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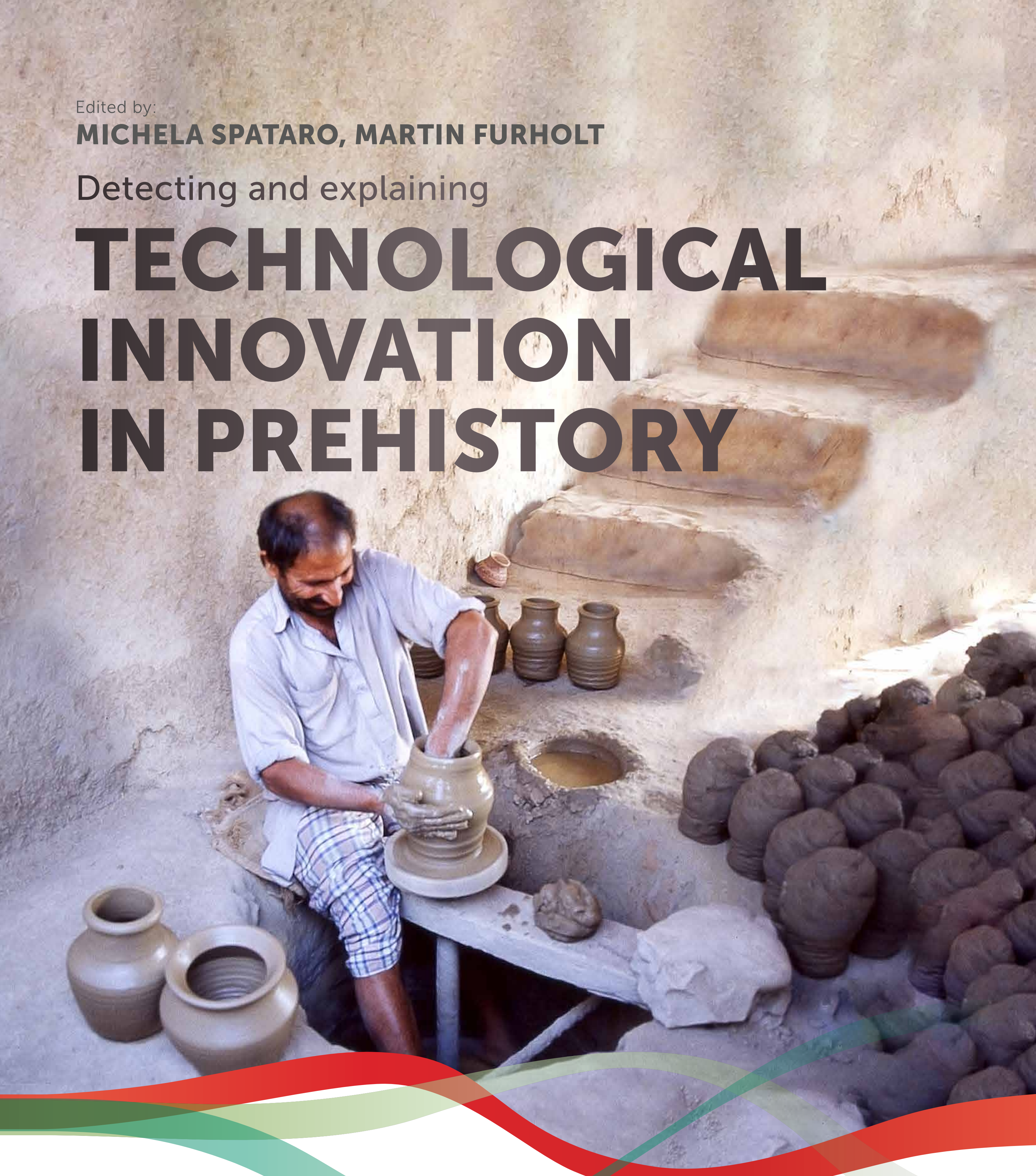
MICHELA SPATARO, MARTIN FURHOLT

Detecting and explaining

TECHNOLOGICAL INNOVATION IN PREHISTORY



SCALES OF TRANSFORMATION IN PREHISTORIC AND ARCHAIC SOCIETIES | 8

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SCALES OF TRANSFORMATION | 08

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Preface of the editors

With this book series, the Collaborative Research Centre *Scales of Transformation: Human-Environmental Interaction in Prehistoric and Archaic Societies* (CRC 1266) at Kiel University enables the bundled presentation of current research outcomes of the multiple aspects of socio-environmental transformations in ancient societies. As editors of this publication platform, we are pleased to be able to publish monographs with detailed basic data and comprehensive interpretations from different case studies and landscapes as well as the extensive output from numerous scientific meetings and international workshops.

The book series is dedicated to the fundamental research questions of CRC 1266, dealing with transformations on different temporal, spatial and social scales, here defined as processes leading to a substantial and enduring reorganization of socio-environmental interaction patterns. What are the substantial transformations that describe human development from 15,000 years ago to the beginning of the Common Era? How did interactions between the natural environment and human populations change over time? What role did humans play as cognitive actors trying to deal with changing social and environmental conditions? Which factors triggered the transformations that led to substantial societal and economic inequality?

The understanding of human practices within often intertwined social and environmental contexts is one of the most fundamental aspects of archaeological research. Moreover, in current debates, the dynamics and feedback involved in human-environmental relationships have become a major issue, particularly when looking at the detectable and sometimes devastating consequences of human interference with nature. Archaeology, with its long-term perspective on human societies and landscapes, is in the unique position to trace and link comparable phenomena in the past, to study human involvement with the natural environment, to investigate the impact of humans on nature, and to outline the consequences of environmental change on human societies. Modern interdisciplinary research enables us to reach beyond simplistic monocausal lines of explanation and overcome evolutionary perspectives. Looking at the period from 15,000 to 1 BCE, CRC 1266 takes a diachronic view in order to investigate transformations involved in the development of Late Pleistocene hunter-gatherers, horticulturalists, early agriculturalists, early metallurgists as well as early state societies, thus covering a wide array of societal formations and environmental conditions.

The publication on detecting and explaining technological innovation in prehistory includes interdisciplinary research, with case-studies from Europe, the Indus Valley, Iran, and Mexico. We are very thankful to the editors of the workshop proceedings Michela Spataro and Martin Furholt and to graphic illustrator Carsten

Reckweg for their deep engagement in this publication. We also wish to thank Karsten Wentink, Corné van Woerdekom and Eric van den Bandt from Sidestone Press for their responsive support in realizing this volume and Hermann Gorbahn and Katharina Fuchs for organizing the whole publication process.

Wiebke Kirleis and Johannes Müller

Contents

Technological innovation and social change. Early vs. late Neolithic pottery production of the Central Balkans

Jasna Vuković

Abstract

The earliest pottery of the Central Balkans (Starčevo culture), characterized by organic inclusions, round, spherical shapes, and oxidized firing conditions, usually lacking traces of use, is usually seen as pottery typical for partly mobile communities. On the other hand, late Neolithic (Vinča) pottery features (mineral inclusions, and reduced firing atmosphere, among others) indicate major changes in manufacturing sequence, conditioned by more elaborate technical knowledge, suggesting the different needs of the consumers, which also affected changes in pottery demand. In this paper, innovation in Neolithic pottery production is considered through several distinct aspects of technology: the standardisation analyses which may reveal social innovation (almost random in the early vs. partly specialized production in the late Neolithic), the shift from organic to mineral inclusions in ceramic paste, as a consequence of changed needs for particular performance of pottery, and the change in the chaîne opératoire in the manufacture of vessels with roughened surfaces, an innovation that led to the adoption of less time-consuming manufacturing procedure. The processes that led to transformation of pottery technology and craft organisation from the early to the late Neolithic are still unknown. They may be traced during the early to late Neolithic transitional period, and may be explained by contact between two different technological traditions, changes in knowledge transmission mechanisms, and lack of social pressure in the practicing of the craft, leading to the emergence of specialized artisans.

Keywords: pottery, technology, early Neolithic (Starčevo), late Neolithic (Vinča), innovation

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Introduction: innovation and technological change

Issues within innovation and technology are widely discussed in archaeological and anthropological literature. Technology may be broadly defined as “the processes and practices associated with production and consumption, including distribution, use, and disposal, from design to discard“ (Miller 2007, 4). Technology may also be seen as set choices depending on many factors (Lemonnier 2002 a, b), but it is based on certain knowledge, which constitutes “a bridge between the techniques and society“ (Lemonnier 1986). According to Schiffer and Skibo (1987), technological knowledge is comprised of several components: recipes for action, teaching frameworks, and techno-science, which includes the awareness of how the finished product will perform its function(s). On the other hand, the concept of technological style, defined as a way of doing something (Hegmon 1992) or a way an artefact was made (Chilton 1999, 50), thus representing expression of social behaviour or shared understanding of how the things have to be done (Stark 1999, 5), and so reveals the presence of technological traditions. These are defined as patterned ways of doing things that exist in identifiable form over a period of time, and they are transmitted vertically – from parents to their offspring (O’Brien and Shennan 2010, 6). Technological styles exhibit high temporal durability, they are extremely conservative (Nicklin 1971, 26) and ensured by social control through learning and teaching frameworks, and even by the presence of social sanctions which ensure existing traditions are maintained (*e.g.* Gosselain 1992; Stark 1999, 41).

Despite the long temporal continuity of technological styles, changes do occur. The factors that trigger technological change, although discussed in the literature still challenge the researchers. Technological change is caused by the presence of innovation, usually defined as a process that includes both invention and adoption (van der Leeuw and Torrence 1989; Hegmon and Kulow 2005), or the process during which a new idea or technique becomes widely accepted (for overview see: O’Brien and Shennan 2010). Invention, therefore, occurs at the level of the individual while adoption occurs on the collective scale (Roux 2010, 217). The long-lasting process of technological change also includes the processes of development and replication (Schiffer 2010). In the archaeological record, technological change can be traced by defining changes and quantities of certain features on a temporal scale in a particular area. However, these processes are of unequal visibility in the archaeological record: only adoption stands out, as it includes high frequencies of archaeological examples. Other processes are very hard to determine. As it was argued, the dominant pattern of technological change over time is increasing formal variation, and this pattern can be attributed to the process of invention (Schiffer 2010).

The spreading of innovation is mainly conditioned by the mechanisms of cultural transmission. They can be vertical – from cultural ancestor to cultural descendant, or horizontal (between cultural groups) (O’Brien and Shennan 2010, 6). As it was mentioned earlier, technological traditions are conservative, so the first one tends to prevent innovation and to maintain the existing way of doing things. Innovation is, however, possible, but under different conditions. From an actor-network perspective, the process of diffusion of cultural traits can be traced through the models relating individual actions, the social network structure and the sociological regularities, stressing the non-linear nature between individual actions and social dynamics and the presence of mediating mechanisms that explain how individual actions generate some macro-social regularities (after Roux and Manzo 2018). Innovation and its adoption are therefore possible within favourable social structures. It may be triggered by some stressful conditions, for instance changed needs of consumers, but also by increased demand for specific products (see below). It may include contacts, interactions, and mixing between different social groups enabling a decrease in social pressure within learning frameworks, making it possible to experiment and apply new techniques, thus increasing variability, including the hybridization of different technological styles.

Technological change also causes changes in social organisation, so social innovation should be distinguished from technical innovation (cf. Schubert 2014). In another words, technological change is also a behavioural change, which includes alterations in activities (Schiffer 2010, 236) which further affect other aspects of social relations. This is especially important regarding the organisation of production, and the position of the artisans within the society.

Pottery as a new technology

Pottery as a new technology was introduced very early on, and the emergence of such new technology among the hunter-gatherer societies was seen as a "prestige" technology used for special foods (Craig 2016), or as containers used for communal feasts in order to display rare and desirable food, therefore stressing the special status of some individuals (Hayden 1990). Another explanation is so-called "architectural hypothesis", *i.e.* the view that the process of innovation in pottery technology was carried out in two steps – the first one included the production of unfired, sun-dried pottery, and the second introduced firing when pottery-making became a real pyrotechnic craft (Vandiver 1987). So-called "culinary hypotheses" (Rice 1999, 6) consider the emergence of pottery as a way to introduce a variety of "new foods" into the diet, making inedible food edible (detoxifying toxic foods or making inedible food digestible by thermal processing) (Arnold 1985, Tab. 6.1); the adoption of pottery enabled new techniques of food processing (*i.e.* soaking, fermentation, cooking and roasting) and storing. Another explanation is a more complex economic approach based on the principle of supply and demand (cf. Rice 1999, 41-42; Skibo and Schiffer 2008, 40-41): ceramics are adopted when other kinds of containers could not withstand increased demand caused by the new ways of food preparation and storing, and when food became important as a social expression.

In the Central Balkans[1] pottery was introduced as a part of the Neolithic package, during the early Neolithic Starčevo tradition, at the beginning of the sixth millennium BCE. The differences between two chronological extremes – Early Starčevo, namely Blagotin (6430-6260 cal BCE – 6220-6020 cal BCE) (Thissen 2009; Whittle *et al.* 2002) and Lepenski Vir (the end of VII and the beginning of the VI millennium) (for discussion of radiocarbon dates see: Budja 2009; Bonsall *et al.* 2015; Perić and Nikolić 2016), and the final phases of late Neolithic Vinča, around 4500 BCE (Tasić *et al.* 2015) can be summarized as follows: organic inclusions, namely chaff in the early (Spataro 2007; 2011), and mineral inclusions in the late Neolithic; round shapes vs. predominantly biconical shapes, and most importantly, the differences in firing procedure: oxidized, which results in reddish, brownish, and orange colours, and reduced, with grey and black finished products of the late phases of Vinča. The differences can also be observed in some other features, such as surface finishing and decoration, most of all impresso vs. channelled ornaments, and the appearance of the motifs. During this long temporal sequence, many innovations in pottery technology occurred followed by changes in social relations. How can they be explained and what caused them? Was it experimentation? Are they conditioned by the needs of the consumers, such as changing food habits, by some external stress, or by changes in the patterns

1 The term "Central Balkans" refers to the areas south of the Danube and Sava rivers. Its western borders go along with the rivers of Drina and Ibar, and the mountains of Šara and Prokletije while its eastern border is marked by the mountains Suva planina and Osogovo. It includes the territory of central modern-day Serbia and parts of Kosovo and North Macedonia (Garašanin 1979, 79). In this paper, only pottery from the sites analysed by the author is included.

of knowledge transfer? How are these factors interrelated? In this paper, only some of the aspects of technological change in the Neolithic pottery of the Central Balkans are going to be examined, and possible answers will be presented.

Social innovation: organisation of pottery production in the Neolithic of the Central Balkans

The organisation of pottery production for the earliest pottery-making communities was rarely considered in archaeological literature. According to all of the proposed models of production organisation (Balfet 1965; van der Leeuw 1977; Rice 1981; Peacock 1982; Sinopoli 1988; Santley *et al.* 1989; Costin 1991; Blackman *et al.* 1993; Costin and Hagstrum 1995), the simplest organisation, present in the egalitarian societies can be related to low intensity of production, part-time involvement in the craft, and the production for the needs of artisan's household. The calculation of the values of coefficient of variation – CV (Eerkens and Bettinger 2001) of the metric parameters of ceramic vessels is considered to be one of the most reliable tools for the determination of the presence of product uniformity and high level of routine and motor skills of the artisans. In order to explore the level of product standardisation, CV values were calculated for the pottery assemblages from two early Neolithic Starčevo sites – Blagotin in central Serbia and Lepenski Vir in the Danube Gorges. Pottery assemblages from both sites exhibit extremely high morphological and dimensional variability. In the Blagotin assemblage, higher frequency of fine pottery, decorated specimens and high variety in shape repertoire were confirmed. Nevertheless, three main morphological groups for standardisation analysis of the pottery from both sites were established: large conical dishes, hemispherical bowls, and S-profiled vessels. CV values were calculated for several metric parameters. However, due to high fragmentation of the material, the rim diameter and wall thickness were the only metric parameters that could be measured on all of the specimens. The results (Tab. 1) revealed relatively high CV values. They indicate non-standardized, almost random production for both sites, especially for the classes of S-profiled pots and conical bowls, which are going to be further examined in this paper. They indicate a large number of producers, and the simplest form of production: household-based and non-specialised, intended to fulfil the needs of the members of the potter's household. This kind of production was also of low intensity and was probably taking place seasonally (Vuković 2017a).

In contrast, late Neolithic Vinča pottery exhibits considerably lower CV values (Vuković 2011), revealing reduced variability. This is especially visible when early and late Neolithic assemblages are compared. Scatter-dot diagram (Fig.1) clearly shows that best-fit regression line for Vinča pottery tends to be lower and closer to the x-axis, revealing considerably more standardized production. However, the late Neolithic low values occur on only one class of ceramic vessels – two types of bowls, indicating the presence of partial standardisation. Some other properties of Vinča pottery must also be mentioned: reduced variability in shape repertoire, but at the same time, the presence of elaborated, "luxurious" vessels made by skilled artisans (Vuković and Miloglav 2018), as well as uniform paste composition originating from a single raw material source (Spataro 2017; 2018). Moreover, the simplification of manufacturing technique is assumed for the late Neolithic standardized bowls and the usage of molds have been assumed (Vuković 2014a). All these aspects indicate the presence of specialisation, probably still household-based, but meant for the consumption outside the potters' household (Vuković and Miloglav 2018).

These differences between early and late Neolithic pottery production clearly show that pottery-making went through a series of changes – from the meeting of one's own needs to the emergence of skilled, probably specialised artisans. These

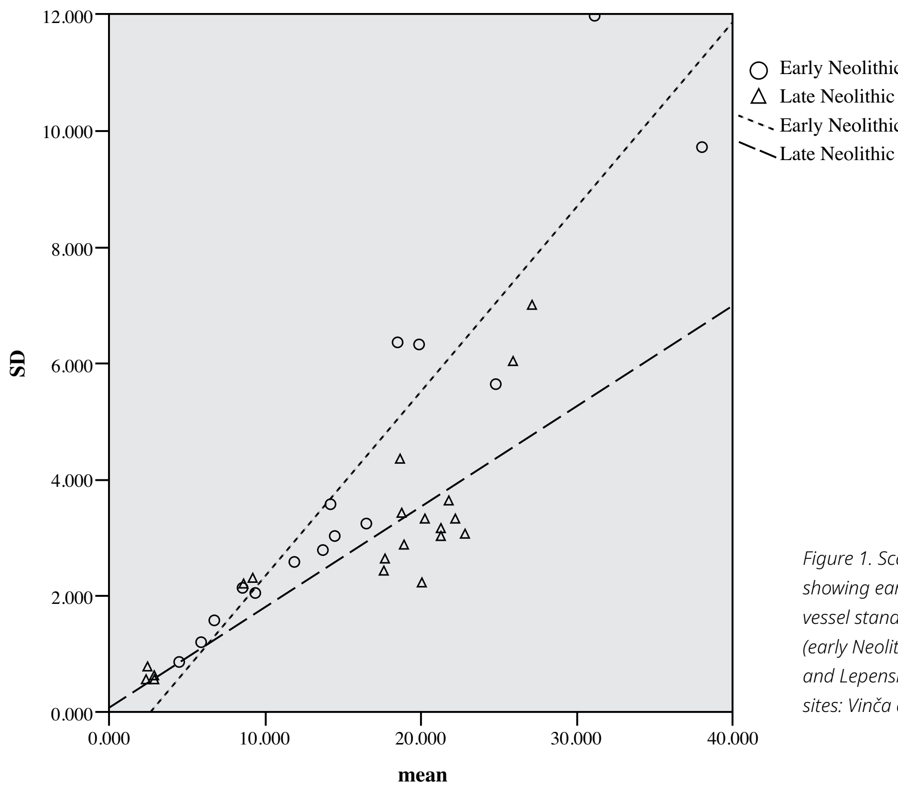

Figure 1. Scatter-dot diagram showing early vs. late Neolithic vessel standardisation level (early Neolithic sites: Blagotin and Lepenski Vir; late Neolithic sites: Vinča and Drenovac).

functional/morphological class	Rim diameter		Wall thickness	
	Blagotin	Lepenski Vir	Blagotin	Lepenski Vir
Mean SD CV (%)	n=60 18.45 6.36443 34.50	n=136 19.9081 6.31465 31.72	n=62 6.73 1.57 23.32	n=136 8.57 2.139 24.96
Mean SD CV (%)	n=22 13.6818 2.78408 20.35	n=35 14.1714 3.56441 25.15	n=22 4.5 0.859 19.08	n=35 5.89 1.207 20.5
Mean SD CV (%)	n=68 30.0588 12.69020 42.22	n=183 38.0000 9.72521 25.6	n=57 9.3 2.044 21.98	n=183 11.87 2.584 21.77

Table 1. CV values for metrical parameters of the early Neolithic pottery vessels.

changes can be considered as social innovation, but they might have been conditioned by many factors: population pressure, the shift in food habits, supply, and demand. Intensification of pottery production is also a consequence of less-time consuming and therefore improved production sequence, resulting in higher output of finished products.

The consequence of innovation: adoption of mineral inclusions in ceramic paste

Fine pottery is a good example of the changes in pottery function and consumption in the Neolithic traditions of the Central Balkans. Bowls of small sizes of both Neolithic traditions share formal properties: thin walls, finely finished surfaces (slipped in the early and burnished/polished in the late Neolithic) and fine fabric with no macroscopically visible coarse inclusions, but they exhibit remarkable differences in function and frequency within the assemblages. In the early Neolithic Starčevo tradition they occur rarely: 7% at Kovačke njive (Vuković *et al.* 2016), 6% at Blagotin (Vuković 2004), around 1% at Lepenski Vir (Perić and Nikolić 2004; cf. Vuković 2010), whereas in the late Neolithic fabric with finely grained mineral inclusions mostly predominate: for instance, around 70% percent in late phases of Vinča – Belo Brdo (Vuković 2010), and Grivac (Nikolić 2004).[2] According to the use-alteration analyses of the Blagotin assemblage, it is evident that fine pottery was used for different purposes – for food processing in the absence of water, but also for storage (Vuković 2010; 2012). In contrast, with the exception of mechanical damage, *i.e.* abrasion, mostly present on the exterior surfaces of the base, other use-wear traces are lacking on the late Neolithic Vinča bowls. Moreover, their high frequency indicates frequent manipulation and exposure to the risks of breakage, suggesting that they were probably used for serving and consuming food or drink. These differences indicate a dynamic role for fine bowls in the late Neolithic, their frequent use, and consequently high breakage and replacement rates, therefore suggesting higher demand and more intensive production (Tab. 2).

Fine fabric and the absence of macroscopically visible, coarse organic inclusions in ceramic paste are directly related to one of most remarkable technological changes that occurred during the Neolithic sequence. The transition to production of pottery with mineral inclusions and complete abandonment of the practice of adding coarse organic admixtures is a general feature of Vinča pottery. The differences in performance characteristics between two types of ceramics are well-known: high vs. low porosity, low vs. high hardness, strength, and mechanical stress resistance, and low. vs. high efficiency in thermal conductivity. If we accept the explanation that pottery with organic temper characterized partly mobile communities, whose technological choices were focused on the production of lighter vessels with high transportability, we may assume that the fine pottery was made occasionally and for special purposes (Vuković 2019; cf. Thissen 2005; Schiffer and Skibo 1987). With the beginning of fully sedentary life, going along with population increase, the need for organic tempered pottery ceased, as it could not fulfil a higher efficiency in thermal food processing for a larger population. The need for preparation of larger quantities of food, as well as dry storage of grains, conditioned a wider adoption of mineral temper. As a consequence, it became generally accepted for all functional classes of pottery.

Innovation and labour investment: impresso vs. barbotine

One of the most noteworthy features of early Neolithic pottery and a significant chronological marker is surface finishing (and/or decoration) in the form of roughened or textured surfaces. According to all chronological schemes (Aranđelović-Garašanin 1954; Dimitrijević 1974; Garašanin 1979) of Starčevo pottery, impresso (made by impressing fingers, fingertips or tools on a still plastic surface) is typical for earlier phases, while barbotine (applying wet clay on the walls of the vessel; this layer can further be processed by finger-dragging, and it's usually called organized barbotine) predominates in late phases, and is still present in the early phases of Vinča tradition. Does this gradual prevalence of barbotine reflect a process of innovation and why did it occur?

These two kinds of surface finishing occur on most frequent morphological classes of vessels in Starčevo assemblages: large conical bowls and S-profiled

2 It must be noted that some of the late Neolithic assemblages contain considerably lower frequencies of fine pottery, for instance Kovačke njive (Vuković *et al.* 2016).

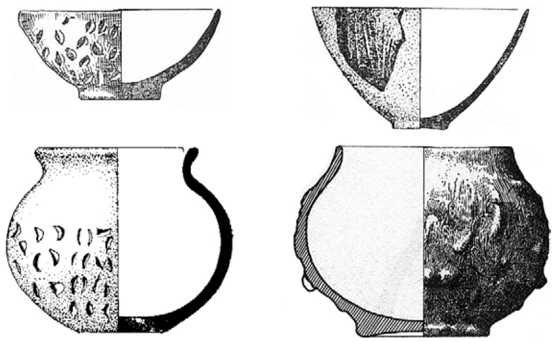

Figure 2. early Neolithic conical bowls and S-profiled vessels with roughened surfaces (after Dimitrijević 1974).

	Early Neolithic	Late Neolithic
Frequency in the assemblage	6%	71%
Use-life	long	short
Breakage rate	low	high
Replacement rate	low	high
Use frequency	infrequent	extremely frequent
Typical for:	storage	serving

Table 2. Differences in use-lives, breakage and replacement rates between early and late Neolithic vessels with mineral inclusions inferred from the analyses of Blagotin and Vinča assemblages (after Vuković 2014b, 10).

vessels (Fig. 2), the classes that exhibit extremely high variability in metrical parameters and high CV values suggesting random production. Conical bowls are usually of large dimensions, with a slipped interior and textured exterior surfaces. The slip on the interior surfaces suggests the need for reducing porosity, indicating the storage of liquids. However, the openness of their profile also suggests ease of access to contents, excluding long-term storage and long-distance transport. Bearing in mind their high frequencies in the assemblages, these vessels were frequently used, and obviously have been exposed to risks of breakage. In the Blagotin assemblage, use-alteration traces are lacking, and they are attributed to the functional class of short-term storage of water for the daily needs of the household. However, it seems that on other sites these vessels were also used for thermal food processing (Vuković 2012). The S-profiled pots also often have slipped or burnished interior surfaces, while their exterior surfaces are roughened, or two different kinds of surface finishing are present: burnishing or slip on the upper parts and texturing on their lower parts. Carbon deposits, as indicators of thermal food-processing, are identified on a limited number of specimens. Textured surfaces provide desirable performance characteristics that affect thermal properties: they increase thermal shock resistance (Skibo *et al.* 1989; Schiffer *et al.* 1994), and because of the larger surface area they are effective in preventing boil-over (Pierce 2005). At the same time, textured surfaces provide a better grip, making the pot easier to carry (Rice 1987, 140-141), and suitable for transport (for more detail see Vuković 2019). It seems that these two classes of vessels could have been multifunctional: for cooking and storage/transport, and specific performance characteristics caused the need for textured surfaces. But, the manufacturing processes of impresso and barbotine pots significantly differ from each other. So, why did barbotine gradually becomes the predominant surface roughening technique? The production sequence *i.e.* chaîne opératoire may provide answers.

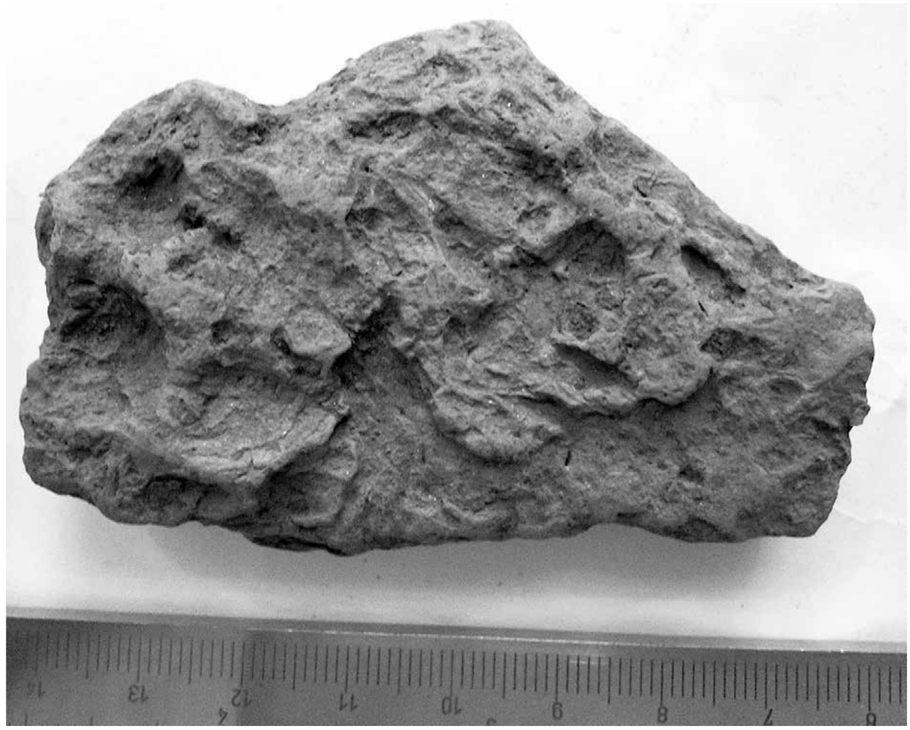

Figure 3. Hybrid between impresso and barbotine – Blagotin (after: Vuković 2013, Fig. 3).

Impresso is made on a still wet vessels' wall. The pressing of an instrument (or fingers) on still plastic surfaces is time-consuming. At the same time, during the procedure the vessel is under the constant risk of collapse, due to a strong force applied to weak and soft vessel's walls, thus requiring more attention from the potter. In contrast, barbotine can be applied on a (partly) dried surface, and then dragged with fingers. The procedure is simpler, less time-consuming, requires less attention, and the risk of collapse is diminished. At the same time, bearing in mind that less effort was needed, this change in chaîne opératoire enabled higher output *i.e.* more vessels produced during the same time interval. It should also be noted that the simplification of manufacturing techniques is seen as one of the most prominent features suggesting craft specialisation (Rice 1981).

The issue of impresso-to-barbotine transformation reveals the processes of invention and adoption of new technological solutions. It perfectly fits with the view that the process of invention leads toward less human energy investment in production (Roux 2010, 218). It has been argued that invention can be seen as a gradual modification and combination of earlier existing elements (Lemonnier 2002b; Schiffer 2005): barbotine is known almost from the beginning of Starčevo tradition, but it became dominant in the later phases. The process of invention, archaeologically visible in higher variability in the material record, in this case is, however, much harder to detect, as these issues were highly neglected in the archaeology of the Neolithic of the Central Balkans. However, several finds can lead us to a better understanding of this phenomenon: the hybrids between impresso and barbotine, so far identified only in the Blagotin assemblage (Vuković 2013). According to the still unpublished results of pottery analyses, it seems that some architectural structures on this site belong to later Starčevo phases.[3] The first example exhibits application of a layer of clay over the vessel's walls, but pressed with fingers, similarly to impresso-technique (Fig. 3). The second – a fragment of an S-profiled pot, is far more interesting. At the first sight, it appears as typical organized (channelled) barbotine,

3 Analysis was conducted by the author.

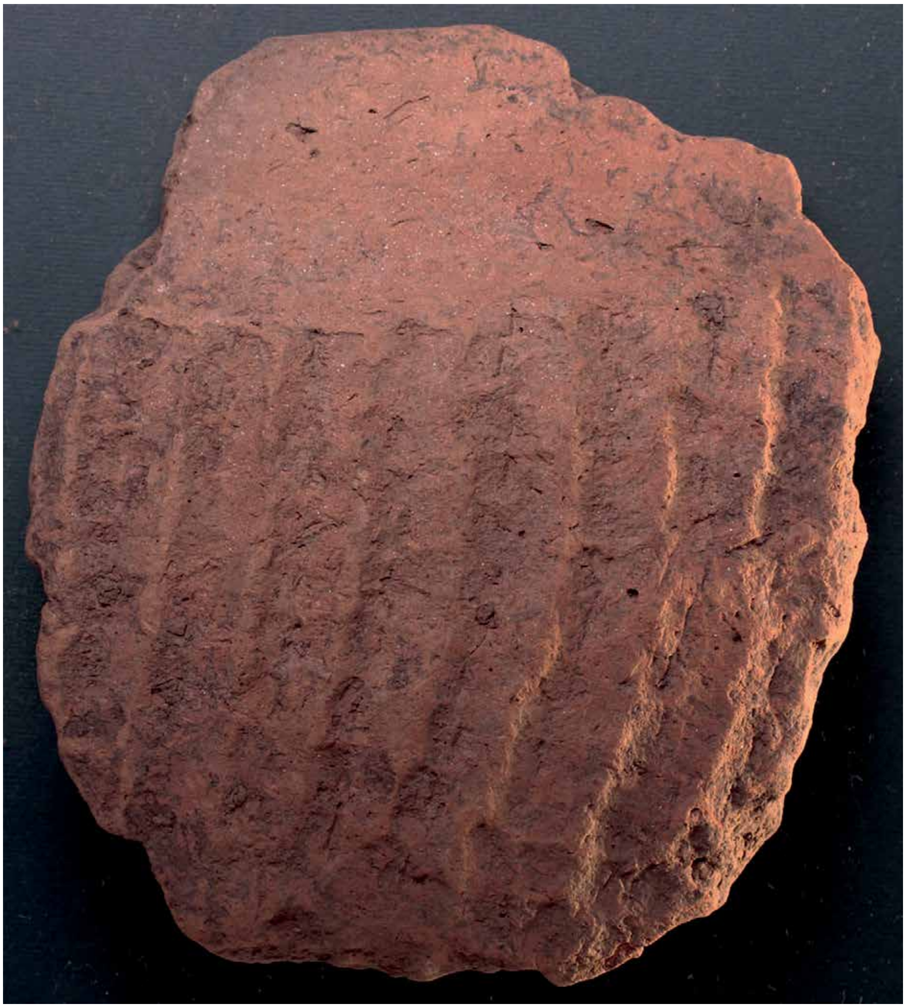

Figure 4. Hybrid between impresso and barbotine – Blagotin (after: Vuković 2013, Fig. 4, height of the fragment: 15 cm).

with parallel vertical ribs (Fig. 4). However, a closer look revealed that these ribs were made by producing fine and shallow finger impressions in a still wet clay. It may be assumed that these examples are not isolated, and more effort should be made in identifying similar specimens within other Starčevo assemblages. Nevertheless, hybridization, as a form of increased variability must be emphasized as a possible clue for assessing the process of invention.

Innovation and social groups: mixing of technological traditions

Some of the very important differences in pottery technology between two chronologically distant points in the Neolithic sequence have been presented so far. Remarkable differences were identified, possibly as a consequences of the changing needs of the consumer and some economic aspects, such as demand and consumption, which resulted in intensification of production. However, the main question – how is the process of technological change related to social relations and social transformation is still unanswered. In the case of the Neolithic of the Central Balkans, the key is the transitional period from the early (Starčevo) to the late Neolithic (Early

Vinča).[4] In modern-day Serbia, there are a number of archaeological sites belonging to the transitional period (Vuković 2015). Their main characteristic is the presence of so-called mixed assemblages – assemblages that contain specimens belonging to different technological traditions. Usually, they occur in the zones of contact between contemporary populations (or "cultures" in traditional archaeology), for instance, between Vinča and Tisza in Vojvodina. It is far more difficult to interpret the case of mixed assemblages consisting of features typical for different periods or chronological phases established in traditional archaeology based on culture history.

The presence of pottery belonging to Starčevo and Vinča traditions in the same occupational layers indicate several important points. Technological traditions, being conservative, actually represent group identities, because they include not only procedures themselves, but also distinct behavior, learned techniques and organisation of labour (Lechtman 1977) or recipes for action (Schiffer and Skibo 1987). Because it involves practical knowledge of techniques, particular operations and behaviours, and social interactions it is indicative of group identities, revealing distinct technological styles. If two different technological styles occur in pottery assemblage, it is reasonable to assume that two different social groups existed in the same settlement.

As it was stressed earlier, high variability in the material record may reveal the process of invention. Undoubtedly, mixed assemblages exhibit variability, but there is also one other very important feature that affects it: technological hybrids. Within the pottery from Pavlovac-Čukar in Southern Serbia many examples were found (Vuković 2017b): vessels in Starčevo fabric with slipped surfaces, but morphologically typical for Vinča and vice versa. Especially interesting is one example of a conical lid – typical of the late Neolithic, but completely unknown in Starčevo. However, it was made in Starčevo fabric with organic inclusions and with red-slipped surfaces. Moreover, it is also decorated in a Starčevo manner, with rough, deep incised lines and with no structured motif. Also, rough, careless manufacture was identified on one distinct group of pottery objects, so-called altars belonging to the Starčevo tradition. It was argued that this kind of poorly made ceramics is not related to the works of novices in the craft, but rather to the mature potters belonging to a different technological tradition, whose inexperience can be explained by their lack of awareness of the symbolic meaning of these objects and socially accepted practices.

The mixed assemblages, that include technological hybrids and imperfect products, therefore may indicate mixing of people as well. The presence of hybrids suggests the change in learning frameworks: from the rigid knowledge transmission patterns which do not encourage experimentation and innovation (cf. Wallaert-Pêtre 2001; Thissen 2017) to the allowance of choices originated from different traditions, suggesting lack of control and social pressure. The process of innovation may be related to the processes of direct interaction between different social groups (Stark *et al.* 1995), and the possibility of integration of potters into new communities (Stark 1999, 30). In the case of the Central Balkans, in the current state of research, it may be assumed that the peaceful coexistence of two social groups existed in the transitional period. Innovation was enhanced by the allowance of technological solutions from different social groups. Moreover, as it was recently argued, the integration of potters can occur in cases of intermarriage, which enhances a specific form of cultural transmission in pottery production, resulting with the presence of hybrids. The hybrids in this sense can be considered as "boundary objects" –

4 The term "middle Neolithic", i.e. late Starčevo, was intentionally avoided. Traditionally, Starčevo culture is attributed both to the early and the middle Neolithic, and these two "phases" are identified by some pottery features (dark painting, reduced firing atmosphere, the presence of biconical shapes, and the prevalence of barbotine surface roughening, among others). According to the existing data and due to the absence of new radiocarbon dates, which could shed some new light on the transitional period, it is highly possible that features identified as characteristics of the middle Neolithic existed simultaneously with the earliest phases of Vinča, therefore putting the validity of the term "middle Neolithic" in question (Vuković 2015).

"the things that cross social boundaries, not demarcate them", or in other words objects produced according to specific learning traditions but at the same time in a nonconformist mode (Mills 2018). It is also worth noting that a "secondary apprenticeship", *i.e.* the re-education of potters after being married and integrated into new communities, implies the performing of all steps in an operational sequence, not partial adoption of some of the technological features (Wallaert 2013). These observations further confirm the possibility of the presence of potters belonging to different traditions in the Pavlovac-Čukar assemblage. In traditional archaeology, it was assumed that Vinča population belongs to the "younger Balkan-Anatolian cultural complex", whose carriers gradually migrated to the areas inhabited by the Starčevo people (Garašanin 1979; cf. Vuković 2015). Recent studies on Neolithic Demographic Transition however, revealed a significant population bust at the end of the early Neolithic, and the beginning of Vinča coincides with increase in population size culminating *c.* 4800 cal BCE (Porčić *et al.* 2016). This shift could be explained as a consequence of a population bottleneck, *i.e.* drift, when certain material culture variants – pottery features – become dominant by chance, but also by the migration of a new population around 5300 cal BCE. Although the radiocarbon dates are still lacking for the Pavlovac-Čukar, its pottery evidence suggesting the presence of different technological styles may contribute to solving this problem.

Instead of a conclusion: innovation and the issues for further research

In the case of Neolithic pottery production, the process of innovation is still elusive, and processes affecting the technological change are diverse and dependent on a number of interrelated factors. Changes in ceramic recipes from organic to mineral inclusions were possibly triggered by changes in the needs of the population, for example, a full sedentary lifestyle and the need for more suitable vessels for cooking and storing. These changes were conditioned by population pressure and increased demand, resulting with an increase in the number of serving vessels. In the Neolithic transitional period, when contact between populations with different technological styles occurred, conservative and long lasting technological traditions were subject to changes triggered by new social interactions, resulting in more flexible knowledge transfer patterns, which enabled less rigid control in pottery production. Finally, in the case of impresso-barbotine transformation, the changes were a consequence of the need for more efficient manufacture, which resulted in higher output of products.

However, the process of technological change is still to a great extent unknown. So, instead of a conclusion it seems more appropriate to address the reasons for further research. To trace innovation we must seek for hybrids, as a cause of increased formal variability in pottery assemblages – the ones that represent mixing of different technological styles, but also the ones that suggest mixing of different procedures leading to the emergence of more simple manufacturing techniques. Identification of the potter's skill level by the presence of imperfect products, as another cause of high variability, and an identification of possible teaching methods also should be emphasized. Another line of research is to analyse the changes that occur in pottery recipes, thus indicating a more complex knowledge of suitability of specific raw materials to specific functions and performance of pottery. One of the most important technological changes in pottery production – the shift from oxidized to reduced firing is still a puzzling issue, since firing locations and firing facilities have not yet been identified in the archaeological record on the Neolithic sites of the Central Balkans. Finally, studying of painted designs, and the differences between light (white) vs. dark (black or red) painted ornaments may reveal the connection between technological change and symbolic expression and behaviour. Only by comparing these data from a number of assemblages can more accurate conclusions be made.

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With her Master of Arts degree in Ceramics as a vantage point she has both revitalised the ceramic sherd as a source of knowledge of our past as well as developed more scientific ways to include contemporary craftspeople in the process of analysis of archaeological finds.

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Detecting and explaining
TECHNOLOGICAL INNOVATION IN PREHISTORY

Technology refers to any set of standardised procedures for transforming raw materials into finished products. Innovation consists of any change in technology which has tangible and lasting effect on human practices, whether or not it provides utilitarian advantages. Prehistoric societies were never static, but the tempo of innovation occasionally increased to the point that we can refer to transformation taking place. Prehistorians must therefore identify factors promoting or hindering innovation.

This volume stems from an international workshop, organised by the Collaborative Research Centre 1266 'Scales of Transformation' at Kiel University in November 2017. The meeting challenged its participants to detect and explain technological change in the past and its role in transformation processes, using archaeological and ethnographic case studies. The papers draw mainly on examples from prehistoric Europe, but case-studies from Iran, the Indus Valley, and contemporary central America are also included. The authors adopt several perspectives, including cultural-historical, economic, environmental, demographic, functional, and agent-based approaches.

These case studies often rely on interdisciplinary research, whereby field archaeology, archaeometric analysis, experimental archaeology and ethnographic research are used together to observe and explain innovations and changes in the artisan's repertoire. The results demonstrate that interdisciplinary research is becoming essential to understanding transformation phenomena in prehistoric archaeology, superseding typo-chronological description and comparison.

This book is a scholarly publication aimed at academic researchers, particularly archaeologists and archaeological scientists working on ceramics, osseous and metal artefacts.

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