an impact on the homogeneity of the product. Values obtained by CV measurements on both sites definitely suggest a certain level of standardization of ceramic vessels, especially of the bowls. The reason for this lies in the fact that the bowls are the most abundant category of ceramics, so that their production has, over time, reached a level of skill connected with experience. However, it should also be taken into consideration that only certain vessels (e.g., bowls of type A 4) could have been produced by specialized potters, as greater standardization generally means a smaller number of producers, and vice versa.

Thus a model of organizational production in Vučedol society must have existed; and it was still taking place within households, but with more intensive ceramic production. These were not yet workshop centres, but it is definite that a certain number of people were singled out by their skills and that they were engaged in ceramic production. This type of specialization is not yet at a professional level in the sense of a full-time job. On the basis of the measurements, it can be concluded that there were several potters who were producing ceramic vessels within the settlement. This is visible from the percentage of CV, which varies considerably and it is possible that each of the potters used specific mechanical attributes in the making of the vessels.

Even singling out and measuring one closed unit (pit SU 47/48), there are no significant differences in CV percentage (*Table 3*). Generally, a larger percentage for the coefficient of variation would suggest a higher number of potters who made ceramic vessels, while a smaller CV suggests a single ceramic worker. As the material from pit SU 47/48, where most of the ceramic material from the Ervenica site was found, is not susceptible to "cumulative blurring" and does not show a greater level of standardization than the level obtained by other measurements, it is most likely that this data substantiates the thesis of several ceramic workers and ceramic units in the settlement.

More ceramic workers making the vessels could mean a specialization of the community and not an individual one, as is suggested by some ethnoarchaeological and archaeological research (Costin 1991, Rice 1989, Stark 1991, Tite 1999). On the basis of the four parameters used by Costin (1991: 8) for the depiction of production organization, I will undertake to define and interpret the results obtained.

Context of production defines the nature of the control over production and distribution. Control of products in Vučedol society by the elite must have existed when it comes to the production of copper objects, i.e., metallurgic production. On the other hand, the elite is not particularly interested in the control of

craft production of everyday goods, because the raw material for this purpose is easily accessible. In the case of the sites at Ervenica and Damića gradina, clay was dug up most likely in the settlement. Although Vučedol society reveals some traces of social inequality, as well as of a certain social hierarchy, these elements are still at an emerging stage and for this reason there was probably no control over all segments of economic and social life. In the case of ceramic production it is more probable that there existed individual specialists, i.e., specialization of community oriented towards production of utilitarian objects for all households and their distribution within and outside the settlements, without control over products and raw material. However, there is a possibility that certain products for special purposes could have been ordered by more affluent families/ individuals; which is confirmed by archaeological material. Possibly this difference is more visible on the Vučedol site, which exhibits more visible traces of social differentiation. However, additional research and testing of the material on the Vučedol site should be undertaken in order to confirm this thesis.

Relative regional concentration of production facilities refers to the geographic organization of production, how specialists are distributed across the landscape, their spatial relationship to one another and the consumers for whom they produce. This part of the production system is perhaps that which could least possibly be defined within the research sites. Although they are very large settlements which belong to the bigger Vučedol sites in the organizational sense, at this point we can only guess in which way the specialists were distributed across the landscape and what their mutual relationship was. As regards distribution, it might have functioned in such a way that smaller settlements in the surrounding area – the settlements belonging to a lesser level of organization than the sites presented in this paper – were supplied.

Scale of production units, which includes the size or number of individuals working in a single production unit and the principles of labour recruitment. It has already been said that the ceramic production took place at the level of households, which could have been organized into several ceramic units. They comprised individuals with certain knowledge, skills and experience or members of the same family. Since there is no direct evidence of the division of labour in the archaeological setting, we cannot identify it with certainty. However, a division based on sex or kinship must have existed.

Intensity of production, which reflects the amount of time producers spend on their craft, i.e., whether it was a part-time or full-time job. As a rule, in the archaeological context it is fairly difficult to talk about the time spent on craft production. Viewed from the wider context of the socio-economic demands of the Vučedol community, the jobs of ceramics workers did not demand a permanent work engagement in the sense of daily engagement in exclusively ceramic work. The work could have been done partially and in combination with other community needs. So the firing of the vessel could have taken place in one part of the day, while the rest of the day could have been dedicated to other chores (land cultivation or stock-breeding). Also, vessels were produced not on a daily basis but depending on weather conditions and economic activities. This means that vessels were not made during rainy seasons and that production was surely more intensive during the time of harvest and other agricultural activities.

Household production can vary from low intensity to fairly intensive production set in a household context (Costin 2005: 1040). A lot of ethnoarchaeological research has produced results confirming that the output from small-scale, part-time, household-based production units could have been very high (Hagstrum 2001).

Howewer, this category can be evaluated by the total amount of pottery produced in relation to households and their lifetimes (Costin 1991). Unfortunately, site formation processes, which had to be considered, do not give us enough data for calculation of this sort.

CONCLUSION

Organization of production within Vučedol society may be best described and placed within the model put forth by van der Leeuw (1977). It would fall within organization at the level of household industry and it relates to production that is still taking place within the household, but most of the production is oriented towards needs existing outside the household, i.e., to trade and exchange beyond household consumption. When we would undertake to elaborate this phase in more detail, it would be caused by the model of demand and supply, implying greater ceramic production conditioned by greater economic activity, an increase in population and social organization in which we can observe the stratification of society and the emergence of hierarchic relationships. Increased ceramic production thus becomes a reflection of the new socio-economic changes and it would include a division of labour in everyday activities. The organization of production should have catered for the everyday needs of the

population and it should have secured a quantity of products for trade and exchange. In the same way, all classes of society should be catered for, from richer individuals/families to smaller and poorer households, the consumption of which had not exceeded the satisfaction of annual and seasonal needs for the ceramic inventory.

For now, aside from the results and proposed hypotheses presented in this work, no other factors exist by which specialized ceramic production within Vučedol society might be confirmed. Therefore, interpretation and discussion are left open for some new research and discovery. By all means, some new factors would need to be taken into account that would enable calibration of the data, such as cross-cultural and diachronic studies, as well as other analysis.

Generally speaking, the identification of specialization and its definition and character in the society, is archaeologically as challenging as it is unobliging, because its connection with the socio-political situation is very complex. It is perhaps best described by Costin (2005: 1062) when she says "specialization is as much a social relation as it is an economic one, because it diminishes autonomy and creates new kinds of interdependencies that underwrite complex forms of social integration".

ACKNOWLEDGEMENTS

I wish to thank the staff of the Archaeological Department of Vinkovci Municipal Museum for making material available. Acknowledgments also goes to the two anonymous reviewers for they effort and for enhancing quality of the paper.

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Ina Miloglav
Department of Archaeology
Faculty of Humanities and Social Sciences
University of Zagreb
I. Lučića 3
10000 Zagreb
Croatia
E-mail: imilogla@ffzg.hr