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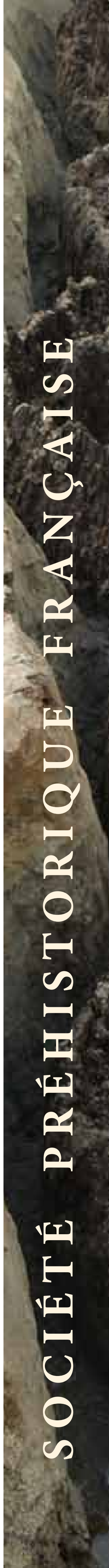

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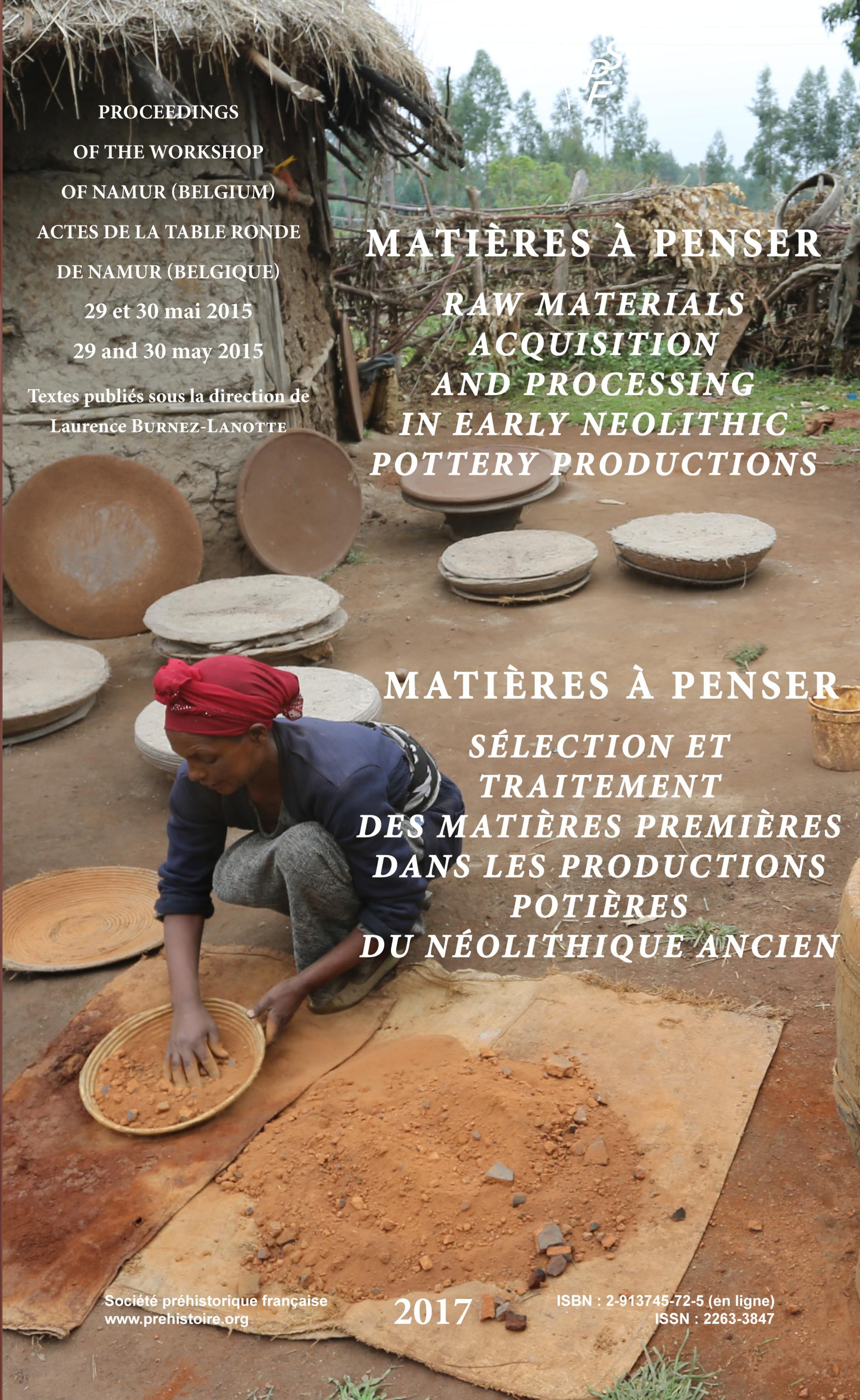

PROCEEDINGS
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ACTES DE LA TABLE RONDE
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29 et 30 mai 2015
29 and 30 may 2015

Textes publiés sous la direction de
Laurence Burnez-Lanotte

MATIÈRES À PENSER

RAW MATERIALS ACQUISITION AND PROCESSING IN EARLY NEOLITHIC POTTERY PRODUCTIONS

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SÉLECTION ET TRAITEMENT DES MATIÈRES PREMIÈRES DANS LES PRODUCTIONS POTIÈRES DU NÉOLITHIQUE ANCIEN

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Innovation and regionalism in the Middle/Late Neolithic of south and south-eastern Europe (ca. 5,500-4,500 cal. BC): a ceramic perspective

Michela Spataro

Abstract: A review of petrographic and geochemical results from over 1000 samples of Early and Middle Neolithic pottery from south and south-eastern Europe provides insights into technological traditions, innovation, resistance and imitation in Impressed Ware, Starčevo-Criş, Danilo/Hvar, Vinča and Korenovo assemblages. The trajectory of technological change varied between regions, and central Balkan potters seem to have become more innovative than their neighbours; Vinča potters in particular seem to have been more innovative than Danilo and Korenovo potters, perhaps due to Vinča social complexity. For the first time they used different materials to make different shapes, according to the function (intended use) of the pot. At the same time, variability in temper choices suggests regionalism in Vinča technical traditions. Some aspects of innovation (e.g. black-burnishing) were spread more readily than others, but the idea seems to have spread and not the whole *chaîne opératoire*. The production of *figulina* ware was an innovation which became a tradition, as it remained unchanged for more than a millennium, without apparently influencing the technology of everyday pottery production.

Keywords: Vinča culture, Danilo/Hvar cultures, Impressed Ware, Starčevo, innovation, imitation, regionalism, change, Early and Middle Neolithic, south and south-eastern Europe, *figulina* ware, ceramic analysis, optical microscopy, SEM-EDX, surface treatment, temper, ceramic class.

Résumé : La mise en perspective des résultats pétrographiques et géochimiques de plus de 1000 échantillons de poterie d’Europe du sud et du sud-est datant du Néolithique ancien et moyen donne un aperçu des traditions, innovations, résistances et imitations technologiques dans l’art de la *céramique imprimée* et le matériel des cultures de Starčevo-Cris, Danilo/Hvar, Vinča et Korenovo. La trajectoire des changements technologiques a varié suivant les régions, et les potiers des Balkans occidentaux semblent avoir été plus innovants que leurs voisins : les potiers de la culture de Vinča, en particulier, semblent avoir été plus innovants que ceux de Danilo et Korenovo, ceci étant peut-être dû à la complexité sociale de la culture de Vinča. Pour la première fois, ces potiers ont utilisé différents matériaux pour produire des formes différentes, en rapport avec la destination fonctionnelle du vase. Simultanément, la variabilité dans le choix des dégraissants suggère un régionalisme dans les traditions techniques de la culture de Vinča. Certains aspects de l’innovation (par exemple, la céramique noire brunie) se sont propagés plus rapidement et plus facilement que d’autres, mais il semble que ce soit le concept et non la chaîne opératoire entière qui se soit diffusé. La production de céramique figulina a été une innovation qui est devenue une tradition, étant donné qu’elle est restée inchangée pendant plus d’un millénaire, sans influencer de manière apparente la technologie de production de céramique usuelle.

Mots-clés : culture de Vinča, cultures de Danilo/Hvar, Céramiques Imprimées, Starčevo, innovation, imitation, régionalisme, changement, Néolithique ancien et moyen, Europe du sud et du sud-est, *figulina*, analyse de céramique, microscopie optique, SEM-EDX, traitement de surface, dégraissants, catégorie de céramique.

INTRODUCTION AND AIMS

The aim of this paper is to examine and identify innovation in ceramic traditions during the transition between the Early and Middle Neolithic of southern Europe.

One of the goals of large-scale diachronic research is to see which aspects of pottery production are most persistent, in time and space, and which are replaced regularly. The fact that clay is a plastic medium permits almost infinite variation in pottery style (form and decoration), allowing archaeologists to construct detailed typochronological schemes. These subdivisions might be expected to correspond to different technical traditions, as pottery design and manufacture must be directly connected through the practice of learning the craft of making pottery, but technical traditions are not infinitely variable, due to the physical attributes of the raw materials. In comparing pottery technology across Neolithic southern Europe, we see both examples of adaptively neutral traditions defined as persistent differences in pottery technology which have no obvious functional explanation (Dunnell, 1978) and of changes in technology that are functionally advantageous, if not essential, for the production of new styles of pottery. Such adaptively advantageous changes may be expected to cross existing cultural boundaries, whereas we would not expect potters to replace one adaptively neutral tradition with another, or for adaptively neutral innovations to spread once pottery-making had become established.

In seeking to understand prehistoric potters, we are fortunate that many aspects of pottery production leave traces in potsherds, which can be interpreted using a suite of archaeometric techniques. We can therefore observe continuity and change in raw material procurement, clay preparation, tempering, forming (partially), finishing, firing and decoration (or decoration then firing), on the same spatial and temporal scale as the evolution of pottery styles. This paper will consider which aspects of Neolithic pottery production in southern and south-eastern Europe reflect cultural continuity or change, and which are technical innovations that confer functional advantages but do not imply cultural transformation. It will also discuss which aspects of technological change may be interpreted as local or regional variations that are not diffused within the wider cultural distribution.

How can innovation and imitation in ceramic traditions be identified? A series of morphological and visual traits can be described and examined, such as shapes, decorative motifs, forming techniques, clay processing, temper, shaping, finishing, firing conditions. Some of these variables can be studied macroscopically, as they are visible to the naked eye (shape, style, forming technique), others (clay processing, temper, firing conditions and surface finishing) need to be studied using more invasive, microscopic techniques.

This paper will focus on clay processing, temper, firing conditions and surface finishing, which will be considered using a large synchronic and diachronic data set, representing a wide geographical area in the Adriatic region and in the central Balkans and spanning almost two millennia, from the Early Neolithic (ca. 6,000-5,400 cal. BC) to the Middle/Late Neolithic (ca. 5,400-4,500 cal. BC).

ARCHAEOLOGICAL BACKGROUND

The earliest Neolithic cultural phenomena in continental Europe are the Impressed Ware (IW) and the Starčevo-Criş or Starčevo (SC) cultures, which began shortly before 6,000 cal. BC (Whittle et al., 2002; Biagi and Spataro, 2002 and 2005; Biagi et al., 2005). IW communities spread mainly along the Mediterranean coastline, whereas SC communities spread along the Danube in the central Balkans. From their earliest appearance, the IW and SC cultures presented the so-called Neolithic package, consisting of agriculture, domestic animals and ceramic production. Pottery is ubiquitous, but kiln structures have very rarely been found at Early and Middle Neolithic sites (Nica, 1977; Minichreiter, 2007).

IW pottery was mainly decorated with impressions obtained with geometric tools (e.g. triangular, rectangular, dots and oval motifs), marine shells, fingers, fingernails, or by pinching, scratching, and incisions (Müller, 1988 and 1994; Cipolloni Sampò, 1998; Spataro, 2002, p. 25-28). Vessel shapes are rather simple; they include large and deep oval-shaped vessels, hemispherical and conical bowls, more rarely biconical vessels, necked jars and flasks (Batović, 1966). Handles are absent in the earliest phases.

At the end of the Early Neolithic, another ceramic type appeared at many IW sites together with pottery decorated with impressed motifs, a finer, light grey, buff, pale-pinkish, yellowish colour, often with a powdery surface, called *figulina* ware (Rellini, 1934, p. 33; Cremonesi, 1965). In contrast to IW everyday pottery, *figulina* ware is plain or painted with elaborate linear or dynamic geometric designs.

Contemporary with the IW in the Adriatic, the SC complex covered a region from Macedonia to Hungary and Slavonia, and from Serbia to eastern Romania. SC communities settled along the Danube and its major tributaries, mainly on alluvial terraces and in some cases in the proximity of salt outcrops. It was a phenomenon of rapid expansion (Biagi et al., 2005).

SC ceramic assemblages feature a wide variety of decorations and surface treatments including, in addition to impressed and incised motifs, monochrome, slipped and/or red-burnished, white-on-red painted, *barbotine* (an uneven extra layer of clay), and in the latest phases, polychrome painted decoration with garland and spiral motifs. SC ceramics include globular vessels with everted rims, short-necked jars, oval-shaped vessels, hemispherical bowls, and during the latest phases, pedestalled vessels (Lazarovici, 1979 and 1993; Minichreiter, 1992).

In the later 6th millennium cal. BC (Forenbaher and Kaiser, 2000), ceramic assemblages changed abruptly in both regions. Along the eastern Adriatic coastline the Danilo/Hvar cultures replaced the IW, with the introduction of new pottery shapes (e.g. carinated bowls, plates) and new motifs and surface treatments (e.g. painted and black-burnished ware decorated with geometric motifs, spirals, S-motifs, hatched triangles) (Korošec, 1958 and 1964).

At about the same time, SC assemblages were replaced in many areas of the central Balkans by the Vinča material culture. The Vinča culture was marked by the appearance of tell sites and the erection of post-built houses and temples, biconical or carinated bowls, pithoi, amphorae, large tronco-conical vessels, etc. Plain and coarse ware is common in Vinča assemblages, whereas decorated pottery is often black-, red-, buff- or brown-burnished, and occasionally painted, probably before firing. The presence of black-burnished pottery with a metallic sheen differentiates Vinča from the earlier SC assemblages. However, particularly during the earliest Vinča phases there are objects such as anthropomorphic and zoomorphic figurines (e.g. Divostin), four-legged altars, *barbotine* ware and biconical pots that are also typical of the latest SC phases (Leković, 1990; Spataro, 2014). Meanwhile, the Korenovo culture appeared in some areas previously occupied by Starčevo communities in Slavonia, north-eastern Croatia, and in south-western Hungary. Korenovo pottery assemblages include spherical, biconical and pedestalled bowls, decorated with deeply incised motifs, individual lines or banded, fingertip impressions, grey and dark-grey burnished surfaces; painted decoration is absent in Croatia (Težak-Gregl, 1993). Interestingly, typical potsherds of the Korenovo Culture (Dimitrievié, 1961) were discovered in the Danilo culture layer at Smilčić (Težak-Gregl, 1993, p. 14; Spataro, 2002, p. 203). These finds should be analysed petrographically to understand whether they were made according to Korenovo or Danilo technological traditions.

SAMPLING AND METHODS

The ceramics discussed in this paper were studied and analysed by petrographic techniques during the author's PhD (Spataro, 2002), post-doctoral and later independent research, mainly carried out at the UCL Institute of Archaeology [(1)].

In this paper a dataset of 1,047 potsherds is considered (table 1; fig. 1). All samples were analysed in thin section by optical microscopy and most of them by scanning electron microscopy with energy dispersive spectrometry (SEM-EDX; see below) [(2)].

Pottery from 11 sites of the Impressed Ware culture (228 samples), plus 18 Starčevo-Criş (477 samples), three Danilo/Hvar (108 samples), three Vinča (106 samples) and three Korenovo (69 samples) cultures sites was analysed (table 1). Fifty-nine *figulina* vessel fragments were sampled from 10 sites attributed to different phases of the Neolithic, including the Impressed Ware, Danilo, Hvar, Serra d'Alto, and Squared-Mouthed Pottery Cultures (Spataro, 2009a, table 1).

Potsherds were collected from open-air and cave sites, some of which had multiple occupation layers [(3)]. Whenever possible, representative potsherds were chosen according to stratigraphic information. Twenty to thirty potsherds were selected from each site for thin-section analysis, but if a site was occupied over multiple phases, ca. 20 sherds were selected per phase (e.g. at Gura Baciului in Transylvania; Spataro, 2008). The ceramic samples were selected on the basis of potsherd typology and style and of recurrent fabric characteristics, such as thickness, colour, surface treatment (Plog, 1980; Spataro, 2002). Shapes were also considered, when the samples were not too fragmented for the reconstruction of the vessel form. Ceramic cult objects (anthropomorphic and zoomorphic figurines, altars - four-legged vessels), spindle-whorls, and net weights, were also analysed, as well as daub, fireplace and plaster samples. In addition, 1-3 samples of sediment suitable for pot making and occasionally river sand samples were also collected 0.5 - 1 km from each site (see also: Spataro, 2002, p. 36 and 2011, p. 177).

The two main analytical techniques used were optical microscopy of thin sections by polarised microscopy, and scanning electron microscopy used with energy dispersive spectrometry (SEM-EDX). This paper focusses more on the optical microscopy and SEM results, rather than EDX. These complementary techniques can provide very high quality images of ceramic fabrics and their surface treatments. The resolution of SEM images at high magnification (e.g. x 1.0-2.0 K) allows us to study ceramic microstructure (Maniatis, 2009), estimate firing temperatures and detect any changes between the ceramic fabric and any surface treatment, or if present, interfaces or interlayers between the surface and the fabric. In addition, SEM-EDX can be used to create compositional maps of the sections to show the spatial distribution of different elements.

RESULTS

Clay selection and processing

IW potters were non-selective. They used both calcareous and non-calcareous clays to manufacture ceramics, with minimal clay processing, as clay pellets are recurrent in the fabrics. In most cases, the ceramic fabrics are very similar in thin section to local soils (fig. 2, top left and right). They did not select specific clay types to manufacture specific products, as there is no correlation between fabrics and shapes. In the Middle Neolithic, Danilo and Hvar potters along the Dalmatian coastline continued the non-selective approach of their Early Neolithic predecessors, using mainly calcareous clays, with minimal processing, and again using the same clays to manufacture different vessel shapes with different surface treatments.

Culture & pottery type	Number of sites (see map)	Number ceramic samples analysed in thin section[1]	Number ceramic samples analysed by SEM-EDX[2]	Site Names
Impressed Ware	11	228	228	Fornace Cappuccini, Maddalena di Muccia, Ripabianca di Monterado, Scamuso, Vižula, Vela Jama, Jami na Sredi, Smilčić, Tinj-Podlivade, Konjevrate, Vrbica
Starčevo-Criş	18	477	215	Foeni-Gaz, Foeni-Sălaş, Dudeştii Vechi, Giulvăz, Fratelia, Parţa, Cauce Cave, Orăştie-Dealul Premilor, Miercurea Sibiului Petriş, Ocna Sibiului, Limba Bordane, Şeuşa La-cărarea morii, Gura Baciului, Vinkovci, Ždralovi, Golokut- Vitnić, Mostonga, Donja Branjevina
Danilo/Hvar	3	108	108	Smilčić (Danilo and Hvar phases), Danilo Bitinj (Danilo phase), Vela Spilja (Hvar phase)
Figulina ware	10	59	48	Caverna Elia, Danilo Bitinj, Fagnigola, Fiorano Modenese, Ripabianca di Monterado, Gravina di Puglia, Grotta delle Mura, Scamuso, Smilčić (Danilo and Hvar phases), Spilamberto
Vinča	3	106	94	Miercurea Sibiului Petriş, Parţa, Vinča Belo Brdo
Korenovo	3	69	56	Malo Korenovo, Tomašica, Kapelica-Solevarec
Total	48	1047	749	

Table 1 – List of ceramics (vessels only) analysed and considered in this paper. The materials from Kapelica-Solevarec and Vinča-Belo Brdo are still under study. There are only 41 sites; 48 is based on double-commande IW sites with figulina or Danilo pottery etc.
Tabl. 1 *– Liste des céramiques (seulement les récipients) analysés et présentés dans cet article. Les séries de Kapelica-Solevarec et Vinča-Belo Brdo sont en cours d'étude. Il y a seulement 41 sites ; le nombre total de 48 correspond aux ensembles regroupant des céramiques de deux ensembles culturels distincts (par exemple avec de la poterie de type figulina ou de type Danilo etc.).*

By contrast, the potters who made *figulina* ware used only specific clay sources, which were highly calcareous and rich in iron, magnesium and potash (Spataro, 2009a). In south-eastern and central eastern Italy, fossiliferous clays were often used (Spataro, 2002, chapter 5). The *figulina* potters often levigated the clay (dissolving the clay in water so that coarser particles settle out while the finer particles are still in suspension: Rice, 1987, p. 118), to obtain a very fine raw material, which was almost inclusion-free (fig. 3).

Starčevo-Criş potters were also selective. Despite the extent of the study region (fig. 1), and the wide range of clay types available, the potters used only non-calcareous and micaceous clays rich in fine alluvial sand, for all different ceramic products, shapes and styles (Spataro, 2006a; Kreiter and Szakmány, 2011, observed the same pattern at Hungarian sites). Like the IW potters, SC potters processed the clays only lightly, as clay pellets recur in most assemblages (fig. 2, bottom left and right).

Like SC potters, Vinča potters were highly-selective in their use of clay, but they processed the clay much more thoroughly. Clay pellets occur very occasionally, and in some cases clay might have been levigated to obtain a really fine fabric. Furthermore, Vinča potters used specific clay types to make different products. For example, thin-walled burnished ceramics were mainly manufactured using clays with very fine inclusions (e.g. loessic and alluvial), whereas different types of clay were used for the thick-walled vessels and not-burnished ware. At Miercurea Sibiului Petriş, Vinča potters used different clay sources to those used by SC potters at the same site, as shown by the consistently different geochemical signatures of the two assemblages. Nevertheless, mineral inclusions suggest that in both cases clays were sourced locally (Spataro, 2014, fig. 10).

Korenovo potters were also selective in their use of raw materials, using loessic clays to manufacture fine burnished ware and different clay types to make coarse, plain and thick-walled vessels (e.g. Spataro, 2003, fig. 2). However, the clay was not always well-processed, as some clay pellets recur in the pottery fabrics.

Temper selection

In this article the term 'temper' is used to indicate minerals or organic material deliberately added to the clay, usually to improve the clay workability. Multiple parameters (size, shape, quantity) have been used to identify intentional tempering, in particular following M. P. Rice (Rice, 1987, p. 410) and M. Maggetti (Maggetti, 1982, p. 123). The angularity and abundance of calcite in eastern Adriatic IW and in the Danilo and Hvar pottery strongly suggest crushing and addition. It is more difficult to say whether limestone was added deliberately, in particular at eastern Adriatic IW sites, as abundant poorly-sorted angular limestone fragments are also present in the soil samples

Fig. 1 – Locations of the sites discussed in the paper.
△Impressed Ware. 1: Scamuso; 2: Maddalena di Muccia; 3: Ripabianca di Monterado; 4: Fornace Cappuccini; 5: Vižula; 6: Vela Jama; 7: Jami na Sredi; 8: Tinj-Podlivade; 9: Smilčić; 10: Vrbica; 11: Konjevrate.
○ Starčevo-Criş. 12: Foeni-Gaz; 13: Foeni-Sălaş; 14: Giulvăz; 15: Parţa; 16: Fratelia; 17: Dudeştii Vechi; 18: Cauce Cave; 19: Orăştie-Dealul Premilor; 20: Limba Bordane; 21: Şeuşa La-cărarea morii; 22: Miercurea Sibiului Petriş; 23: Ocna Sibiului; 24: Gura Baciului; 25: Golokut- Vitnić; 26: Mostonga; 27: Donja Branjevina; 28: Vinkovci; 29: Ždralovi.
▲Danilo and Hvar cultures. 9: Smilčić (Danilo and Hvar phases); 30: Danilo Bitinj (Danilo phase); 31: Vela Spilja (Hvar phase).
☼ *figulina*. 9: Smilčić (Danilo and Hvar phases); 30: Danilo Bitinj; 1: Scamuso; 32: Grotta delle Mura; 33: Caverna Elia; 34: Gravina di Puglia; 3: Ripabianca di Monterado; 35: Fiorano Modenese; 36: Spilamberto; 37: Fagnigola.
● Vinča culture. 15: Parţa; 22: Miercurea Sibiului Petriş; 38: Vinča-Belo Brdo.
■ Korenovo culture. 39: Tomašica; 40: Kapelica-Solevarec; 41: Malo Korenovo.

***Fig. 1** – Localisation des sites présentés dans cet article.*
△Céramique imprimée. 1 : Scamuso ; 2 : Maddalena di Muccia ; 3 : Ripabianca di Monterado ; 4 : Fornace Cappuccini ; 5 : Vižula ; 6 : Vela Jama ; 7 : Jami na Sredi ; 8 : Tinj-Podlivade ; 9 : Smilčić ; 10 : Vrbica ; 11 : Konjevrate.
○ Starčevo-Criş. 12 : Foeni-Gaz ; 13 : Foeni-Sălaş ; 14 : Giulvăz ; 15 : Parţa ; 16 : Fratelia ; 17 : Dudeştii Vechi ; 18 : Cauce Cave ; 19 : Orăştie-Dealul Premilor ; 20 : Limba Bordane ; 21 : Şeuşa La-cărarea morii ; 22 : Miercurea Sibiului Petriş ; 23 : Ocna Sibiului ; 24 : Gura Baciului ; 25 : Golokut- Vitnić ; 26 : Mostonga ; 27 : Donja Branjevina ; 28 : Vinkovci ; 29 : Ždralovi.
▲ Cultures Danilo and Hvar. 9 : Smilčić (phases Danilo et Hvar) ; 30 : Danilo Bitinj (phase Danilo) ; 31 : Vela Spilja (phase Hvar).
☼ figulina*. 9 : Smilčić (phases Danilo and Hvar) ; 30 : Danilo Bitinj ; 1 : Scamuso ; 32 : Grotta delle Mura ; 33 : Caverna Elia ; 34 : Gravina di Puglia ; 3 : Ripabianca di Monterado ; 35 : Fiorano Modenese ; 36 : Spilamberto ; 37 : Fagnigola.*
● Culture Vinča. 15 : Parţa ; 22 : Miercurea Sibiului Petriş ; 38 : Vinča-Belo Brdo.
■ Culture Korenovo. 39 : Tomašica ; 40 : Kapelica-Solevarec ; 41 : Malo Korenovo.

(see fig. 2, top left and right). In western Adriatic IW, the abundance and bimodal size distribution of flint, grog, granitic rock fragments and volcanic sand, and comparison with local soil samples (which often include similar minerals but in finer and lower proportions) indicate deliberate addition. In SC pottery, the frequency of elongated planar voids and charred remains including cereal chaff imply tempering. In the Vinča and Korenovo cultures, sand or grog is abundant, with a bimodal size distribution.

IW potters used local mineral temper to make most of their pots, exploiting local raw materials, such as crushed calcite in the eastern Adriatic region, and other local minerals and sands (e.g. volcanic sand, flint, radiolarian chert) at sites on the western Adriatic coastline (for details see Spataro, 2002, p. 142, 151, 162 and 172-175). At all IW sites, the same type of temper was used to manufacture different vessel shapes, with a wide variety of decorative motifs (fig. 4).

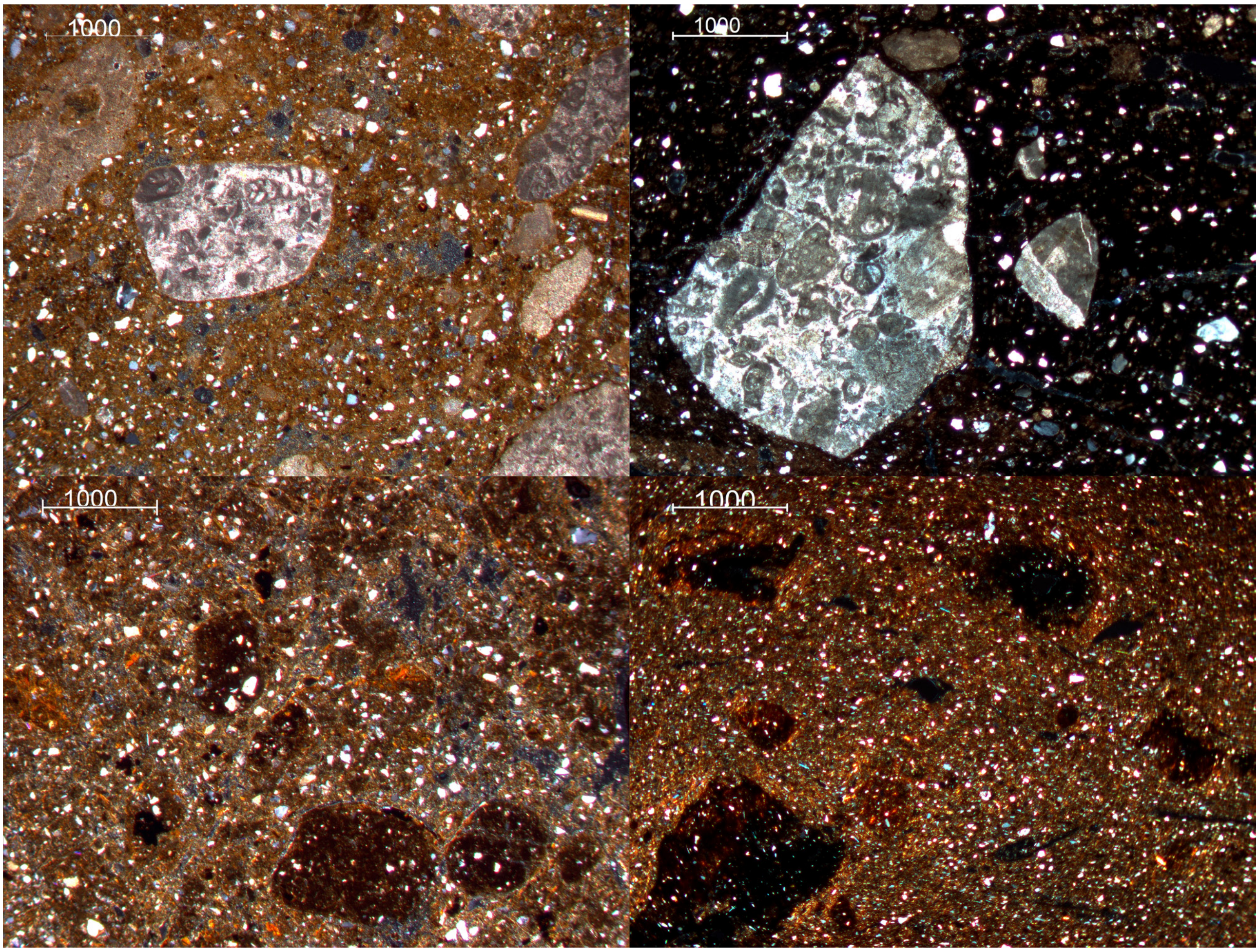

Fig. 2 – Photomicrographs of a thin section of a soil sample (top left) from the site of Tinj Podlivade in Croatia and the fabric of a small body sherd (top right) of Impressed Ware from Tinj (sample TN4) showing similar fossiliferous limestone fragments (cross-polarised light, XPL); the fabric of a soil sample (bottom left) from the site of Gura Baciului (Romania) showing clay pellets in the fabric and a sample (DBR12; bottom right) of a fine burnished oval-shaped pot from Donja Branjevina (Vojvodina, Serbia) showing similar clay pellets (XPL).

***Fig. 2** – Micrographie d'une lame mince d'un échantillon de sol (en haut à gauche) et d'un petit fragment de céramique imprimée (échantillon TN4, en haut à droite) provenant du site de Tinj Podlivade en Croatie, présentant tous les deux des fragments similaires de calcaire fossilifère (lumière polarisée croisée) ; d'un échantillon de sol (en bas à gauche) provenant du site de Gura Baciului (Roumanie), et d'un échantillon (DBR12, en bas à droite) d'un récipient de forme ovale en céramique fine brunie provenant du site de Donja Branjevina (Vojvodina, Serbie), présentant tous les deux des boulettes d'argile semblables dans la pâte (lumière polarisée croisée).*

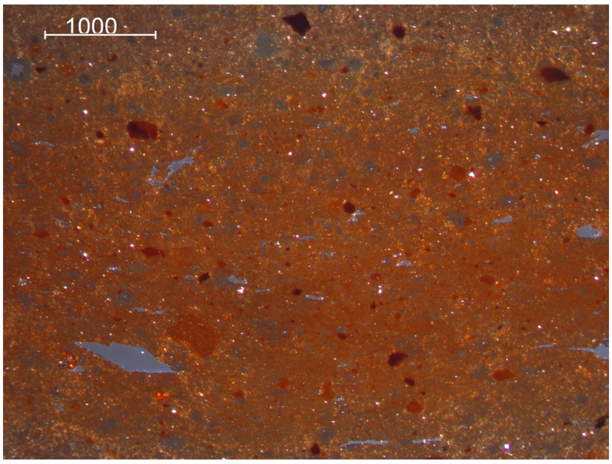

Fig. 3 – Photomicrograph of a thin section of fine *figulina* ware from the site of Danilo Bitinj (Croatia), showing an almost inclusion-free paste that was highly-fired (cross-polarised light, XPL). Only very fine quartz inclusions, and iron oxides are visible in the paste.

***Fig. 3** – Micrographie d'une lame mince d'une céramique fine* figulina *provenant du site Danilo Bitinj (Croatie), présentant une pâte quasiment dénuée d'inclusions et qui a été cuite à haute température (lumière polarisée croisée). Seules de très petites inclusions de quartz et d'oxydes de fer sont visibles dans la pâte.*

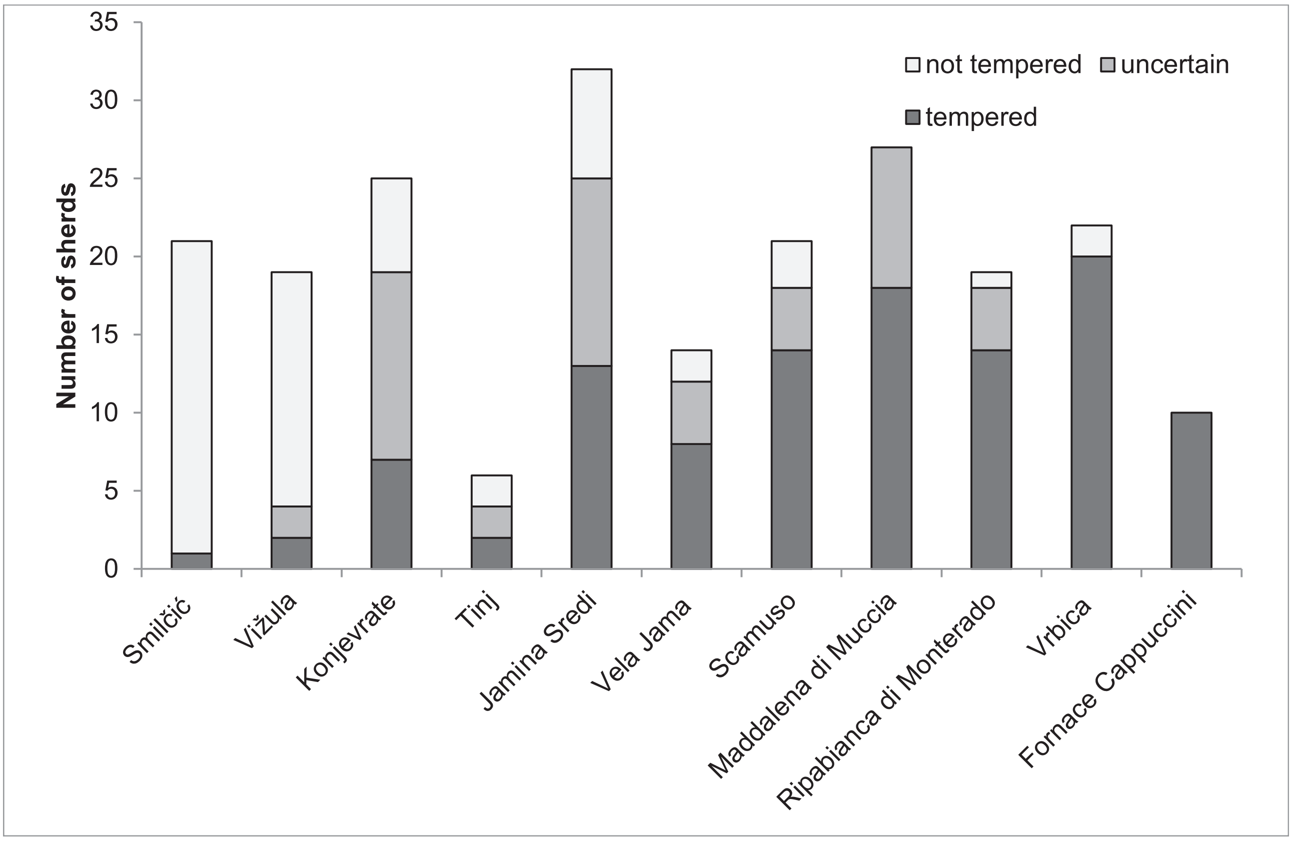

Fig. 4 – Bar chart of temper for the Adriatic Early Neolithic in the 6th millennium cal. BC: a lower proportion of pottery was tempered at the Croatian sites.

***Fig. 4** – Diagramme en bâtons des dégraissants pour l'Adriatique au Néolithique ancien au VIe millénaire cal. BC : la proportion de céramique dégraissée est inférieure sur les sites croates.*

Whereas a significant proportion in the eastern Adriatic (39–62%) of IW pottery was not tempered, Danilo and Hvar potters almost always tempered their pots with locally available minerals, i.e. crushed calcite, regardless of ceramic class, decoration and surface treatment. The makers of *figulina* ware did not use any tempering agent, as their goal was a fabric almost free of inclusions (see above).

SC potters almost always used organic temper (chaff, domestic cereals; e.g. Spataro, 2010, p. 96–97, fig. 2), from the earliest to the latest phases (Spataro, 2010); local minerals were used only occasionally (fig. 5). In contrast to their SC predecessors and Danilo/Hvar contemporaries, Vinča potters used a variety of tempering agents and many vessels, especially the fine ware, were not tempered (fig. 6). Among the temper types, grog (recycled pottery), crushed rock fragments and sand are recurrent (Spataro, 2014, p. 185, 187, fig. 5, 6 and 7, tables 1 and 2); chaff temper almost disappeared, accounting for ca. 1% of Vinča ceramics (Spataro, 2014; see also the Serbian Vinča C2-D1 site of Opovo: Tringham et al., 1985, p. 436).

Although only three Vinča sites have been considered so far, in addition to Opovo, temper choice in the Vinča culture seems to be rather arbitrary, as different types of temper were used at each site. For example, grog recurs at the Vinča B site of Parţa, in Romanian Banat, but not at Miercurea Sibiului Petriş in Transylvania (Spataro, 2014, p. 190, fig. 6). Although it occurs very occasionally at Vinča-Belo Brdo (Spataro, forthcoming), it was the main tempering agent at Opovo, where it was used for ca. 60% of the coarse ceramics (Tringham et al., 1985, p. 436). At Miercurea Sibiului Petriş, crushed rock fragments were relatively common, and were used to temper thin-walled vessels, large and deep pots and a large hemispherical bowl with finger impressions (Spataro, 2014, table 1). At Parţa the coarse thick-walled ceramics, such as globular vessels decorated with plastic cordons or bosses, were tempered with felspatic sand; tronco-conical vessels, oval-shaped pots and a bowl decorated with bosses were tempered with crushed and coarse grog (Spataro, 2014, table 1, fig. 8).

The formulas (recipes) used to make Vinča fine black-burnished ware vary only slightly between sites. At Opovo, thin-walled black-burnished vessels such as highly-polished open bowls and necked jars were not tempered (Tringham et al., 1985, p. 437). At Vinča-Belo Brdo, all the burnished ware is untempered (Spataro, forthcoming). Six of the nine untempered fine vessels from Parţa, are black or grey-burnished, but one black-burnished ware was made with some added finely cut chaff temper, and two small globular black-burnished vessels were made with some very finely crushed grog (Spataro, 2014, table 1). At Miercurea Sibiului Petriş, only one of the fine ware sherds examined was black-burnished, and it was made with a fine untempered fabric (Spataro, 2014, table 1).

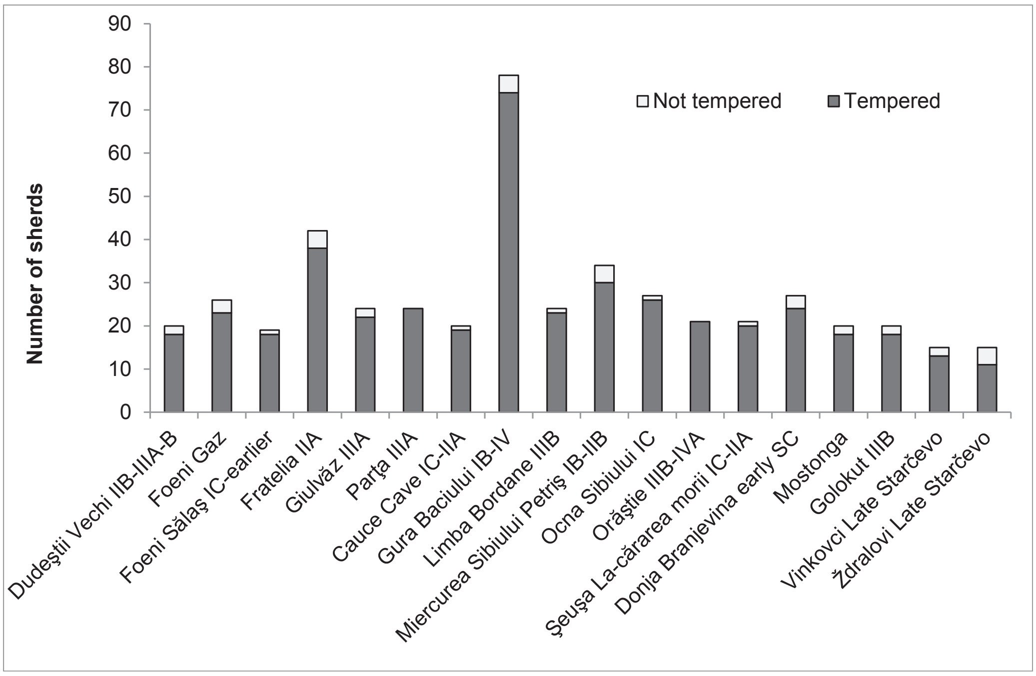

Fig. 5 – Bar chart of temper for the central Balkans Early Neolithic in the 6th millennium cal. BC: most of the pottery was tempered.

Fig. 5 – *Diagramme en bâtons des dégraissants pour les Balkans occidentaux au Néolithique ancien au VIe millénaire cal. BC : la plupart des poteries ont été dégraissées.*

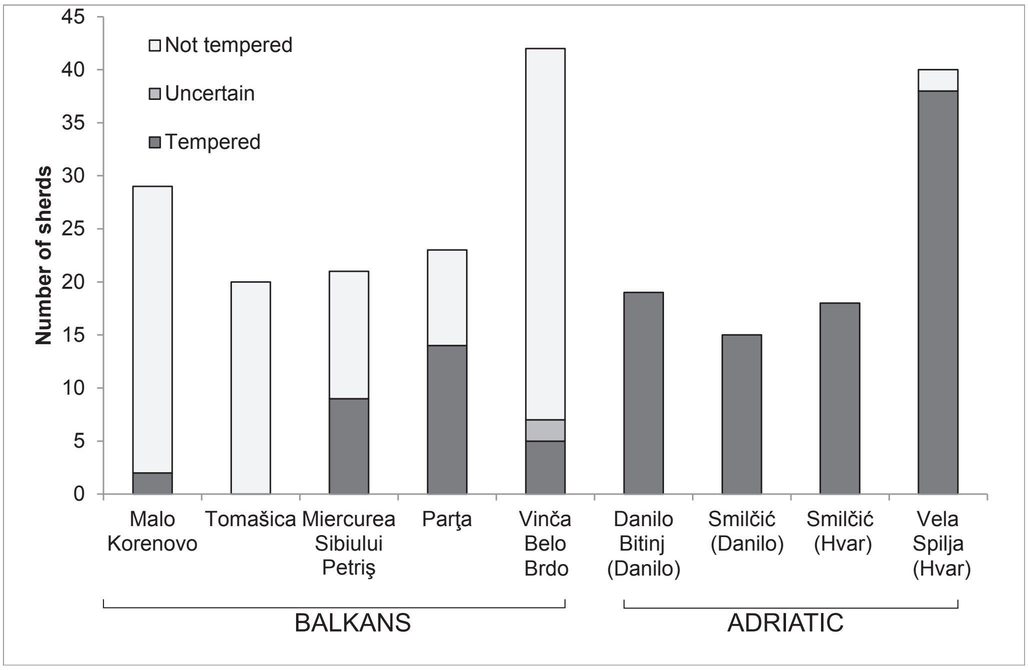

Fig. 6 – Bar chart of temper for the eastern Adriatic and the central Balkans Middle Neolithic in the 5th millennium cal. BC: in the Balkans most of the pottery was not-tempered whereas at the Adriatic sites temper is ubiquitous.

Fig. 6 – *Diagramme en bâtons des dégraissants pour l'Adriatique oriental et les Balkans occidentaux au Néolithique moyen au Ve millénaire cal. BC : dans les Balkans, la plupart des poteries ont été relativement peu dégraissées tandis que pour les sites en Adriatique, les dégraissants sont omniprésents.*

Korenovo potters (fig. 6) used temper for plain, coarse and thick-walled vessels, most probably for functional reasons. They used crushed intrusive igneous rock fragments, which were available close to the sites, but the grey, dark-grey burnished thin-walled vessels were not tempered.

In the 5th millennium cal. BC the pattern of pottery temper is almost the opposite of that in the 6th millennium cal. BC (fig. 5 and 6). Middle/Late Neolithic ceramics from the central Balkans and Slavonia were mainly not-tempered; tempering seems to have been more common at the Romanian Vinča sites.

Surface treatment

The only surface treatment of IW ceramics was impressed or incised decoration, which was added after the vessel was shaped and before firing. SC ceramic surface treatments were more elaborate and varied, with slips, burnishing and painting as well as incisions and impressions. Burnish and slip treatments are sometimes difficult to distinguish by eye, and microscopic analyses are needed to determine whether an extra coating layer (a slip) was added or whether the surface was well-compressed and burnished.

Burnishing became a widespread surface treatment in the Middle Neolithic of southern Europe, being common in the Danilo, Hvar, Vinča and Korenovo cultures. Danilo and Hvar burnished ware was made using the same fabrics used to make coarse ware with untreated plain surfaces. The paste was made of calcareous or non-calcareous clay, which was heavily tempered with crushed calcite. The only technological difference was the burnishing of the surfaces, and compressing and smoothing the external layer of clay platelets using a smooth-surfaced tool (e.g. pebbles, potsherds, bones, cloth, etc.). The pot was then fired in a reducing atmosphere to obtain the red, buff and black glossy surface. The burnished layer is clearly observable in thin section (fig. 7, left).

A different *chaîne opératoire* was followed for the burnished Vinča ceramics. Black-, red-, and buff-burnished wares were mainly manufactured using very fine loessic or alluvial and non-calcareous raw materials, rich in fine quartz inclusions. After shaping the vessel, the potter would burnish the surface with a smooth tool, as a distinct orientation of the clay platelets is visible, and fire it in reducing or oxidising conditions. However, in some instances, e.g. at Parţa, black-burnished ceramics were not only fired in a reducing atmosphere, but were also smudged, as a thin carbon surface layer is visible in some of the sections (fig. 7, right)[(4)]. Smudging implies that the ceramics were deliberately coated with a layer of fine soot, e.g. by adding green wood during the firing, after lowering the temperature (Rice, 1987, p. 158; Skibo, 1992, p. 160; see also Fowler, 2008, p. 497 for smudging as a post-firing treatment). At Opovo, black-burnished ceramics were the product of smudging or just of reducing firing conditions (Tringham *et al.*, 1985, p. 437); the smudged pottery generally looks less shiny.

Korenovo grey and dark-grey burnished ware was made using very similar raw materials to those used by Vinča potters. Well-burnished spherical, biconical and pedestalled bowls were produced with loessic clay, rich in very fine-grained quartz sand, which was ideal for burnishing as it did not contain coarse angular inclusions. After shaping and wetting the surfaces they were very well-burnished using a smooth-surfaced tool. The surfaces were only smoothed and compressed, as the inclusions have a distinct orientation, but are composed of the same minerals found in the rest of the fabric (fig. 8, left and right; fig. 9). Thus Vinča and Korenovo potters selected the most suitable clays to make burnished pottery, whereas Danilo/Hvar potters merely adapted the existing formula, despite the fact that coarse mineral temper made burnishing more difficult.

Figulina ware was also in some cases smoothed and then painted. The ceramic microstructure shows smoothing and compressing of the clay platelets (fig. 10), and ceramic tools made of fine pastes were used as burnishers at central and southern Italian IW sites, such as Colle Santo Stefano di Ortucchio in the Abruzzo region and Trasano in Basilicata (see also Angeli and Fabbri, 2013; Angeli, in press).

Firing conditions

Firing temperatures of prehistoric pottery fired in bonfires cannot be determined exactly, as various factors govern the effective temperature, including clay types, atmosphere conditions, fuel used and in particular the duration of the firing and cooling.

In the Early Neolithic, pots were mainly fired at low temperatures. In the IW the temperatures never exceeded 750 °C, as the crushed calcite used as temper is perfectly intact (Shoval et al., 1993, p. 271). For SC ceramics the average temperature was around 600-650 °C, as charred organic remains are often visible in most of the potsherds (e.g. Rice, 1987, p. 88; Gibson and Woods, 1990, p. 113). Higher temperatures were rarely achieved, as vitrified fabrics are rare in most Early Neolithic assemblages. IW and SC potters fired the ceramics in oxidising conditions, but SC pots often have a darker 'sandwich-core', due to incomplete oxidation of the organic temper or component.

In the Danilo and Hvar cultures the firing temperature was similar to that used for IW production, as in most cases a good sintering of the clay (when the clay particles begin to soften and stick together, see: Rice, 1987, p. 93; Gibson and Woods, 1990, p. 241), can be observed in the fabrics but there is no evidence of vitrification of clay filaments, and crushed calcite is perfectly conserved. However, potters started to use reducing conditions to make black-burnished ceramics (see above, fig. 7).

In contrast, *figulina* ware was fired at high temperatures in an oxidising atmosphere. The fabrics are vitrified, in some cases showing bloating (fig. 11), suggesting firing temperatures of up to 950 °C. The neoformation of

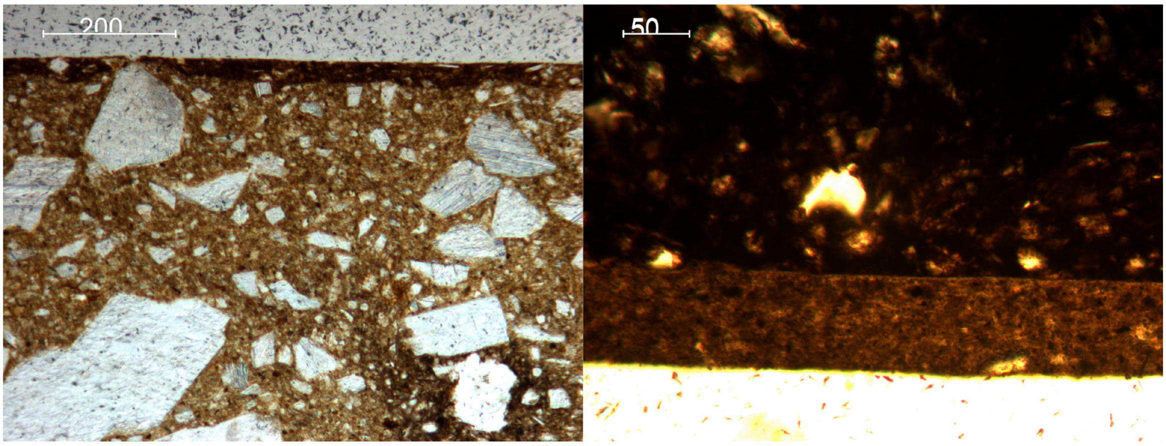

Fig. 7 – Photomicrograph of a thin section of sample VS17 (left; plane polarised light, PPL), a black-burnished vessel from the Hvar site of Vela špilja (Korčula island), showing a coarse fabric rich in crushed calcite and a smoothed and compressed surface layer due to the smoothing and burnishing of the surface which was then fired in reducing atmosphere (fine quartz and mica flakes are still visible in the smoothed layer); right: photomicrograph of a thin section of a small black-burnished globular vessel from Parţa (Romanian Banat), showing a thin layer of carbon deposit on the surface left by smudging (PPL).
***Fig.** 7 – Micrographie d'une lame mince de l'échantillon VS17 (à gauche, lumière polarisée) d'un récipient noir bruni provenant du site Hvar de Vela špilja (île de Korčula), présentant une pâte grossière riche en calcite écrasée et une couche de surface lisse et comprimée réalisée grâce au polissage de la surface qui a ensuite été cuite en atmosphère réductrice (de fines paillettes de quartz et mica sont visibles dans la couche polie) ; et (à droite) micrographie d'une lame mince d'un petit récipient noir bruni de forme globulaire provenant du site de Parţa (Banat roumain), présentant une fine couche superficielle de carbone laissée par l'enfumage (lumière polarisée).*

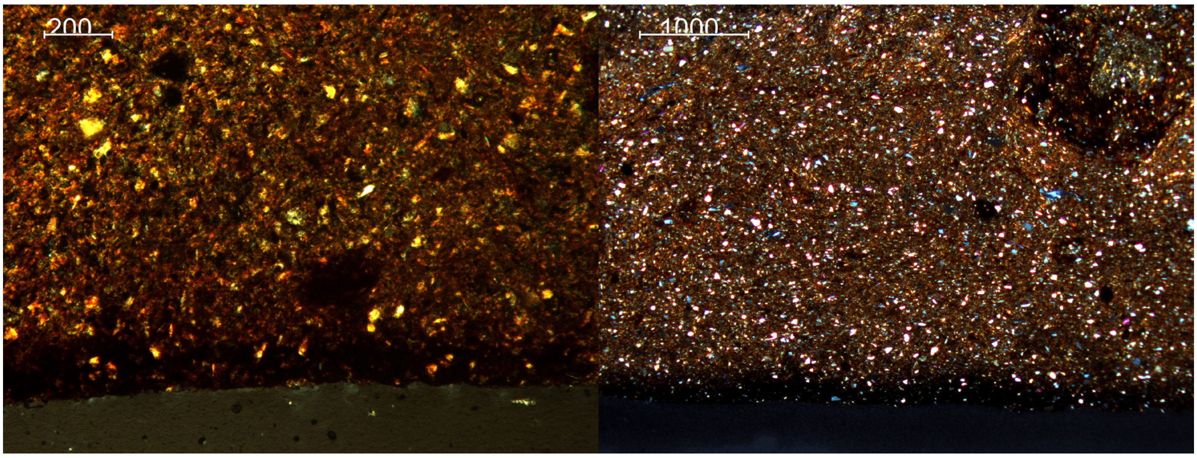

Fig. 8 – Photomicrographs of thin sections of sample MK13 from the site of Malo Korenovo (left) and sample TMS3 from the site of Tomašica (right) in Slavonia. The burnished surface is clearly visible in the smoothed and compressed surface layer on both samples (XPL).
***Fig. 8** – Micrographie de lames minces des échantillons MK13 provenant du site de Malo Korenovo (à gauche) et TMS3 provenant du site Tomašica (à droite) en Slavonie. Pour ces deux échantillons, la surface brunie est clairement visible au niveau de la couche superficielle qui a été lissée et comprimée (lumière polarisée croisée).*

gehlenite in *figulina* ware from Middle/Late Neolithic Serra d'Alto sites in Apulia and Basilicata, indicates firing temperatures of up to 1050 °C (e.g.: Heimann and Maggetti, 1981; Muntoni and Laviano, 2008, p. 128). Despite the availability of *figulina* ware at the Danilo and Hvar sites, everyday pottery continued to be fired at the same low temperature.

On the basis of the SEM microscopy, the majority of Vinča potsherds have well-sintered clays, and in many cases, at all three sites examined, clay filaments began to vitrify. However, Vinča potters did not need a very high firing temperature to make black-burnished ware, although the SEM microstructural analyses show that in some cases they experimented with high-firing, reaching 850-900 °C and even higher temperatures, for coarse ware and occasionally also for black-burnished ware (Spataro, 2014). Some of the pastes are vitrified, particularly at Vinča-Belo Brdo (Spataro, forthcoming). Nevertheless, some black-burnished ware was also low-fired, as suggested by the presence of charred organic remains at Parţa (see fig. 12).

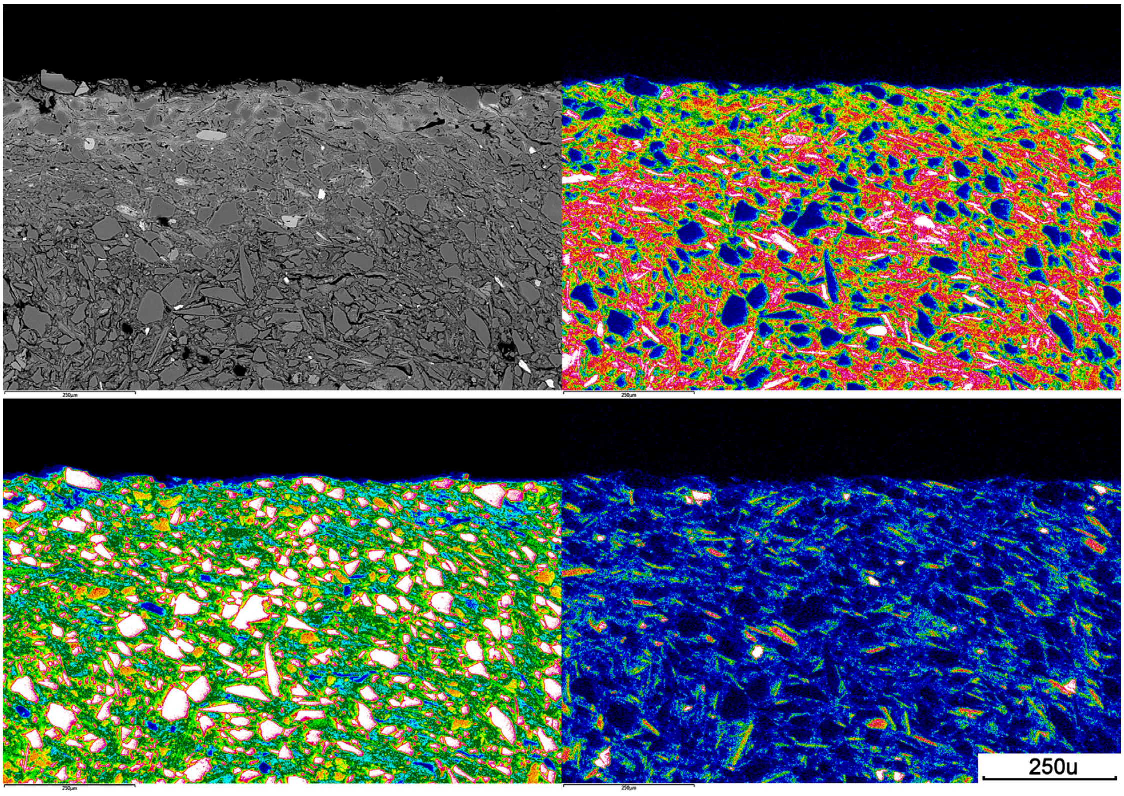

Fig. 9 – SEM-EDX elemental map of sample TMS3 from the Korenovo site of Tomašica (see Spataro, 2006), a black-burnished deep cup with very thin walls, which shows no chemical difference between the paste and the surface of the sample. Top left: mapped area (× 120, covering ca 1.0 × 0.8 mm); top right: the elemental map for aluminium, which is abundant in the fabric throughout the sample; bottom left: the elemental map for silicon, very abundant in the fabric of the samples and no differences can be identified between the paste and the surface layer; bottom right: the elemental map for potassium, concentrating in the mica flakes of the sample, similarly spread in the fabric and surface of the potsherd.

Fig. 9 *– Carte de la répartition des éléments de l'échantillon TMS3 provenant du site de Korenovo de Tomašica (see Spataro, 2006), acquise par analyse MEB-EDX ; cet échantillon vient d'une coupe haute en céramique noire brunie aux parois très fines et ne montre quasiment pas de différence entre la pâte et la surface. En haut à gauche : zone cartographiée (× 120, couvrant environ 1.0 × 0.8 mm) ; en haut à droite : carte de la répartition des éléments pour l'aluminium, qui est abondant dans la pâte dans l'ensemble des échantillon ; en bas à gauche : carte de répartition des éléments pour le silicium, très abondant dans la pâte des échantillons ; aucune différence ne peut être identifiée entre la pâte et la couche de surface ; en bas à droite : carte de la répartition des éléments pour le potassium, qui est concentré dans les paillettes de mica qui sont distribuées de manière homogène entre la pâte et la couche de surface du fragment de poterie.*

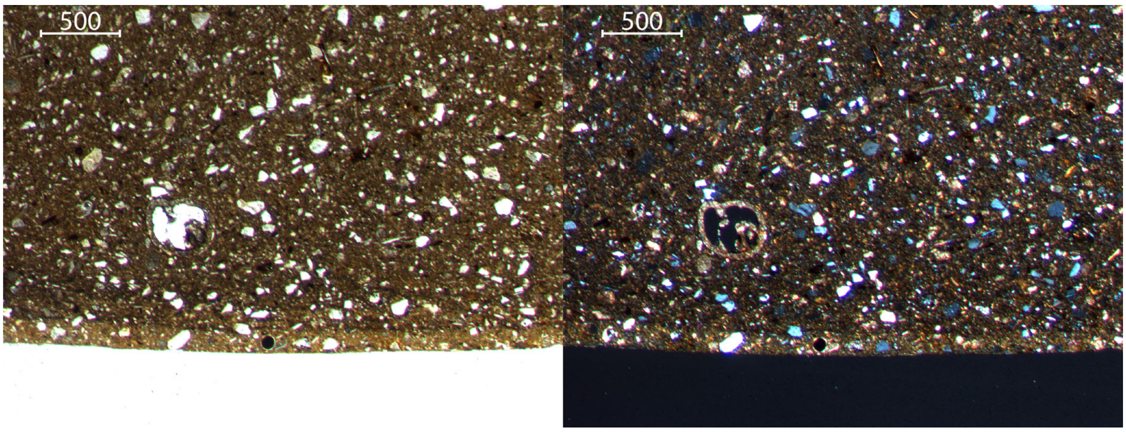

Fig. 10 – Photomicrographs in PPL (left) and XPL (right) of a *figulina* sample RDM23 from Ripabianca di Monterado (Italy) showing a compressed and burnished surface.

Fig. 10 *– Micrographie en lumière polarisée (à gauche) et lumière polarisée croisée (à droite) de l'échantillon RDM23 d'une* figulina *provenant de Ripabianca di Monterado (Italie) et présentant une surface comprimée et brunie.*

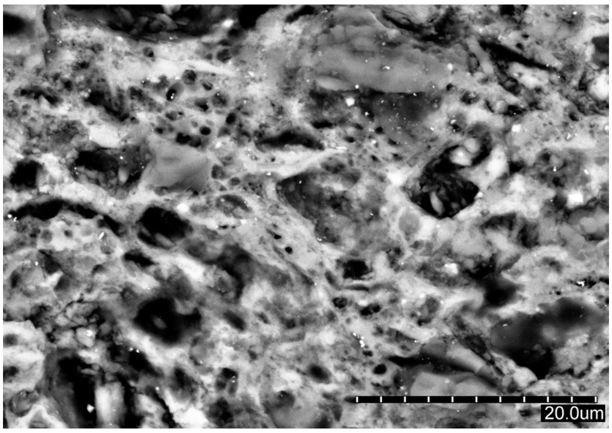

Fig. 11 – SEM backscattered electron image at high magnification of a *figulina* pottery thick-polished sample from Scamuso (South-eastern Italy), showing the high-fired paste with bloating.
***Fig. 11** – Image MEB en électrons rétrodiffusés à fort grossissement d'une section épaisse polie d'une poterie* figulina *provenant du site de Scamuso (Italie du Sud-est) et présentant une pâte cuite à haute température et fortement vitrifiée.*

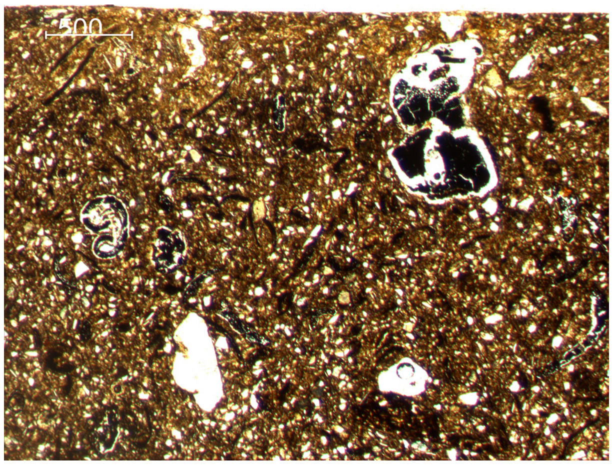

Fig. 12 – Photomicrograph of sample PRTV5, a black-burnished globular vessel with cylindrical neck from Parţa (PPL). The fabric of the sherd is rich in fine quartz sand inclusions and also finely cut plant matter. The burnt charred remains (black areas infilling the voids) are still visible in the fabric of the pot, indicating a low firing temperature.
***Fig. 12** – Micrographie de l'échantillon PRVT5 d'un récipient noir bruni de forme globulaire avec un col cylindrique provenant de Parţa (lumière polarisée). La pâte de ce fragment est riche en fine inclusions de sable de quartz et de matière végétale finement coupée. Les résidus carbonisés (zones noires remplissant les vides) sont encore visibles dans la pâte, ce qui indique une basse température de cuisson.*

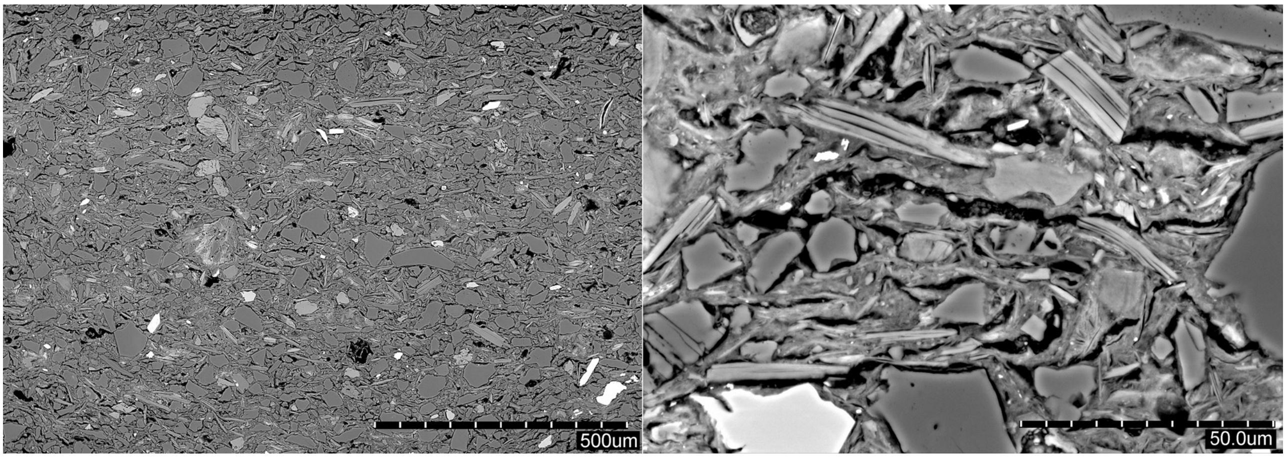

Fig. 13 – SEM backscattered electron image of a thick-polished section of sample TMS4 from Tomašica at low (left) and high (right) magnification, showing a fabric with well-sintered clay, but no initial stage of vitrification.
***Fig. 13** – Image MEB en électrons rétrodiffusés d'une section épaisse polie de l'échantillon TMS4 provenant du site de Tomašica à faible (à gauche) et fort (à droite) grossissement et présentant une pâte bien fusionnée, mais sans l'étape initiale de vitrification.*

There was significant variation in firing temperatures between the sites analysed, which cannot be a temporal trend, as Miercurea and Parţa were attributed to early Vinča, and the high firing temperatures at Vinča-Belo Brdo appear from the earliest phases (Spataro, forthcoming). At Opovo, thick-walled ceramics, which were tempered with grog, were highly-fired (ca. 900-950 °C), whereas untempered vessels were fired at lower temperatures (800-840 °C; Tringham et al., 1985, p. 436).

At Korenovo sites, coarse plain surface and thin-walled dark grey-burnished ceramics were fired respectively in oxidising and reducing conditions. The temperatures did not exceed 850 °C, as vitrification was not identified in the 69 potsherds examined. SEM analysis of their microstructure shows that the clays were well sintered but the clay filaments had not begun to vitrify, suggesting a typical firing temperature around 800 °C (fig. 13).

DISCUSSION: TRADITIONS, INNOVATIONS, IMITATION AND RESISTANCE

Traditions

For more than 1,500 years, from the first appearance of ceramics along the eastern Adriatic coastline, potters used the same fabric and firing conditions for coarse and fine ware production. Ceramics were invariably tempered with crushed calcite, reflecting local geology (5). Although more radiocarbon dates are needed, it appears that the use of calcite temper increased over time. Low firing temperature and heavy reliance on only calcite temper is a low-technology pottery production package (table 2). As all shapes and surface treatments were made using the same package, there is no correlation between different ceramic products and pottery fabric. The potters must have known that calcite temper is incompatible with high firing temperatures (e.g. 850 °C), as these would cause cracking and spalling, with flakes of clay blown out of the surface of the ceramics (see Gibson and Woods, 1990, p. 246). Nevertheless, evidence that Danilo coarse ware was used for cooking is provided by sooting and long-chain ketones identified in material from Nakovana Cave in the Croatian Pelliješac peninsula (Debono Spiteri, 2012, p. 250).

Although IW potters seem very conservative, Middle Neolithic Danilo potters experimented with new surface treatments and firing conditions, while continuing to use the same fabrics and firing temperature used by their predecessors. This production mode would imply no particular investment in raw materials, as they were easy to find, or in firing equipment, as the pottery could have been fired in a bonfire. There is no sign of production for a market, and pottery may have been produced at household level (Spataro, 2009b, p. 72). However, the sophisticated and elegant decorative motifs of the Danilo and Hvar cultures required more skills and time. These might have been produced by the most skilled potters. It is likely that the person who decorated the pots was sometimes different to the person who made them, as pots were all made with the same fabric, but some were particularly costly to produce. The IW and Danilo/Hvar technological traditions persisted despite the availability of *figulina* pottery.

In contrast to the originality and variety of decorative motifs and surface treatments, SC potters did not experiment with ceramic fabrics. For ca. 700 years (Spataro, 2010), SC potters used the same formula to make pottery: non-calcareous and micaceous clays tempered with abundant chaff, and fired at low temperature in oxidising conditions. This again would imply no investment in workshops and no sign of production for a market (Spataro, 2014, table 2).

We might ask if this far-reaching, persistent and common formula was a pragmatic choice, or a non-choice as potters saw no advantage in innovation. From a functional point of view, organic temper has some advantages (e.g. the pots are lighter) but also disadvantages, as for example sand-tempered or grog-tempered ceramics are more resistant to thermal shock (Skibo et al., 1989, p. 140; Tite et al., 2001). Petrographic analyses show that a small minority of vessels from a few SC sites were also tempered with sand, or sand with organics. These sand-tempered pots recur through the different SC phases (e.g. from the earliest to the latest phases at Gura Baciului in Transylvania; see Spataro, 2008), but sand temper never replaced chaff temper. Thus organic temper can be regarded as an adaptively neutral tradition. This reinforces the idea of a very conservative society (Spataro, 2014, p. 194), more conservative than the following Vinča.

The IW, SC and Danilo/Hvar pottery productions imply a cultural transmission which is both vertical, from one generation to the next, with the maintenance of local production methods over 700 years, and horizontal, based on the exchange of ideas over a broad geographical area (Spataro, 2007). However, the persistent differences in pottery technology between the Adriatic region and the central Balkans during the Early Neolithic reinforce the idea of a cultural boundary, which is not only typological (Spataro, 2011, p. 43; Spataro and Meadows, 2013, p. 72-73), but also technological. The technological and stylistic boundary persists in the Middle Neolithic, but new types of boundaries appear within the Balkans, once the new Middle Neolithic cultures appear, as typologies and decorative motifs between the northern (Korenovo) and southern (Vinča) regions are different, but similar ceramic technological packages developed. There is more technological variation within the Vinča groups than there is between Vinča and Korenovo ceramic production. These variations reinforce the idea of regionalisation of Vinča technological traditions.

Innovation and Innovative Tradition

After almost a millennium when ceramics were manufactured without any correlation between fabric and shape (e.g.: Spataro 2006a and 2011), the concept of ‘ceramic class’, requiring a consciously different step in the *chaîne opératoire* system, appeared in southern Europe in the Middle Neolithic. For example, red-burnished SC ceramics were always made using the same fabric used to make the other ceramics, including coarse and plain ware (table 3). By contrast, Vinča potters at Parţa, Miercurea Sibiului Petriş and Vinča-Belo Brdo selected loessic and fine alluvial clays to manufacture thin-walled burnished ware, and used different clays and tempers to produce coarse ware (Spataro, 2014). Similar patterns may be observed at Opovo, where a correlation between vessel type and fabric was suggested (see: Tringham et al., 1985, p. 436 and fig. 10), and in two of the three Korenovo assemblages discussed here (no coarse ware from Tomašica was analysed).

The coarse ware at each Vinča site considered here was made using different tempering agents. At Parţa, for example, globular vessels with plastic decorations and

Aspect	Impressed Ware	Starčevo-Criş
Clay selection and processing	Unselective Minimal processing	Only one type of clay Minimal processing
Temper use and selection	Increasing reliance on calcite as temper; local minerals	Almost exclusive and ubiquitous use of chaff
Surface treatment	Basic, impressions and incisions, before firing	Rough surfaces, barbotine, polished and burnished, red-slipped, painted, plastic, impressed, incised: diverse
Firing conditions	Low-firing; oxidising atmosphere	Low-firing; sandwich-core due to burning of the organics

Table 2 – Comparison of technological aspects of the Early Neolithic Impressed Ware and Starčevo-Criş cultures.
Tabl. 2 *– Comparaison entre les aspects technologiques des cultures de la céramique imprimée et de Starčevo-Criş au Néolithique ancien.*

Attributes	Vinča-Belo Brdo (Vinča A-D)	Parţa (Vinča B)	Miercurea Sibiului Petriş (Vinča A1-B)	Korenovo	Danilo/Hvar	*Figulina* ware
High firing (>850 °C)	√					√
Controlled atmosphere	√	√	√	√	√	√
Clay selection	√	√	√	√		√
Clay levigation	?	?	?			√
Correlation between shape and fabric	√	√	√	√		
Correlation between fabric and appearance	√	√	√	√		
Sophisticated surface treatment	√	√	√	√	√	√

Table 3 – Attributes of innovation in relation to the Middle Neolithic cultures and sites discussed in the paper.
Tabl. 3 *– Attributs d'innovation en relation avec les cultures et sites du Néolithique moyen discutés dans cet article.*

tronco-conical vases with plastic and impressed decorations were tempered respectively with metamorphic sand and grog (Spataro, 2014, table 2). At Opovo, grog was the main choice for coarse thick-walled vessels. Grog seems to be a Middle Neolithic choice and effectively a Middle Neolithic invention in this region, as it is almost absent from the ceramics analysed in the Early Neolithic assemblages. At Miercurea, thick-walled pots were made of sand-tempered pastes (Spataro, 2014). At the three Korenovo sites analysed so far, only vessels with thick walls and plain and unburnished surfaces were tempered; the only temper used was crushed igneous rock.

On these bases, the use of specific temper types (rock fragments and grog) which were effective for thermal-shock resistance purposes, and the fact that the tempered pots were mainly plain coarse ware, would suggest that in both Vinča and Korenovo cultures, temper was used selectively for functional reasons. In addition, different clays were used to make coarse ware from those used to manufacture the mainly untempered burnished ware.

The variations of temper and formulas used to make fine and in particular coarse ware might reflect a temporal or regional pattern. The Miercurea and Parţa samples come from the early Vinča phases, whereas the ceramics from Vinča-Belo Brdo cover the entire Vinča sequence. Opovo, in Vojvodina, is only 60 km north of Vinča-Belo Brdo, but Parţa is in Romanian Banat, and Miercurea is in Transylvania, over 300 km from the Serbian sites (fig. 1).

Burnished Vinča and Korenovo ceramics were mainly made of very fine raw materials, loessic or alluvial sediments, which were ideal for burnishing. On the other hand, although Danilo potters introduced red-, buff- and black-burnished ceramics to the ceramic repertoire of the Dalmatian coast, they did not use different raw materials to those used for coarse ware production. Their calcite-tempered fabrics were not ideal for burnishing, as the many coarse/medium angular inclusions complicated the polishing process. The fact that Danilo/Hvar black-burnished ware was made following local fabric traditions implies that it was made by local potters, and not by itinerant or immigrant potters from the central Balkans. The adoption of black-burnishing can be seen an adaptive change, as Danilo potters used the same solution as Vinča and Korenovo potters to obtain shiny surfaces, without copying the shapes and designs of Vinča and Korenovo pots; the technology spread, not the typology. The idea of the end-product, presumably tied to display, may also have spread. The visibility of black-burnish might have quickly influenced potters' choices and techniques in surrounding areas, even if the process by which it was obtained was not openly displayed (see: Gosselain, 2000, p. 191).

Burnishing is not a Middle Neolithic invention, but was first developed when pots were fired under oxidising conditions. In the Middle Neolithic, with the use of more suitable clays in the Korenovo and Vinča cultures, and the adoption of firing in reducing conditions, this trait crossed cultural boundaries independently of the *chaîne opératoire*, as the temper was not a determinant. The question that arises is whether black-burnishing met a functional requirement that could not be met before. It is doubtful that only burnished ware was used to hold liquids, as residue analyses of Starčevo ceramics from the Iron Gates site of Schela Cladovei and the Hungarian site of Ecsegfalva 23 showed that both slipped burnished and coarse vessels contained dairy products (Craig et al., 2005). It is possible that with increasing social complexity, public display and feasting became more important (Spielmann, 2002).

Another important innovation of the Middle Neolithic is enhanced control over firing conditions. As black-burnished ware is commonly found throughout the area from the eastern Adriatic to Slavonia and eastern Transylvania, potters in all the three Middle Neolithic cultures considered here must have mastered firing with a reducing atmosphere. At Korenovo and Danilo sites, the black-burnished effect was obtained by smoothing and compressing the clay platelets, before firing in reducing atmosphere. On the other hand, some of the Vinča black-burnished ceramics were made with an extra step in the *chaîne opératoire*, the smudging (or smoking) technique. Control of temperature and a constant atmosphere or manipulating the fuel supply is required to manufacture well-sintered vessels and smudged pots or highly-fired ceramics. Vinča ceramics are distinguished from Korenovo and Danilo ware by their firing temperature (table 3). Vinča potters often used higher firing temperatures than those in neighbouring cultures, as testified by vitrified ceramic fabrics or the initial vitrification of clay filaments; highly-fired ceramics are common at Vinča-Belo Brdo and Opovo.

Finally, *figulina* ware can be seen as an 'innovative tradition'. This was a new technology, and there seems to have been no intermediate product between coarse IW pottery and *figulina*, i.e. proto-*figulina* ceramics have not been found. The *figulina* tradition lasted about 1,500 years and yet its production seems not have evolved. *Figulina* production implied a substantial investment of resources, in terms of training and equipment. The potter had to learn to find the right clay sources, to shape the pots without using any temper, and to control the firing conditions exactly. The high contents of calcium, magnesium, and potash suggest a well-defined choice since these elements can promote the vitrification of the ceramics at rather low firing temperatures (Spataro, 2009a, p. 70). In addition, the removal of inclusions might have helped to avoid spalling when reaching high temperatures.

The potter would have been able to control the temperature for these highly-fired products only using a kiln(6). Equipment was also required to levigate the clay (table 3). Considering the greater investment involved, *figulina* production might have been a full-time occupation, in contrast to possible seasonal work for the production of Early Neolithic and perhaps some of the Middle Neolithic pottery. Surprisingly, there seems not to have been communication or exchange of ideas between the *figulina* potters and the potters who produced the Danilo/Hvar found in the same ceramic assemblages. This might imply cultural transmission only within a restricted group of artisans.

Imitation and resistance

Some technological traits spread across Middle/Late Neolithic cultural boundaries and some did not. Firing in reducing conditions to produce black-burnished ware was one of the main developments in south-European Middle/Late Neolithic pottery. Burnishing and painting[7] spread across cultural boundaries (Danilo, Vinča and Korenovo cultures), and may be regarded as having had functional advantages as well as aesthetic appeal. As well as improving the appearance of the ceramics, giving a finer exterior, with a sophisticated sheen, it might have made them less permeable, without the use of a glaze, and limit crack propagation (Kerr et al., 2004, p. 74).

The metallic sheen of Vinča ceramics was probably both an aesthetic and functional trait, and not likely to imitate or substitute any metal vessel, as metal vessels are not known from these phases. Although burnishing is a trait which transcends cultural boundaries, smudging was only identified in the Vinča pottery. This was most likely a Vinča innovation, which so far has only been detected in one assemblage, at Parţa.

The ideal clays used for pots with a burnished surface treatment should contain few or fine inclusions, and the Vinča and Korenovo loessic and alluvial clays were ideal. The use of loess has some advantages, as it has a low drying shrinkage and stability at low firing temperatures (Kerr et al., 2004, p. 101). Nevertheless, Danilo black-burnished bowls and jars were manufactured using a clay which was tempered with abundant, coarse and angular inclusions. This suggests that the Danilo communities did not think they needed to change the traditional fabric, to make new ceramic types, regardless of their function, but they also adopted firing in reducing conditions. They tried to adapt their technical tradition (the fabric) to the new ideas (the burnishing).

Similarly, the very specific choice of clay, processing and firing used for the *figulina* ware did not spread, as these traits were not adopted by other potters. This might be due to the fact that the cultural transmission of these traits was restricted to a very small group of potters, as investment in equipment and skills was essential and high.

Some of the variations identified can be interpreted as regionalism, or local aspects of a single culture. Regional variations are visible in the Vinča culture, from a typological point of view, e.g. between the ceramic assemblages from Vinča-Belo Brdo, Selevac and Gomolava (see Chapman, 1981; Tringham et al., 1985, p. 437), and also from a technological perspective. In contrast to the use of just one formula for ceramic production during the 6th millennium cal. BC, coarse ceramics, in particular, were manufactured with a variety of tempers, clays and firing temperatures, which varied between Vinča-Belo Brdo, Parţa, Miercurea Sibiului Petriş and Opovo.

In some cases, the surface treatment of typical black-burnished ware was more sophisticated. This complexity suggests a possible centre of innovation, which might have influenced potters elsewhere, whereas smaller workshops in different villages might have developed their own, less sophisticated solutions, rather than adopting all aspects of new technology (i.e. high firing and use of smudging technique).

Successful innovation requires an innovator (or user-innovator) and a consumer, as if an innovation is not welcomed or needed, it will not become established. The innovation must provide some benefits and there is always a category of beneficiaries from innovation, a market place (von Hippel, 1986). An important aspect of innovation is to understand "*when* it is economically optimal to be an innovating user, manufacturer or supplier and *how* to manage each role" (von Hippel, 1986, p. 332). The benefit derived from an innovation such as black-burnishing may of course have been a social advantage (e.g. enhanced status or group identity), rather than a strictly utilitarian benefit.

The Middle Neolithic societies were more receptive to innovation, but pottery on its own is not sufficient to explain the reasons of change in society, as other aspects of the material culture should be considered. Two factors to be considered might be the mobility of the artisans and pottery as a culturally learned behaviour (Gosselain and Livingstone Smith, 1995, p. 158; Livingstone Smith, 2000, p. 34). Farming activities in the Vinča world were more established than in the previous millennium and towards the end of the period, pottery standardisation seems to develop from a typological perspective as well (Vuković, 2011).

CONCLUSIONS

In the Early Neolithic of the IW and SC communities, all the vessels were fired with low firing temperatures, and clay processing was minimal, although SC potters were selective about which clays they used. In the Adriatic region, temper use apparently increased over time and eventually became almost universal, whereas in the Balkans temper was always used, throughout the Early Neolithic. Only mineral temper was used in IW pottery, whereas SC pottery was almost always chaff-tempered. IW surface treatments (impressions, incisions) were more basic, whereas SC potters applied a wider range of surface treatments, including *barbotine*, painting and burnishing. The fact that SC pottery technology did not change over time is also reflected in the common traditions of lithic and bone industries at the same sites (Vitezović, 2011). The stability of Early Neolithic pottery technology might be related to the training process required to become a potter, and also to the expectations of the consumers.

Several innovations occurred in the Middle Neolithic: firing in a controlled atmosphere and more sophisticated surface treatment were used in all regions; Korenovo and Vinča potters, but not Danilo and Hvar potters, used different clays and tempers for different types of ceramics; high firing temperatures were only used by *figulina* and Vinča potters, and clay levigation was probably only practised by *figulina* potters (table 3).

Between the end of the Early Neolithic and beginning of the Middle Neolithic, we observe clear signs of specialisation in the Adriatic region. It is possible that *figulina* ware was made by a small elite of specialist potters, who had the requisite training to make untempered pots and fire them at high temperatures. In the central Balkans, after almost a millennium of pottery made using mainly one recipe, the idea of using specific clays and tempers for defined shapes or coarse and fine vessels (ceramic classes), which are often related to the type of surface treatment, suddenly appeared with the Vinča and Korenovo cultures. In both the Adriatic region and the Balkans, the concept of ceramics itself might have changed between the Early and Middle Neolithic, as a wide variety of new products were available and produced in a more systematic way, requiring more skills and being more capital-intensive.

Ethnoarchaeological research shows that ceramic manufacturing processes in contemporary societies are less susceptible to change than styles and post-firing treatments (Stark, 2003, p. 211-212). As O. P. Gosselain explains, "parts of these "aggregates" [pottery-making traditions] appear to be unequally affected by change, such that some may be altered readily at the time of technical transmission or during practice, whereas others are characterized by a remarkable stability. The reason is that the different components of pottery chaînes opératoires do not share a similar technical fluidity or involve similar processes of social interaction. Hence, important differences exist in the potential for technical behavior to be reproduced and to change over time and space and, as we will see, to reflect certain facets of identity. This should render pottery technology especially attractive for those interested in the archaeological reconstruction of social boundaries" (Gosselain, 2000, p. 191).

A natural question would be why some societies are receptive to innovations and other societies are more conservative. The break with SC tradition, the high firing temperatures and the smudging techniques suggest that the Vinča culture was more technologically developed than Korenovo and Danilo, and social complexity might have been behind the technological development. The Vinča tell sites, the erection of temples, the abundance of possible ritual artefacts, the beginning of metal production (Chapman, 1981; Lazarovici et al., 2001), all these aspects seem to show a Neolithic society more complex than those in the surrounding regions, where tells, temples, cult objects and metals, are absent or rare.

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NOTES

(1) I would like to thank Prof. S. Shennan (Institute of Archaeology, UCL) who allowed me to use the facilities of the institute for another year at the end of my post-doctoral research fellowship.

(2) The polarising microscope utilised for the thin section description is a Leica DMLP. The SEM-EDX used with the Impressed Ware ceramics was a Jeol JSM-35 CF with an Oxford ISIS detector with a thin film window. During the project on Starčevo, Korenovo and Vinča, a Philips XL30 ESEM was used, and the EDX data were processed using INCA Oxford Instruments software. I would like to deeply thank Mr K. Reeves (Institute of Archaeology, UCL) for his help and technical suggestions on the SEM throughout my PhD and post-doctorate. The SEM-EDX study consisted of bulk (regional) analyses from 5 different areas of each sherd (each covering an area of ca. 1.5 × 1.0 mm) (Spataro, 2014, p. 177-183).

(3) For example the site of Smilčić along the Dalmatian coastline, which was occupied from the Early Neolithic throughout the Late Neolithic (Impressed Ware, Danilo and Hvar cultures), or the site of Gura Baciului in Transylvania, which was occupied throughout the four SC phases, or the Romanian sites of Parţa and Miercurea Sibiului Petriş which show multilayered of occupation (e.g. SC and Vinča).

(4) The carbon does not usually penetrate the surface deeply, so it is often difficult to detect smudging in pottery thin sections (Gibson and Woods, 1990, p. 245).

(5) Calcite is still used as temper today by some potters in southern Croatia, south-east Slovenia, western Serbia and Bosnia-Herzegovina (see Carlton and Djordjević, 2013).

(6) Two kilns were found yielding *figulina* pots, one kiln with interconnected pits for the *figulina* pottery production has been found in Serra d'Alto near Matera in Basilicata (Ridola, 1924-26) and one at Rivaltella, Ca' Romensini (early Square-Mouthed Pottery Culture), dated to 5,300-4,720 cal. BC (6,070 ± 110 BP; I-12519) (Tirabassi, 1987).

(7) Mainly typical of the Danilo and Hvar cultures.

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