

LUMEA NOUĂ PAINTED POTTERY: EXPERIMENTAL STUDY ON NEOLITHIC CERAMIC TECHNOLOGY

ALINA BINTINȚAN*

Introduction

In the study of ceramic technology, experimental archaeology has so far proved to be broadly applicable due to the diversity of the craft of pottery over time as well as to the inherent technical nature of the discipline. The wide range of experimental approaches demonstrates the flexibility and versatility of methods in this research field, and, therefore, a brief and concise definition for experimental archaeology is difficult to formulate. Early studies have stated that the purpose of experimental archaeology is to ‘reproduce past conditions and circumstances’,¹ and terms such as *reconstruction*,² *reproduction* and *replication* are frequently associated with experimental archaeology, though they do not fully address the meaning and goals of current archaeological experiments. Some attempts to define the discipline mention the production of materials and behaviours with the aim of observing the processes that occurred during the production, use, abandonment, deterioration and recovery of material culture,³ while others point out the indispensably hypothetical nature of the experiments.⁴

The main ideas that later became real principles of experimental practice underline the difference between the notion of *archaeological experimentation*, which is seen as the testing of a hypothesis under individual circumstances, and that of *experimental archaeology*, which is based on

* PhD, Independent researcher, Alba Iulia, Romania; e-mail: alina.bintintan@yahoo.com.

¹ John M. Coles, *Archaeology by Experiment*, (Londra: Hutchinson & Co., 1973); John M. Coles, *Experimental Archaeology* (Londra: London Academic Press, 1979).

² For explanations on the meaning of the term, see Peter Reynolds, “The Nature of Experiment in Archaeology,” in *Experiment and Design. Archaeological Studies in Honour of John Coles*, Ed. A. Harding, (Oxford: Oxbow, 1999), 159.

³ James M. Skibo, “Ethnoarchaeology, experimental archaeology and inference building in ceramic research,” in *Archaeologia Polona* 30 (1992): 18.

⁴ Reynolds, “The Nature,” 159.

extensive, long-term research programs that include several archaeological experiments.⁵

James Mathieu posits a more modern and comprehensive definition of experimental archaeology as a branch of archaeological research. The author emphasises the use of controlled experiments in the replication and/or simulation of objects, materials, processes, behaviours and even entire social systems in order to allow the researcher to create and test hypotheses about the past, subsequently generating analogies useful for archaeological interpretation.⁶ A similar perspective on the archaeological experiment, which appears in the work of Marianna Rasmussen, sees it as an analogy as well as part of a scientific research process.⁷

Today, experimental archaeology has prevailed over ethnographic and historical anthropological approaches, as it provides a wide range of valuable information on technological processes as well as a viable solution to the discrepancies that may arise when old technologies are analysed from the perspective of modern science.

Terminology

In archaeological research based on the study of material culture, the term *technology*⁸ refers to all actions carried out by humans that transform raw materials. As a set of processes, methods and operations used to obtain a particular finished product, *technology* can provide a broad perspective on the evolution of a society, beginning with the development of production techniques, the adoption of new techniques and the pursuit of closely interconnected social, economic and cultural transformations. From the technological processes of which they are the result, the artefacts discovered in archaeological excavations become the carriers of concrete information on the people and communities that made them, but they also render indirect, less

⁵ Michael B. Schiffer, James M. Skibo, Tamara C. Boelke, Mark A. Neupert and Meredith A. Aronson, "New perspectives on experimental archaeology: surface treatments and thermal response of the clay cooking pot," in *American Antiquity* 59/2 (1994): 198–199.

⁶ James R. Mathieu, "Introduction – Experimental Archaeology: Replicating Past Objects, Behaviors and Processes," in *Experimental Archaeology: Replicating Past Objects, Behaviors and Processes*, Ed. James R. Mathieu (Oxford: Archaeopress, 2002) [BAR International Series 1035], 1–2.

⁷ Marianne Rasmussen, "Building houses and building theories – archaeological experiments and house reconstruction", in *Iron Age houses in Flames. Testing houses reconstructions in Lejre. Archaeological experiments and house reconstruction*, Ed. Marianne Rasmussen (Lejre: Historical Archaeological Experimental Centre, 2007) [Studies in Technology and Culture 3], 10.

⁸ The explanatory dictionary of the Romanian language: <https://dexonline.ro/definitie/tehnologie>.

palpable, intangible intentions such as their value, importance, functions and meanings.⁹

The concept that illustrates how technology summarises and transcends the material dimensions of the object and provides a theoretical and methodological framework in the study of technology is undoubtedly that of *chaîne opératoire*. Initially developed as an analytical technique in anthropology by André Leroi-Gourhan¹⁰ and based on principles previously stated by Marcel Mauss,¹¹ it shifted the emphasis of research on archaeo-technology from the finished object and the changes suffered by the raw material during the production process to the *gestures* of the human being within such a process. This new analytical technique enabled the identification, ordering and reconstruction of the operational sequences of the technological process through which a natural material is ultimately transformed by man into a cultural product with certain functionalities and meanings. Therefore, the approach described above must be viewed as fundamentally different from a simple diagram of a production process.¹²

Chaîne opératoire is considered today to be a conceptual framework – a methodology¹³ that has the ability to rigorously highlight, explain and connect the details of the technological context that gave rise to the ceramic object

⁹ Heather L. Miller, *Archaeological Approaches to Tehnology* (Toronto: Toronto Academic Press, 2007), 5; Selena Vitezović, “From artefacts to behaviour: Technological analyses in prehistory”, in *Anthropologie LI/2* (2013): 176; Daniel A. Santacreu, *Materiality, Techniques and Society in Pottery Production. The Technological Study of Archaeological Ceramics through Paste Analysis* (Berlin: De Gruyter Open, 2014), 56; Tine Schenck, *Accessing intangible technologies through experimental archaeology. A methodological analysis*, (Exeter University, PhD Tesis, 2015), 20–25; Cătălin Lazăr, Monica Mărgărit and Valentin Radu, “Evidence for the production and use of Lithoglyphus naticoides beads in Europe during the Holocene: The case of the Sultana–Malu Roșu site (Romania)”, in *Quaternary International XXX* (2017): 1–13; Monica Mărgărit, Valentin Radu and Adina Boroneanț, “Experimental studies of personal ornaments from the Mesolithic Iron Gates,” in *Archaeological and Anthropological Sciences* (2017) [DOI: 10.1007/s12520-017-0522-5].

¹⁰ André Leroi-Gourhan, *Le geste at la parole: Technique et langage*, I, (Paris: Albin Michel, 1964); André Leroi-Gourhan, *Evolution et Technique: Milieu et Technique*, II, 2nd edition, (Paris: Albin Michel, 1973).

¹¹ Marcel Mauss, “Les Techniques du corps,” in *Journal de Psychologie XXXII* (1936).

¹² Miller, *Archaeological*, 29–30.

¹³ Marcia-Anne Dobres, “Technology’s links and Chaînes: The Processual Unfolding of Technique and Technician,” in *Contemporary Archaeology in Theory. The New Pragmatism*, Eds. Robert W. Preucel and Stephen A. Mrozowski (New Jersey: Wiley-Blackwell, 2010), 124.

under study. It has established itself as an indisputable *analytical tool*¹⁴ by which the archaeologist can understand the processes through which the artefacts were manufactured, used, reused and/or abandoned using a wide collection of ordered and correlated data. As Martínón-Torres has already stated, we are faced with a succession of actions ‘in which materials, people or other sources of energy, gestures, tools and knowledge can be studied together’.¹⁵

By exploring ceramic technology from this perspective, it is also understood that beyond the constraints imposed on society by the natural environment, there is always a wider or narrower range of options (*technical choice*) left in the hands of the potters. Technological choices, generally based on individual or collective knowledge and experience, give rise to technological tradition, which can be identified in the chaining of technical sequences¹⁶ and can be relevant to archaeological research.

Archaeological background

Romanian archaeologists have studied Lumea Nouă painted pottery since the second half of the last century, especially with regard to typological-stylistic analysis and cultural-chronological framing. This subject remains an issue of scientific debate. Research in the intra-Carpathian area at the eponymous Alba Iulia–Lumea Nouă site, as well as at Limba, Tărtăria and Zau de Câmpie, highlighted that Lumea Nouă materials are often associated with the Vinča pottery of phases A2–3¹⁷ and B¹⁸ and with late Vinča or Turdaș

¹⁴ Ibid., 125; Olivier P. Gosselain, “Technology,” in *The Oxford Handbook of the Archaeology of Ritual and Religion*, Ed. Timothy Insoll (Oxford: Oxford University Press, 2011), 246; Caroline D. Jeffra, “Experimental approaches to archaeological ceramics: unifying disparate methodologies with the chaîne opératoire,” in *Archaeological and Anthropological Science* 7/1 (2015).

¹⁵ Marcos Martínón-Torres, “Chaîne opératoire: The concept and its applications within the study of technology,” in *Gallaecia* 21 (2002): 33.

¹⁶ Jasna Vuković, “Archaeological Evidence of Pottery Forming Sequence: Traces of Manufacture in Late Neolithic Vinča Assemblage,” in *Archaeotechnology: studying technology from prehistory to the Middle Ages*, Eds. Selena Vitezović and Dragana Antonović (Belgrad, 2014), 177–198.

¹⁷ See for Vinča A3 Phase Gheorghe Lazarovici, Cornelia-Magda Lazarovici and Marco Merlini, *Tărtăria and the sacred tablets* (Cluj-Napoca: Mega, 2011), 78 and for Vinča A3–B1 Phase Sabin A. Luca, *Tărtăria Rediviva* (Alba Iulia: Editura Muzeului Național Brukenthal, Altip, 2016) [Bibliotheca Brukenthal LXXI], 25, 84, Fig. 57/1, 89, Fig. 61/4, 97, Fig. 69, 159, Fig. 212, 213, 245, Fig. 167; Marius-Mihai Ciută and Elena-Beatrice Ciută, “New Considerations about Neolithic Development Habitation in the Archaeological Site Limba-Oarda de Jos (Alba County),” in *Acta Terrae Septemcastrensis* XIV (2015): 62, Fig. 18.

materials.¹⁹ On the other hand, discoveries of this type in the caves of Cheile Turzii,²⁰ at Vadu Crişului–*Peştera Devenţ*²¹ and in NW Romania (Doh²² and Şimleul Silvaniei – *Str. T. Vladimirescu*²³) in stratigraphic contexts from which incised materials of the Vinča or Turdaş type are totally missing show that the definition of the cultural group remains an issue under discussion.

Materials and methods

The scientific research project we propose subscribes to experimental archaeology as a complex approach to testing methods, techniques and hypotheses formulated based on archaeological data that constitutes the *primary reference*.²⁴ Our experimental work deals with several technological

¹⁸ Cornelia-Magda Lazarovici and Gheorghe Lazarovici, *Arhitectura neoliticului și epocii cuprului din România* (I) *Neoliticul* [The Neolithic and Eneolithic architecture in Romania (I) The Neolithic] (Iasi: Trinitas, 2006), 406; Mihai Gligor, *Așezarea neolitică și eneolitică de la Alba Iulia–Lumea Nouă în lumina noilor cercetări* [Alba Iulia–Lumea Nouă Neolithic and Eneolithic Settlement in the Light of Recent Research] (Cluj–Napoca: Mega, 2009), 159; Luca, *Tărtăria*, 213.

¹⁹ Lazarovici and Lazarovici, *Arhitectura*, 406; Gheorghe Lazarovici, “Cronologia absolută, relativă și evoluția culturii Zau” [The Absolute and Relative Chronology and the Evolution of Zau Culture], in *Identități culturale locale și regionale în context european, Studii de arheologie și istorie, In memoriam Alexandri V. Matei*, Eds. Horea Pop, Ioan Bejinariu, Sanda Băcuet Crișan and Dan Băcuet Crișan (Cluj–Napoca: Mega, 2010): 64; Gligor, *Așezarea*, 159; Sorin Marcel Colesniuc, *Cultura Zau* (Constanța: Ex Ponto, 2014), 47, 190–191, 197, 198, 199, Fig. 136, Fig. 137; Luca, *Tărtăria*, 25.

²⁰ Gheorghe Lazarovici, Mihai Meșter and Lidia Dascălu, “Cheile Turzii 1994. Raport de cercetare arheologică și etnoarheologică” [Cheile Turzii 1994. Archaeological and Ethnoarchaeological Report], in *Acta Musei Napocensis* 32/I (1995): 546; Gheorghe Lazarovici and Mihai Meșter, “Cheile Turzii, Jud. Cluj. Punct: Peștera Ungurească” [Cheile Turzii, Cluj County, Research Point: Peștera Ungurească] in *Cronica Cercetărilor Arheologice din România* (1996): 31; Lazarovici and Lazarovici, *Arhitectura*, 419; Gligor, *Așezarea*, 158.

²¹ Nicolae Vlăsa, *Neoliticul Transilvaniei* [The Neolithic in Transylvania] (Cluj–Napoca, 1976) [Bibliotheca Musei Napocensis III], 20–24, Fig. 3/1–2; Lazarovici and Lazarovici, *Arhitectura*, 418, Fig. IIIe 15a; Colesniuc, *Cultura*, 144, Fig. 76.

²² Sanda Băcuet Crișan, *Neoliticul și eneoliticul timpuriu în depresiunea Șimleului* [The Neolithic and Early Eneolithic in Șimleu Depression] (Sibiu: Brukenthal. Bibliotheca Musei XXIII, 2008), Pl. 235–238.

²³ Sanda Băcuet Crișan and Horia Pop, “Așezarea neolitică de la Șimleul Silvaniei–Str. T. Vladimirescu nr. 7 (II),” [The Neolithic Settlement of Șimleul Silvaniei–Str. T. Vladimirescu nr. 7 (II)], in *Arheovest* II. *Interdisciplinaritate în arheologie. In Honorem Prof. Univ. Dr. Gheorghe Lazarovici* (Szeged: JATEPress Kiadó, 2014), 33–50, Fig. 6, 8, 10.

²⁴ John Coles, “Experimental Archaeology,” in *Proceedings of the Society of Antiquaries of Scotland* 99 (1967): 1–20; Reynolds, “The Nature”; Rasmussen, “Building”; Tine Schenck, *Accessing*.

aspects of making, ornamenting and firing the Lumea Nouă Neolithic painted pottery type, overcoming the limitations of an isolated archaeological experiment.²⁵

The range of colours displayed by the painted geometric motifs – which may include thin or thick oblique lines, strips of vertical or horizontal parallel lines, and spiral, meandering or arched motifs – is very wide, presenting shades of orange, bright red, dark red-cherry and brick brown applied to a slip of yellowish-white or cream colour. Some fragments show very skilled polishing of the painted surface, both inside and outside the vessel. Other fragments illustrate the use of a raw black complementary decoration, most likely based on an organic pigment. Having been applied after firing, it is found nowadays only on a small number of fragments, mostly in the form of infused traces barely visible on the engobe background.

With regard to the Neolithic and Eneolithic eras, painted decorations serve as real indicators of the level of technical development reached by the human community in question. They may reveal information about conscious efforts related to knowledge and use of strategies to procure the materials necessary for their creation. They can also serve as vivid proof of what cultural choices, experiences, traditions and the mobility of human groups mean. These observations are even more important in the intra-Carpathian area, where painting represents the distinctive ornamentation techniques of the Lumea Nouă communities, which are still in the process of cultural definition.

Regarding the operating conditions, the present experiments fit into the category of field experiments using materials and techniques that are appropriate to the era and technology being studied. They were conducted in an environment that reflects, to the greatest extent possible, the ways in which the processes could have been carried out in the past. As part of a larger study on Neolithic painted pottery, this experimental project complements the information obtained so far from typological-stylistic and archaeometric analyses, exploring the degree of involvement and the role of the human factor in prehistoric pottery technology. Under the given conditions, it is important to note that maintaining full control over the variables remains the prerogative of the laboratory experiment. However, in this case, some aspects of interest have been carefully measured and recorded using modern equipment. This systematic documentation serves to ensure the repeatability of the results.

²⁵ According to Schiffer et al., “New perspectives,” 198.

The combined research of the sequences in the ceramics production chain, resulting in individual experiments, was intended to identify analogies in the production process,²⁶ which could then be used to interpret traces of ceramic technology present on artefacts discovered in the archaeological excavation.

Thus, the work combines aspects belonging to the first two categories of experiments according to Reynolds' classification – that of testing a structure (in our case, a 1:1 built firing installation) and the category suggestively referred to as *process and function*, which refers to the investigation of how objects and technological processes were carried out in the past.²⁷

Experimental results and discussions

The literature offers a comprehensive description of the operational chain related to the ceramic production technology of archaeological interest.²⁸ Briefly, the sequences most frequently mentioned are as follows: 1)

²⁶ According to the definition given by Mathieu, "Introduction," 1–2.

²⁷ Reynolds, "The Nature," 158–162.

²⁸ Linda Elis, "Ceramics," in *Archaeology in Practice*, Eds. Jane Balme and Alistair Paterson, 2nd edition (New Jersey: John Wiley & Sons, 2014), 207–231; Daniel A. Santacreu, *Materiality, Techniques and Society in Pottery Production. The Technological Study of Archaeological Ceramics through Paste Analysis* (Berlin: De Gruyter Open, 2014), 5–108; Jaume Garcia Rosselló and Manuèl Calvo Trias, *Making pots: el modelado de la cerámica y su potencial interpretativo* (Oxford: Archaeopress, 2013) [BAR International Series 2540]; Miller, *Archaeological Approaches to Tehnology*, 103–128; Dan Anghel, "Consecințele metodelor de prelucrare asupra stării de conservare și a măsurilor de restaurare aplicate în cazul unor vase neo-eneolitice decorate prin pictare," [The Consequences of Processing Methods on the State of Preservation and Restoration Measures Applied in the Case of Decorated Neo-eneolithic Vessels by Painting] in *Patrimonium Apulense* I (2001): 208–214; Dan Anghel, "Metode și etape în studiul tehnologiilor de confecționare a ceramicii preistorice," [Methods and Phases in the Study of Ceramics Technologies of Prehistoric Pottery Making], in *Apulum* 43 (2006): 393–401; Marius Breazu, "Aspecte privind tehnologia de confecționare și decorare a ceramicii pictate aparținând grupului cultural Lumea Nouă," [Aspects Regarding the Technology of Painted Ceramics Belonging to the Lumea Noua Cultural Group], in *Buletinul Cercurilor Științifice Studențești* 5 (1999): 43–45; Marius Breazu, "Restaurarea-conservarea unui vas ceramic pictat de tip Lumea Nouă," [Restoration/Preservation of a Lumea Noua Painted Pottery Pot], in *Buletinul Cercurilor Științifice Studențești* 6 (2000): 175–180; Clive Orton, Paul Tyers and Alan Vince, *Pottery in Archaeology* (Cambridge: Cambridge University Press, 1993), 111–131; Carla M. Sinopoli, *Approaches to Archaeological Ceramics* (New York: Plenum Press, 1991), 9–42; Prudence M. Rice, *Pottery Analysis. A Sourcebook* (Chicago: The University of Chicago Press, 1987), 113–167; Anna O. Shepard, *Ceramics for the Archaeologist* (Washington: Carnegie Institution of Washington, 1985), 49–94.

procurement of raw material; 2) clay preparation; 3) making of the ceramic pot; 4) surface decoration; 5) drying; 6) firing.

The first step towards the finished object, which in the craft of pottery always meets practical or aesthetic needs, is the appropriate choice of raw material. In this phase of the experimental project, the main aim was to locate possible sources of raw material for the manufacture of vessels from and in the immediate vicinity of the archaeological site from which the artefacts originate.²⁹ For this reason, six clay samples were analysed using a scanning electron microscopy (SEM) SU-70 spectrometer coupled with an energy dispersion spectrometer (EDS), wavelength spectrometer (WDS) and ATR-FTIR analysis. The results of the analyses indicated a high degree of correlation between the analysed ceramic fragments and two types of clay from the eponymous site.³⁰

The materials needed to create the bichrome painted decoration – slip and red colour – were procured from outside the city of Alba Iulia. Thus, the search area for resources was considerably widened. Knowing that these materials were used in much smaller quantities than the basic raw materials, and were thus even easier to carry, the maximum threshold of distance (7 km) of the resource from the archaeological production context, indicated by Arnold's diagram,³¹ was reached. A source of white clay was thus identified in the village of Șeușa and a source of reddish-brown clay in the Bărăbanț (Alba county) was identified on the bank of the Ampoi river. Additionally, for the

²⁹ Without exceeding 1 km, the most common distance for the procurement of basic raw materials, attested to by ethnographic research conducted on dozens of pottery communities in different geological areas in Latin America. For more information, see Dean E. Arnold, "Linking society with the compositional analyses of pottery: a model from comparative ethnography," in *Pottery Manufacturing Processes: Reconstruction and Interpretation* (Oxford: Archaeopress, 2005) [BAR International Series 1349], 15–21; see also Dean E. Arnold, *Ceramic theory and cultural process* (Cambridge: Cambridge University Press, 1985), 39–49, Table 2.1, Table 2.3; Dean E. Arnold, *Ecology and Ceramic Production in Andean Community* (Cambridge: Cambridge University Press, 1993), 201. A similar situation was noted for potters in the region of Moldova by Felix A. Tencariu, *Instalații de arderea ceramicii în civilizațiile pre-și protoistorice de pe teritoriul României* [Pottery Firing Installation in Pre- and Protohistorical Civilizations in Romania] (Iași: Editura Universității 'Alexandru Ioan Cuza', 2015), 147; Ruxandra Alaiba, *Complexul cultural Cucuteni-Tripolie. Meșteșugul olăritului* [The Cucuteni-Tripolie Cultural Complex. The Pottery Craft] (Iași: Junimea, 2007), 45.

³⁰ Alina Bințințan, Mihai Gligor, Ioana-Daniela Dulamă, Sofia Teodorescu, Raluca Maria Știrbescu and Cristiana Rădulescu, "ATR-FTIR and SEM-EDS Analyses of Lumea Nouă Painted Pottery from Alba Iulia-Lumea Nouă Neolithic Site," in *Revista de Chimie* 68, 4 (2017): 847–852.

³¹ Arnold, "Linking," 17, Figure 1.

yellowish-white colour slip, which is characteristic of the Lumea Nouă pottery type, yellowish-white clay lumps were used, collected from the natural soil uncovered in the archaeological campaigns at the Alba Iulia–*Lumea Nouă* site.

It should be added, however, that in order to procure raw material for decoration, ethnographic and archaeological research indicates that considerable distances were covered and these materials were most often obtained through exchange.³² As a result, in addition to those already mentioned, we note raw materials (clay with reddish hues) obtained in their natural states from the environment that are not directly related to the potential area of resource procurement within the studied context and that, according to their consistency or colour, serve as means of comparison in the study of working methods and techniques.

Preparation of raw materials – the toolkit

The preparation of raw materials as a sequence in the operational chain has remained less explored from an experimental point of view. Experimentation with mixtures of mineral or vegetable degreaser in varying proportions was not pursued in any way, and the paste obtained by mixing two or more types of clay³³ occurred only involuntarily in the workshop. The clays were chosen according to their quality, plasticity, lack of plant residues and animal or geological impurities from accessible areas where they were identified by their dense appearance and sometimes by colour.

To prepare them, the lumps were crumbled, transformed into fine powder and then mixed with water. The removal of impurities was performed by hand, through a process of grinding and repeated kneading. Density and homogenisation were achieved by repeated beating of the clay with a wooden stick. Several types of clay were randomly used to make experimental vessels, proving different degrees of plasticity.

In preparing the raw material for painted decoration before firing (the central point of this paper), we proceeded much more rigorously. The attainment of the very fine clay material was performed using levigation.³⁴ The

³² Alaiba, *Complexul*, 46; Arnold, *Ceramic*, 39–49; Rice, *Pottery*, 116, Table 5.1.

³³ This is a practice of improving the quality of clay that alters its properties and interferes with studies of provenance affecting the chemical composition; see Ellis, “Ceramics,” 211; Arnold, *Ceramic*, 15.

³⁴ Daniel A. Santacreu, *Materiality, Techniques and Society in Pottery Production. The Technological Study of Archaeological Ceramics through Paste Analysis* (Berlin: De Gruyter Open, 2014), 68; Edward B. Banning, *The Archaeologist’s Laboratory. The Analysis of*

ochre lumps were left to dry and then crushed to obtain a very fine powder, which was dissolved in water. This suspension allowed for the effective separation of the sediment content (Pl. I/a–d) by extracting the liquid with very fine pigment particles and removing impurities and coarse-grained sand.

This process must be repeated several times, leading to impressive results in addition to being efficient and relatively easy to perform. The process is completed with the achievement of the desired granulation and quantity. The resulting substance is left to decant, and the excess water can be removed to produce the optimum consistency. In liquid form, it can be stored for short periods of time in covered vessels, but when a larger quantity is prepared, it is most often kept in the form of dry matter (Pl. I/c).

At this stage in the operating chain, it is necessary to point out that all interventions of the potter on the raw material, performed in order to refine and prepare the paste for the painted layer, significantly alter the material's physico-chemical properties³⁵ and therefore its composition. This property, as well as the well-known practice of adding mineral pigments, iron oxides, manganese, carbon and calcium carbonate into the paste,³⁶ interferes with the approach of identifying the provenance of materials. This observation, however, justifies the need for a combined approach, both from archaeometric and experimental perspectives on the study of Neolithic painted pottery, which must be seen as the result of natural and cultural³⁷ variables.

Direct information on the degree of specialisation and organisation of the ceramic production activity in prehistoric communities comes primarily from archaeological discoveries. Research on archaeological contexts revealed the existence of pottery workshops³⁸ in which the spatial organisation of the

Archaeological Data (New York: Kluwer Academic Publishers, 2002), 167; Alex Gibson and Ann Woods, *Prehistoric Pottery for the Archaeologist* (Leicester: Leicester University Press, 1990); Shepard, *Ceramics*, 52; Linda Ellis, *The Cucuteni-Tripolye culture, a study in technology and the origins of complex society* (Oxford: Archaeopress, 1984) [BAR International Series 217], 114.

³⁵ Arnold, "Linking," 16.

³⁶ Rice, *Pottery*, 148–149; Alaiba, *Complexul*, 37–47.

³⁷ Arnold, "Linking," 15.

³⁸ Sándor J. Sztáncsu, *Grupul cultural Ariușd pe teritoriul Transilvaniei* [The Ariușd Cultural Grupul in Transylvania] (Cluj–Napoca: Mega, 2015), 130; Tencariu, *Instalații*, 81–82; Colesniuc, *Cultura*, 251; Alaiba, *Complexul*, 21; Gheorghe Lazarovici and Magda Lazarovici, "The Neolithic Architecture in Banat, Transylvania and Moldavia in Recent research in the Prehistory of the Balkans," in *The Prehistoric Research*, Ed. V. Grammenos (Thessaloniki: Archaeological Institute of the Northern Greece, 2003), 382–383; Lazarovici and Lazarovici, *Arhitectura*, 185–187.

specific arrangements of this process, including characteristic inventory, was preserved. These workshops provide a general – though fragmentary³⁹ – image of the space in which the production activity occurred and illustrate the size and scale of the craft within the community. On the other hand, the tools⁴⁰ associated with ceramic production in spaces with certain specialisations provide a singular yet concrete image of a technical sequence, and the traces left on the ceramic vessels can be identified, studied and tested experimentally.⁴¹

Once the importance of tools in the restoration of technical aspects of the process of making and decorating ceramics was observed, we began to pay more attention to the tools used (Pl. II) within the experimental project. For shaping, this involved wooden tools of various sizes with sharp edges and resembling elongated spatulas in shape on one or both sides. This type of tool was used for roughing by scraping the walls of the vessels as well as for smoothing. During the modelling of the vessels, freshwater clam valves were used to remove excess clay from inside the vessels. Ceramic pots of various capacities, including miniatures, were made and used to store the paste for the slip, for painting or for the process of levigation and decanting. Fine colour powders for painting were obtained by rubbing pigments on a porous stone. The painted decoration, consisting of parallel thin lines, was applied using textile threads, and the slip was applied by feather or hand. River stones were used in the polishing of the surfaces, chosen by shape and size so that the active part would meet the needs imposed by each situation.

Experimental methods of vessel manufacturing

Among the forms that characterise the painted pottery of the Lumea Nouă type, discovered at the eponymous site,⁴² we chose the experimental reconstruction of a bowl-type vessel with a hemispherical appearance (Pl. XV/a), a rounded rim, a height of 9.5 cm and a maximum diameter of 13 cm. The quantity, diversity and fragmentative state of the ceramics analysed so far

³⁹ See also Caroline D. Jeffra, *The Archaeological Study of Innovation: An Experimental Approach to the Pottery Wheel in Bronze Age Crete and Cyprus* (Exeter: Exeter University, 2011), 50–53.

⁴⁰ Alaiba, *Complexul*, 29, 33–34; Sztáncsu, *Grupul*, 205.

⁴¹ See for example Garcia Rosselló and Calvo Trias, *Making* and Monica Mărgărit, “Spatulas and abraded astragalus: Two types of tools used to process ceramics? Examples from the Romanian prehistory,” in *Quaternary International* 438 (2017): 201–211.

⁴² Gligor, *Așezarea*, 64–69, Pl. CLXVII/1b-1c.

have allowed some detailed macroscopic observations,⁴³ which, not surprisingly, indicate the use of several modelling techniques. At the same time, investigations by polarised microscopy of transmission on thin sections, on a batch of ceramic fragments of this type, coming from the Zau site, highlighted the use of at least two ways of shaping.⁴⁴

Both ethnographic analogies⁴⁵ and some experimental reconstructions⁴⁶ show that the techniques of making vessels may differ from one community to another, from one vessel to another or even in the manufacture of the same vessel. Although the most notable technique of prehistory is that of coils or *en colonbin*, which largely provides the basic shape of the vessel, other techniques such as hand modelling or concave and convex moulding should at least be considered complementary, as they define and refine its shape.⁴⁷ In the complex process of making ceramics, which is related to the properties of the raw material, due to the future functionality of the vessel and the specific working techniques of the potter, the traces of manufacturing characteristics of one or the other may fade.⁴⁸

⁴³ Based on the methodology for the archaeological and experimental study of pottery formation techniques described in detail by Rémi Martineau, “Methodology for the archaeological and experimental study of pottery forming techniques,” in *Ceramics in the Society. Proceedings of the 6th European Meeting on Ancient Ceramics*, Eds. E. Di Pierro, V. Serneels and M. Maggetti, (Fribourg, 2001), 210–214.

⁴⁴ Gheorghe Lazarovici, Corina Ionescu and Lucreția Ghergari, “Artefacte ceramice din neoliticul mijlociu în Transilvania: Cultura CCTLNI din stațiunea Zau (jud. Mureș),” [Ceramic Artifacts from the Middle Neolithic in Transylvania: The CCTLNI Zau Culture Site (Mureș County), in *Angustia* 7 (2002): 10.

⁴⁵ Rice, *Pottery*, 125–128; Orton et al., *Pottery*, 117–120.

⁴⁶ Guillermo A. De La Fuente, “Chaîne opératoire, technical gestures and pottery production at Southern Andes during the Late Period (c. AD 900–AD 1450; Catamarca, Northwestern Argentina, Argentina),” in *Archaeological Ceramics: A Review of Current Research*, Ed. Simona Scarcella (Oxford: Archaeopress, 2011) [BAR International Series 2193], 89–102, 98, Fig 14; Aikaterini Glykou, “Pointed-based pottery: An experimental approach to the manufacturing of the pottery of the Late Mesolithic in Northern Germany,” in *The Old Potter’s Almanack* 17, 1 (2012): 11.

⁴⁷ Orton et al., *Pottery*, 117; Jasna Vuković, “Archaeological Evidence of Pottery Forming Sequence: Traces of Manufacture in Late Neolithic Vinča Assemblage,” in *Archaeotechnology: studying technology from prehistory to the Middle Ages*, Eds. Selena Vitezović and Dragana Antonović (Belgrad, 2014), 177–198, 179–180; Edward Banning, *The Archaeologist’s Laboratory. The Analysis of Archaeological Data*, (New York: Kluwer Academic Publishers, 2002), 168–173.

⁴⁸ According to Yuri Tsetlin, “Experimental Research into Pottery Making,” in *The Old Potter’s Almanack* 15/1 (2010): 8, Fig. 4.

However, the characteristic traces of one method do not necessarily exclude the use of the other.⁴⁹

As a result, in this experiment, two of the main manufacturing techniques attributed to the Neolithic era were individually applied: the shaping by hand⁵⁰ of the entire vessel, and the technique of ‘successive coils’⁵¹ and pressing into shape.⁵² The simplest and likely the oldest manufacturing technique is hand modelling. However, since this technique is primarily suitable for the making of small vessels and generally open shapes, it could not have been used for the entire process of constructing the type of vessel we envisaged.

The technique of scrolls means that the vessel walls were constructed from clay scrolls added successively by pressing (Pl. III/b). The diameter of the pot and its thickness were controlled by the length and thickness of the coils. Smoothing of the surface by hand or with a wooden tool, both on the inner and outer surface of the vessel wall, was performed from the bottom up as the height of the vessel increased. For refinement, the wall of the vessel was roughened and made uniform by scraping. The vessel was given shape by beating with a wide and smooth wooden tool. The rim of the vessel was evened by scraping with a sharp-edged tool, then smoothed with water. Thus, several vessels were built following the typology of the chosen model. The approximate dimensions were obtained by calculating the contraction of the clay after the evaporation of the added water. Experimental work has shown that this technique requires precision, experience and plenty of time.

The technique of pressing into support-forms (moulds), previously performed in another study on prehistoric ceramics (Pl. III/a), involves the production of vessels with refined and complex typologies by pressing in forms

⁴⁹ See, for example, Ina Berg, “What’s in a forming technique? An investigation into wheel-throwing and wheel-coiling in Bronze Age Crete,” in *The Old Potter’s Almanack* 16/2 (2011): 9–12.

⁵⁰ Paula Mazăre, “Tehnici de fasonare a vaselor ceramice,” [Pottery Making Techniques], in *Ceramica neolitică – o lecție de istorie* (Alba Iulia: Aeternitas, 2007), 115, Fig. 1; Tencariu, *Instalații*, 52, Fig. 18; Susan Peterson and Jan Peterson, *The Craft and Art of Clay* (London: Pearson, 2003), 32.

⁵¹ Anna O. Shepard, *Ceramics for the Archaeologist* (Washington: Carnegie Institution of Washington, 1956), 57–59; Rice, *Pottery*, 127–128; Tencariu, *Instalații*, 53, Fig. 20.

⁵² Shepard, *Ceramics*, 63–65; Rice, *Pottery*, 126; Orton et al., *Pottery*, 118–120; Tencariu, *Instalații*, 53, Fig. 21.

of unburnt clay.⁵³ Beginning from the previous observations, regarding the painted pottery type, a single piece was initially created by taking into account the characteristics of the artefact chosen as a model. Then, a concave shape was made, in which it was replicated as many times as needed. The pressed vessels were easy to build, with thin walls and controlled thickness. However, the small size and simplicity of the shape of the vessel in this case only partially justify the use of such an elaborate technique.

Based on previous experiments, and considering that the choice of the technical method applied in the production process remains a prerogative of the potter, we attempted to increase the yield (improving the ratio between production time and effort made) by combining the techniques described above. Considered suitable for the construction of the lower part of the vessel, the hand modelling technique was combined with that of successive coils for the upper part of the vessel. Throughout the manufacturing process, it was necessary to use a non-stick support (textile or vegetable) to allow left-right handling and easy rotation of the vessel.⁵⁴

Consequently, we concluded, regarding the method of making the bowl-type vessel, that it was a type of vessel in which the methods of production were combined as so: modelling by hand of the lower part, possibly until the maximum diameter was achieved, after which the shape was closed by successively adding clay coils, not necessarily cylindrical in shape, or by beating flattened scrolls (*slabs*)⁵⁵ on a relatively straight surface. The bonding of the scrolls was performed by pressing, after which the contact surface was smoothed by scraping both inside and outside. Finally, the shape was perfected by being beaten with a wide wooden tool (pallet).

In this way, the vessel displays on its walls the traces of several manufacturing techniques: modelling (which gives the bottom of the vessel a

⁵³ Alina Bințințan, "Confecționarea experimentală a ceramicii preistorice: tehnica presării în forme de lut," [Manufacturing Experimental Prehistoric Pottery: Pre-shaped Clay Molds Pressing Technique], in *Analele Banatului*. S. N. Arheologie-Istorie XXIII (2015): 89–94.

⁵⁴ The use of such supports during lifting or (most likely) during drying is attested to throughout the Neolithic and Eneolithic by the presence of textile or vegetal impressions on the bottoms of ceramic vessels. See Vuković, "Archaeological," 158, Fig. 6; Susanna Harris, "Cloth culture in the Middle Neolithic Square-mouthed Pottery culture of Northern Italy (c. 4900–4250BC) with special reference to basketry," in *Accordia Research Papers* 13 (2013): 111–120, Fig. 5–18, 20; Alaiba, *Complexul*, 54.

⁵⁵ See Rice, *Pottery*, 125; Orton et al., *Pottery*, 118; Tencariu, *Instalații*, 52, Fig. 19.

coarse appearance and requires retouching being sometimes pushed inside),⁵⁶ pressing (unevenly, by hand, to stick the coils or push the paste outwards when making ornamental buttons, and on a flat surface), beating (secondary technique of centring and refining the shape) and coiling.

For certain fine pottery fragments discovered in the excavation, it is reasonable to suppose the use of even more elaborate shaping methods. The combined use of manufacturing techniques must be considered an indicator of technological development in the studied communities.

Drying of experimental vessels

The importance and duration of the stage in which the ceramic vessels are dried before firing have been revealed by the experiments carried out so far.⁵⁷ Drying is the slow evaporation of added water from the paste, which gradually reduces the plasticity of the material as well as the volume and the weight of the vessel, giving it resistance. The duration of the operation, from a few days to a few weeks,⁵⁸ must account for the thickness of the walls created, the material and the ambient temperature. The methods of carrying out the drying, which have been archaeologically supported⁵⁹ and for which there are good ethnographic analogies, are varied: in ovens, in rooms, on special supports or outdoors, in the shade and at a constant temperature. The end of the first stage of drying, known as the ‘critical point’ or *leather-hard stage*,⁶⁰ occurs

⁵⁶ Gligor, *Așezarea*, 65, Pl. CLXVII 1c; Mihai Gligor, “Grupul cultural Lumea Nouă,” [The Lumea Noua Cultural Group], in *Ceramica neolitică – o lecție de istorie* (Alba Iulia: Aeternitas, 2007), 46, Fig. 27.

⁵⁷ Alina Bințișan, “Arheologie experimentală. Arderea controlată în aer liber – o posibilă modalitate de obținere a efectului cromatic black-topped,” [Experimental Archaeology - Controlled Open Air Firing - A Possible Method of Black-Topped Pottery Production], in *Buletinul Cercurilor Științifice Studențești* 19 (2013); Alina Bințișan, “Arheologie experimentală. Arderea în instalația verticală – o altă posibilă modalitate de obținere a efectului cromatic black-topped,” [Experimental Archaeology. The Firing in the Vertical Installation – Another Possible Method of Black-Topped Pottery Production], in *Buletinul Cercurilor Științifice Studențești* 20 (2014); Alina Bințișan, “Confecționarea experimentală a ceramicii preistorice: tehnica presării în forme de lut,” [Creating Experimental Prehistoric Pottery: Pre-shaped Clay Molds Pressing Technique], in *Analele Banatului*. S. N. Arheologie-Istorie XXIII (2015); Tencariu, *Instalații*, 172; Felix A. Tencariu and Ioana Robu, “Experimente privind arderea neolitică,” in *Carpica* XXXIII (2004): 56.

⁵⁸ Rice, *Pottery*, 152.

⁵⁹ Alaiba, *Complexul*, 54.

⁶⁰ Santacreu, *Materiality*, 81.

when the paste becomes rigid and stable in terms of contraction. After reaching this state, it is possible to treat the surface in varied ways.

As far as the present research is concerned, on ceramics painted before firing, the essential aspect of the drying stage is the identification of the right time for the application of the slip (support of the painted layer). Finally, the experimental vessels were left to dry for three to four days until reaching the critical point at which their dimensions ceased to change (Pl. IV/a). After ornamentation, a second drying took place, which prepared the vessels for the firing.⁶¹

Experimental ornamentation of painted ceramics

Only one type of painted decoration technique was meant to be studied – namely, the one applied before firing, with red and chestnut brown parallel stripes on a yellowish-white engobe background forming arches and a parallel band to the rim. It is worth mentioning that the artefact also has a complementary decoration with black pigment⁶² that was applied after firing but that we have not yet studied in experimental practice.

In this type of decoration, the first layer to be applied after drying is the slip, which gives the vessel proper hardness (Pl. IV/b). In short, the term is defined by a fluid suspension of clay in water that coats the body of the vessel before firing. The fine layer of clay can generally have several colours, qualities and thicknesses, depending on the mineral composition, the size of the particles and their degree of dispersion in the suspension.⁶³ Sometimes called engobe,⁶⁴

⁶¹ See also Marie-Agnès Courty and Valentine Roux, “Identification of wheel throwing on the basis of ceramic surface features and microfibrils,” in *Journal of Archaeological Science* 22 (1995): 24; García Rosselló and Calvo Trias, *Making*, 35–36.

⁶² Gligor, *Așezarea*, 66, Pl. CLXV/1, 3–4, Pl. CLXVII/1a–1b, Pl. CLXVIII/8, Pl. CLXIX/1–2, Pl. CLXX/3, 5–6, Pl. CLXXIII/8–10, Pl. CLXXV/11, Pl. CLXXVI/7, Pl. CLXLI/1–1a. Analysis by gas chromatography coupled with mass spectrometry (GC-MS) allowed for the exact identification of the composition of the black painted layer, which is organic in nature, present on the Neolithic ceramic fragments discovered at the site of Porț-Corău. The black pigment has been shown to be predominantly birch bark tar mixed with natural bitumen according to Polixenia Georgeta Popescu, “Aplicații ale metodelor spectrale de analiză în caracterizarea ceramicii arheologice pictate cu negru,” [Applications of Spectral Methods of Analysis in the Characterization of Archeological Painted Pottery with Black Pigment], in *Sargetia. Acta Musei Devensis V/XLI* (2014): 433–446 and Polixenia Georgeta Popescu, Cristian Enache-Preoteasa, Florin Dinu Badea, Emanoil Pripon and Maria Maganu, “GC-MS Spectroscopy as Valuable Tool for the Study of Archaeological Ceramics,” in *Revista de Chimie* 63, 5 (2012): 470–474.

⁶³ Rice, *Pottery*, 150; Shepard, *Ceramics*, 68.

the slip aims to provide a colourful, smooth and clean surface for the painted decoration. The application of the painted support can be performed in many ways: immersion, casting, wiping,⁶⁵ brushing and/or dripping.⁶⁶ This substance adheres to the body of the vessel by polishing it with stone, and it is fixed via firing.⁶⁷ As we have already shown, the slip as a substance was obtained through levigation and decanting the yellowish-white clays previously converted into powder. The proper consistency of the suspension was established gradually and only during its application.

In the first stage, the application of the engobe was experimented with on three vessels made using the same technique but in three different stages of the drying process:

1. raw (the day after manufacture);
2. semi-dry (third or fourth day after manufacture);
3. completely dried (seventh day after manufacture);

Brushing with a feather was used in the application of the decoration, and the vessel was placed on a stable stand. The body of the vessel and the rim (Pl. IV/b) were first covered, and after the water was drained, the bottom of the vessel was also worked, supported with a hand from the inside. Observations were made regarding the coverage power of the slip, the uniform distribution of the substance on the treated surface and possible retouching. The tendency of the suspension to permanently settle on the bottom of the container in which it is stored requires the mixing of the substance upon each application for a uniform dispersion of the particles in the water.

The experimentative process covered the superficial imperfections and gave the pots' surfaces the desired uniformity, though only for those in the first two stages of drying. Dry application was difficult due to the immediate absorption of water into the dry wall of the vessel, which caused uneven volume increases and cracks in the upper part towards the rim. The procedure therefore excludes the application of the slip on a completely dry vessel. The other two vessels were polished with stone immediately after the application of the slip, which increased their adhesion and gave their surfaces a compact, uniform and glossy appearance.

⁶⁴ See, for example Alaiba, *Complexul*, 63. However, while the slip prepares the surface of the vessel for painting, the engobe appears to have only the purpose of changing the colour of the surface; see also Rice, *Pottery*, 149.

⁶⁵ *Ibid.*, 151–152; Miller, *Archaeological*, 120.

⁶⁶ Banning, *The Archaeologist's*, 175.

⁶⁷ Breazu, "Aspecte," 43.

After the complete polishing of the vessels, the application of the parallel line strips that comprise the central element of the painted decoration began. The colour used in the pre-firing painting of archaeological pottery is generally described as a mixture of fine clay in suspension with an added inorganic pigment, which is resistant to heat during firing.⁶⁸

In the present work, the colour for the painting was obtained using a method of levigating the ochers⁶⁹ (naturally coloured soils) into two shades of red of different intensities without additional pigment (iron oxide). Based on modern analytical methods, various studies have addressed issues related to the treatment of ceramic surfaces, especially the link between the colour of ochres and their chemical composition.⁷⁰ Additionally, the literature demonstrates the degree of complexity of techniques and mixtures in the decoration of Neolithic⁷¹ and Eneolithic⁷² painted pottery.

The red paste was applied on the polished and still-wet slip with a textile thread (hemp), the length and thickness of which were adjusted so that the mark left by it was as similar as possible to that of the original decoration (Pl. IV/c–d). Each thin line was drawn individually (Pl.VI) until the characteristic stripe was obtained around the rim. Then, the even distribution of the painted decoration was marked using vertical bands, and finally, the four arches were added. The polishing with the stone was performed gradually on

⁶⁸ Rice, *Pottery*, 148–149; Banning, *The Archaeologist's*, 175; Alaiba, *Complexul*, 62–63.

⁶⁹ For definitions, examples and explanations, see M. Elias, C. Chartier, G. Prévot, H. Garay and C. Vignaud, “The colours of ochres explained by their composition,” in *Materials Science and Engineering B* 127 (2006): 70.

⁷⁰ See, for example Elias et al., “The colours”.

⁷¹ See Lucia Angeli, Claudio Arias, Gabriele Cristoforetti, Cristina Fabbri, Stefano Legnaioli, Vincenzo Palleschi, Giovanna Radi, Azenio Salvetti and Elisabetta Tognoni, “Spectroscopic techniques applied to the study of Italian Neolithic potteries”, in *Laser Chemistry* 61607 (2006): 1–7; Zsuzsanna Tóth, Mihály Judith, Tóth Attila Lajos and Ilon Gábor, “Vibrational spectroscopic and scanning electron microscopic study of pigment raw materials and painted ceramics excavated at Szombathely-Oladi Plató, Hungary,” in *Archeometriai Műhely X*, 2 (2013): 103–110.

⁷² See Roxana Bugoi, Bogdan Constantinescu, Emmanuel Pantos and Dragomir Popovici, “Investigation of Neolithic ceramic pigments using synchrotron radiation X-ray diffraction,” in *Powder Diffraction* 23, 3 (2008): 195–199; Dumitru Boghian, Ion Sandu, Viorica Vasilache and Sergiu-Constantin Enea, “Studiul unor probe de pigmenți minerali din situl cucutenian de la Buznea (com. Ion Neculce, jud. Iași),” [Study of Mineral Pigments from the Cucutenian Site of Buznea (Ion Neculce, Iași County)], in *Orbis Praehistoriae. Mircea Petrescu-Dîmbovița – in memoriam*, Eds. Victor Spinei, Nicolae Ursulescu, and Vasile Cotiugă (Iași: ‘Editura Universității Alexandru Ioan Cuza’, 2015), 435–450.

freshly painted and still-wet sections, using orderly movements (not back and forth) and following a certain direction of particle orientation, providing a gloss that serves the intended purpose.

Finally, the vessels were left to dry for ten days under identical conditions. During the drying process, the painted layer on the raw vessel wall detached 50% at the bottom of the pot. Therefore, the raw vessel, painted the day after manufacturing, continued to decrease in volume during the drying process due to the evaporation of water, and the disparate contraction coefficients of the two surfaces caused the appearance of flaking (Pl. IV/e).

The last stage of the decoration experiment involved the firing of the only vessel that, after drying, retained an intact painted layer. During firing, exposure to heat may cause irreparable damage due to the different dilation coefficients of the materials. Exposed to a temperature of about 700°C, the vessel presented a uniform and crack-free surface, validating the applicability of the techniques described. Subsequently, several vessels were made and decorated using these techniques, proving control over the proposed method and the repeatability of the results.

Experimental firing of painted pottery

From a firing technology perspective, based on published archaeological discoveries and analytical studies, we know a few features that can be used as reference when constructing a working hypothesis on the firing of Lumea Nouă artefacts. Difractometric analyses on ceramic fragments from the Alba Iulia–Lumea Nouă⁷³ and Zau⁷⁴ sites indicate a very wide range of temperatures reached (600–900°C). As firing installations discovered in the excavation are

⁷³Aurica Goleanu, Ana Marian, Mihai Gligor, Cristian Florescu and Simona Varvara, “Chemical and structural features of the Neolithic ceramics from Vinča, Lumea Nouă and Petrești cultures (Romania),” in *Revue Roumaine de Chimie* 50, 11–12 (2005): 939–949. 944, Table 4; Simona Varvara, Bruno Fabbri, Sabrina Gualtieri, Paola Ricciardi and Mihai Gligor, “Archaeometric Characterisation of the neolithic pottery discovered at Alba Iulia-Lumea Nouă archaeological site (Romania),” in *Studia Universitatis Babeş-Bolyai. Chemia* LIII, 1 (2008): 10, Table 2; Bruno Fabbri, Mihai Gligor, Sabrina Gualtieri and Simona Varvara, “Archaeometric comparison between the Neolithic pottery of different cultures at the archaeological site of Alba Iulia (Transylvania, Romania),” in *Studia Universitatis Babeş-Bolyai. Geologia* 54, 1 (2009): 25.

⁷⁴Lazarovici et al., “Artefacte,” 9; Corina Ionescu and Lucreția Ghergari, “Modeling and firing technology – reflected in the textural features and the mineralogy of the ceramics from Neolithic sites in Transylvania (Romania),” in *Geologica Carpathica* 53 (2002): Table 1.

currently lacking, aspects related to pyrotechnology are a suitable object of experimental study using a hypothetical-deductive process.⁷⁵

In this vein, the fact that the macroscopic examination of the analysed painted ceramic fragments highlights the ‘sandwich-like’ structure serves as a starting point for study. In addition to being the result of incomplete firing of organic clay compounds or exposure to low temperatures,⁷⁶ this may also be the result of an initial technique of reducing firing temperature, followed by a brief oxidative firing.⁷⁷ However, taking into account the attainment of temperatures, which, according to diffractometric analyses, may reach up to 900°C, this trace of incomplete firing can also be seen as a result of a short but intense combustion that causes partial oxidation of the ceramic wall from the outside in.⁷⁸

A lack of archaeological information can generate many working hypotheses in order to answer the question, ‘how elaborate must a firing installation be to obtain such a refined artefact?’. However, this project aims to answer an even more challenging question: what is the simplest firing installation known to date for the Middle Neolithic that can support and fulfil the technical conditions imposed by such an artefact?

Archaeological evidence of the use of simple and efficient firing installations in the Early and Middle Neolithic periods, do exists in the Starčevo-Criș (Pl. VII-VIII) and Vinča-Dudești⁷⁹ cultural areas. In the most recent typology of ceramic firing installations in Romania, Adrian F. Tencariu mentions that in the broader context of the discoveries of the Starčevo-Criș area, including Hungary and Croatia, potters displayed a predilection towards

⁷⁵ Alan K. Outram, “Introduction to Experimental Archaeology,” in *World Archaeology* 40, 1 (2008): 1-6.

⁷⁶ Joeri Kaal, Oscar Lantes-Suárez, A. Martínez Cortizas, B. Prieto and M. Pilar Prieto-Martínez, “How Useful is Pyrolysis-GC/MS for the Assessment of Molecular Properties of Organic Matter in Archaeological Pottery Matrix? An Exploratory Case Study from North-West Spain,” in *Archaeometry* 56 (2014): 187–207; Schenck, *Accessing*, 201.

⁷⁷ See, for example Somayeh Noghani, Mohammadamin Emami, “Mineralogical phase transition on sandwich-like structure of Clinky pottery from Parthian Period, Iran,” in *Periodico di Mineralogia* 83/2 (2014): 171–185.

⁷⁸ Horst Klusch, “Considerații critice pe marginea respectării tehnologiei tradiționale în producerea ceramicii populare,” [Critical Considerations Regarding Traditional Technology in Pottery Production], in *Studii și cercetări de istorie a civilizației populare din România* 1 (1981): 256; Anghel, “Consecințele,” 207.

⁷⁹ Marin Nica, “Cuptoare de olărie din epoca neolitică descoperite în Oltenia,” [The Neolithic Pottery Kilns Discovered in Oltenia], in *Drobeta* 2 (1978): 18, 20–21, 22–24.

the single-chamber kiln type with a fuel supply tunnel and access pit.⁸⁰ The author considers that this type of kiln, of which two variants (surface and buried) are known, could be a suitable technological solution for obtaining painted pottery, which is why it has been documented in other cultural areas with painted ceramics.

The buried kiln with fuel supply tunnel and access pit is an installation that, judging by its structure, allows for the separation of fuel from the load of vessels while remaining monocameral. As the Cârcea findings demonstrate, the shape of the chambers is not strictly set and may be conic, ovoid or cylindrical. The dimensions of the component parts also vary for each feature.

The installation model described above was chosen and experimentally tested in the firing of painted pottery due to its advantages: insulation from the outside environment, lack of need for reconstructive interventions, control over temperature and firing atmosphere (reducing and oxidising), provision of separation of the fuel from vessels (Pl. IX) and ease of construction without requiring special skills or the handling of large quantities of clay.

First, the access pit was dug with a width of 1.60 m (Pl. X/a) and a depth of 1.10 m. Then, the effective digging of the kiln was carried out in two directions, one from the entrance of the firing tunnel and the other from the small diameter of the firing chamber towards the base (Pl. X/bc). A buried single-chamber firing installation (Pl. XI) was obtained with the following characteristics and dimensions: fire tunnel (0.70 m/0.60 m/0.35 m), firing chamber for the vessels of circular shape and cone trunk profile (small diameter=0.35 cm; large diameter=0.70 cm) and access pit (width 1.60 m and depth 1.10 m). In addition to the components of the kiln, a box of 0.60/0.40 m was dug, which stretched to the lower level of the firing chamber of the vessels, where one of the probes (T1) was installed to record the temperature (Pl. X/e). The second probe (T2) was placed in the fire tunnel. Both were coupled with a Voltcraft K204 digital pyrometer, with which the temperature was constantly measured and recorded. After digging, the kiln was burned empty for about three hours to strengthen and evaporate water from the interior walls.

Within the experimental project, two main firings were performed, which were intended to illustrate the results of the painted ceramic fragments'

⁸⁰ Felix A. Tencariu, "Some thoughts concerning the pottery pyrotechnology in Neolithic and Chalcolithic," in *Signa praehistorica: studia in honorem magistri Attila László septuagesimo anno*, Eds. Neculai Bolohan, Florica Măţău, and Felix Adrian Tencariu (Iaşi: 'Editura Universităţii Alexandru Ioan Cuza', 2010): 126; Tencariu, *Instalaţii*, 85–89.

short-term exposure to high temperatures. The main objective was to achieve the oxidising atmosphere imposed by the painted surface at an average temperature (in the range of 700–800°C) using a variant of the single-chamber firing installation. In addition to the general objectives, another aim of this project was to obtain the sandwich structure seen as a result of the heating rate and exposure times to the maximum temperature.

As a result, the default firing time was approximately 90 minutes. In this type of kiln, the placement of the vessels in the hearth was conducted through the upper opening of the firing chamber (Pl. XIII). Together with the painted samples, it was also necessary to use undecorated vessels, which formed a charge similar to a real one and appropriate to the dimensions of the combustion chamber, playing an important role in the creation of an efficient draught in the enclosure. The positioning of painted vessels in the fire has been highlighted as a key aspect in achieving positive results.

The firing began in the fuel tunnel, using straw or dry branches, and had the effect of gradually heating the load of vessels (Pl. XIV/a). The basic fuel generally consisted of dry wood of various essences (primarily oak) with different thicknesses and lengths. As in previous experiments, it has been observed that there is a time frame in which rapidly oscillating temperatures can cause irreparable damage to the vessels due to the forced release of water as vapour. As a result, surface dislocations, superficial or deep cracks and even partial or total breakage of the pots can occur. Within the single-chamber installation, the vessels most exposed in the specified range are those in front of the fire tunnel, where the contact with the suddenly rising heat is direct. Such a situation occurred in the 25th minute of one of the firings, when the increase in temperature from 257°C to 341°C in just five minutes caused the explosion of the bottom of a vessel whose humidity was still high due to its thickness.

The two firing sessions within the single-chamber type of kiln buried in the ground showed that after about 35 to 40 minutes and under temperatures exceeding the threshold of 350°C, the water is removed and the temperature can be safely raised using a more consistent fuel supply. After the moment of firing, between 350° and 400°C, the blackening of the vessels occurred in both cases. Essentially, around a temperature of 500°C, the firing reaches a new phase, that of irreversible physico-chemical transformation of clay into ceramics. Increases in temperature after this threshold are more difficult, although the supply of fuel was frequent and consistent. As the graph shows, after each supply of the fire tunnel, in the first phase, there was a decrease in the temperature in the chamber of vessels, followed by a sometimes

considerable increase. The maximum temperatures reached during firing were 800°C for the first session and 724°C for the second.

The exposure time of the vessels at the maximum temperature was minimal, because the supply was ceased immediately after reaching the desired temperature. At the end, the air shaft was covered in order to slow down the cooling process, which proved to be quite pronounced. Initially, only one measuring probe, located in the chamber of vessels, was used, and the temperature was recorded every five minutes. This working method was not effective due to temperature fluctuations occurring in even shorter time intervals, and as a result, it was gradually adjusted according to the situation. In the second firing session, the recordings were made from minute to minute, and another probe was added to the fuel tunnel.

The results, measurements and observations were processed in a graph (Pl. XVI) based on which, at present, we can manage operational sequences within the firing technique. It was possible to identify the moment during the firing at which the ceramic was subjected to the most intense thermal stress, which, as it is known, causes irreparable damage. We also know the reaction time of the kiln to the fuel supply and the existence of moments in which the temperature equalises inside the firing installation. Perhaps most notably, the measurements and their comparative interpretations make it possible to explore the effects of the heating rate and exposure times to temperature, which are much more important aspects of the firing technique than the final temperature itself.⁸¹

The experimental firings were completed after obtaining six well-fired and perfectly functional ceramic bowls (Pl. XV). The painted layers of the vessels have a glossy appearance and remained intact after firing, though each of the vessels displays variations in colour in terms of both slip and red painting. It is important to note that such reducing side effects, which turn the red pigment (hematite) into shades of brown (magnetite), can also be observed on the original artefact.⁸²

As a result, in terms of temperature, experiments with the type of single-chamber kiln buried in the ground proved the efficiency of the

⁸¹ Alan Livingstone-Smith, "Bonfire II: The Return of Pottery Firing Temperatures," in *Journal of Archaeological Science* 28 (2001): 998–999; Yannis Maniatis, "The Emergence of ceramic technology and its evolution as revealed with the use of scientific techniques," in *From Mine to Microscope: Advances in the Study of Ancient Technology*, Eds. Andrew J. Shortland, Ian C. Freestone and Thilo Rehren (Oxford: Oxbow Books, 2009), 4.

⁸² See also Anghel, "Consecințele," 210.

installation in reaching high temperatures. In section, the internal structure of the experimental ceramic fragments is similar to that of the original fragments (Pl. XVII/a), showing that it may be the result of intense short-term firing, which produces partial oxidation of the wall from the outside in. From the methodological point of view, this approach provides a concrete database for the attainment of controllable and repeatable results, transforming them into valid research assumptions about this technological phenomenon.

On the other hand, the surfaces of the vessels indicate that total control over the firing atmosphere is closely related to the positioning of the pots in the firing chamber. This issue is a defining one in the process of obtaining painted pottery, and it has been proved to be difficult to manage, even in the case of experimental reconstructions that use more advanced types, such as bicameral firing installations.⁸³

Conclusions

The combined use of experimental manufacturing techniques justifies the observations made during research on dozens of archaeological ceramic materials and highlights the variety of techniques used by potters in prehistoric communities. Methods of obtaining the engobe for painting without any difficulty through the repeated washing and decanting of natural ochers provide a valid hypothesis on the local strategy for the procurement of raw materials as well as an explanation regarding the variety of red, brown and chestnut shades.

It should also be noted that our method does not exclude the possibility of enrichment of the painting paste with various mineral pigments (suggested by the intensity of the colours present on some fragments). However, this has not yet been attested to by archaeological discoveries in the research area, as in the case of Cucuteni pottery.

The most complex sequence of the operational chain of Neolithic pottery production is the painted decoration before firing. Identifying when or how to apply and fix it to vessels requires thorough skills and knowledge of the needed materials. As a result, the painted decoration has revealed itself to be a

⁸³ See Ovidiu Cotoi, "The Cucutenian painted pottery. An archaeological experiment at Cucuteni (Iași County, Romania)," in *Interdisciplinary Research in Archaeology. Proceedings of the First Arheoinvest Congress*, Eds. Vasile Cotiugă and Ștefan Caliniuc (Oxford: Archaeopress, 2012) [Bar International Series 2433], 155.

conclusive mark of the technical and artistic level achieved by this prehistoric human community.

The technological information acquired so far can easily be extended to several types of painted pottery from Transylvania at the level of the Neolithic and Eneolithic period. Coupled with the results of archaeometric analyses carried out on ceramic pastes and pigments analysed in close connection with the originating archaeological context, experiments of this type can help to identify and decipher technological traditions that have manifested themselves locally or regionally in certain historical periods.

In terms of firing, experiments have shown that it is possible to obtain painted pottery using a single-chamber firing installation. This structure has the capacity, size, components and operating principles suitable for obtaining painted pottery. This indicates the possible use of simple but efficient kilns and suggests the necessity of reconsidering the idea that high-quality ceramics can only be obtained from elaborate, bicameral-type firing installations.

A remarkable aspect related to the technology studied, which provides even more clues about the precise way the firing is carried out – in the case of Lumea Nouă type pottery – was the internal structure of the numerous fragments that, in section, show traces of incomplete firing. The attainment of vessels with the appearance and sandwich-like internal structure specific to the original artefacts validates the experimental firing techniques presented in detail in this paper.

As we have already shown, a variable of the given firing procedure is the firing atmosphere. So far, observations have been made regarding the influence of the load size on the draught in the combustion chamber as well as the influence of the vessels' positioning in the fire on the final appearance of the surface. These future lines of research could answer an important question related to firing techniques. Diagrams that record the arrangement of the vessels could determine more precisely whether the firing of painted pottery was performed separately from the usual one or whether the painted type occupied only certain positions within the mixed load. Therefore, these firings could be improved with experimental sessions focused on increased control and uniform distribution of the oxidising atmosphere within the kiln.

It should be noted that the identified variables are very likely a result of the experiences of the potter and are undoubtedly the result of the accumulation of a specific set of knowledge and practices over time that we call tradition.



Plate I. Preparation of raw materials. Levigation and decanting. [a-b] – Obtaining the red engobe for painting; [d-e] — Obtaining the yellowish-white engobe background (the slip); [c] – Keeping the engobe in the form of dry matter.

Lumea Nouă painted pottery



Plate II. The toolkit.



Plate III. Experimental methods of vessel manufacturing.

[a] –The pressing technique; [b] – The technique of ‘ successive coils.

Lumea Nouă painted pottery



Plate IV. Experimental ornamentation of Lumea Nouă painted ceramics. [a-b] – The application of the slip after reaching the ‘critical point’ or leather-hard stage; [c-d] – Painted decoration with red parallel stripes applied with a textile thread; [e] – The appearance of flaking during drying process.

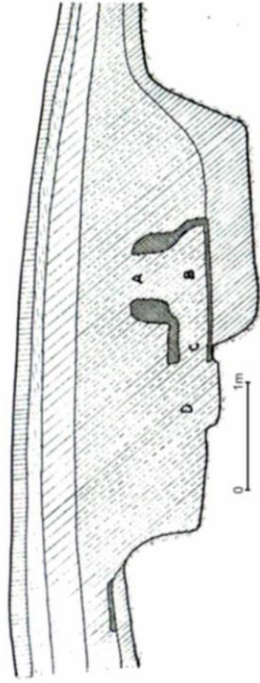


Plate V. Experimental pots painted before firing.

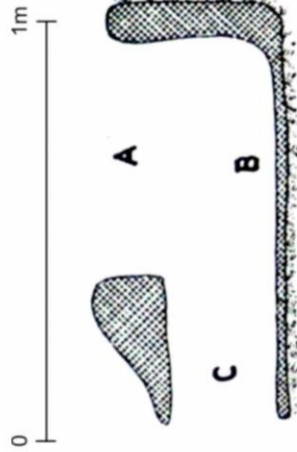
Lumea Nouă painted pottery



Plate VI. Stages of painted decoration process before firing.



a.



b.

Plate VII. Single-chamber kiln type buried in the ground; [a] Cârcea- *Viaduct*, Starcevo-Criș IV; [b] Cârcea- *Viaduct*, Starcevo-Criș IV (Marin Nica, " Cuptoare de olărie," 20-21).

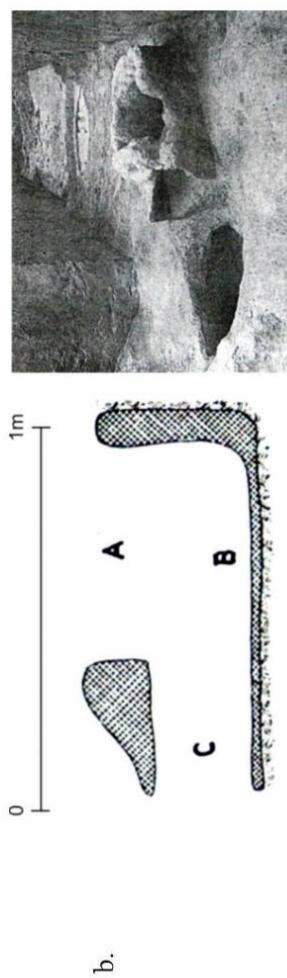
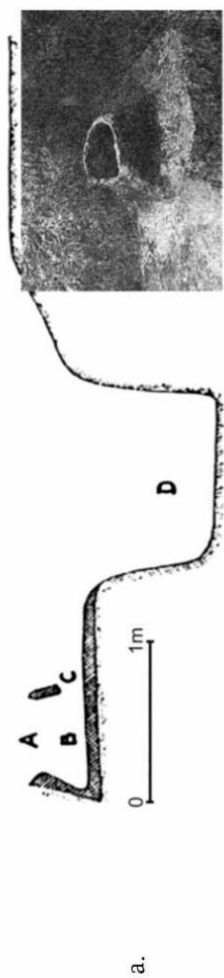


Plate VIII. Single-chamber kiln type buried in the ground; [a] Cârcea- *Viaduct*, Starčevo-Criș IV; [b]–Cârcea- *Viaduct*, Dudești-Vinča (Marin Nica, “ Cuptoare de olărie,” 22-24).

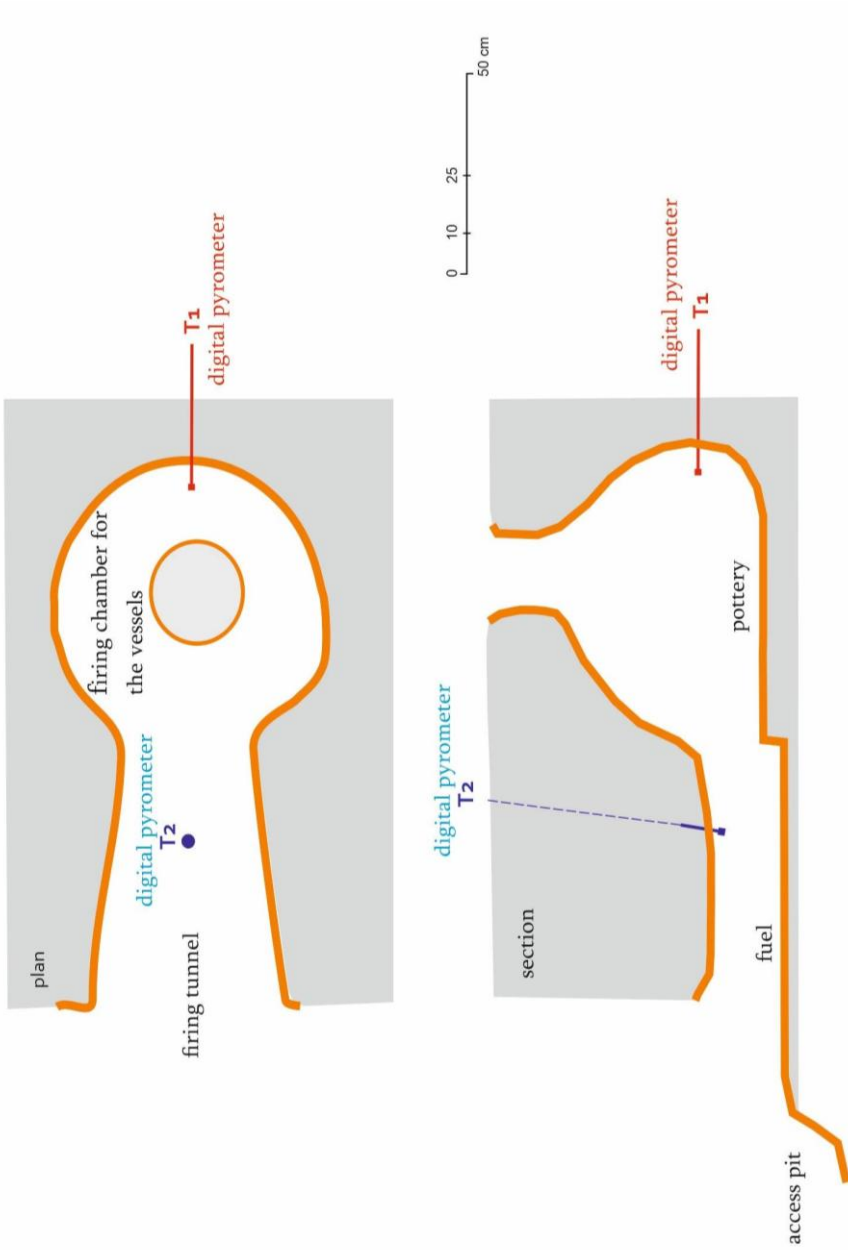


Plate IX. Schematic representation of the experimental kiln.



Plate X. Building the single-chamber kiln.

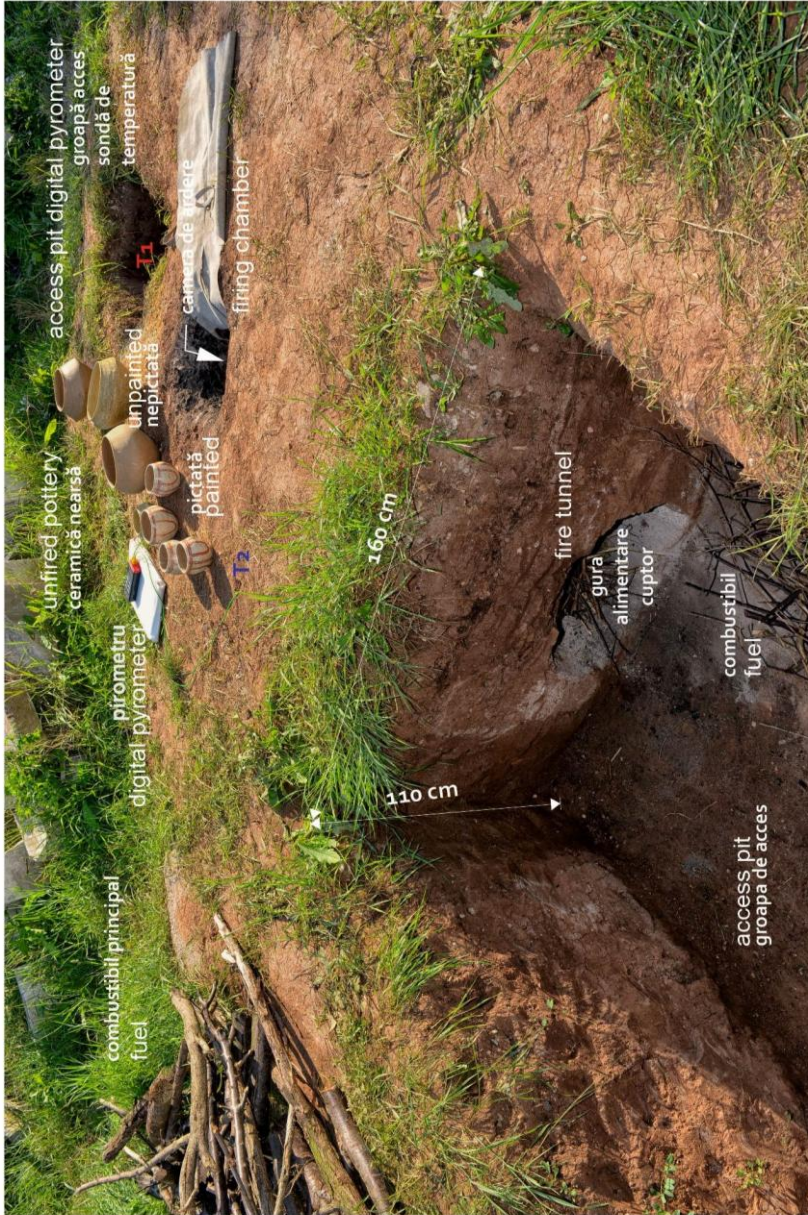


Plate XI. The experimental kiln before the firing.

Lumea Nouă painted pottery

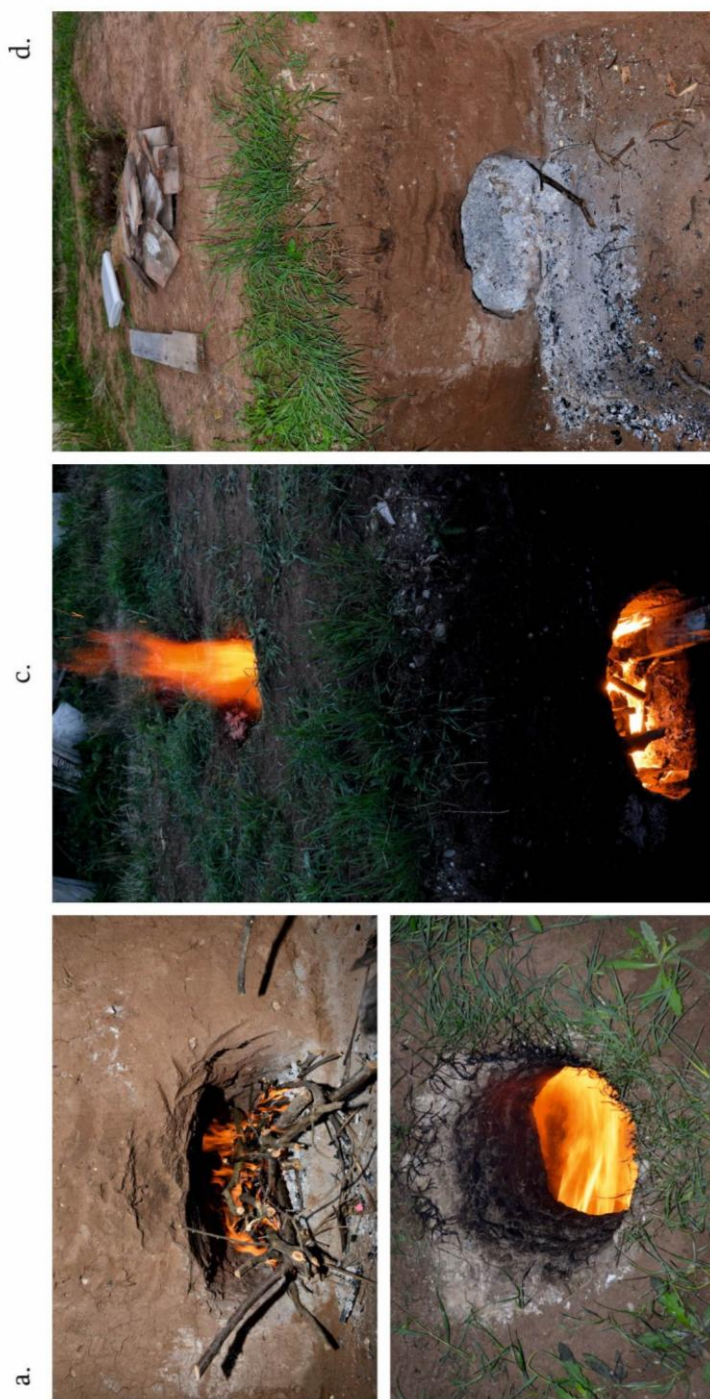


Plate XII. The operating principle of the experimental firing installation.

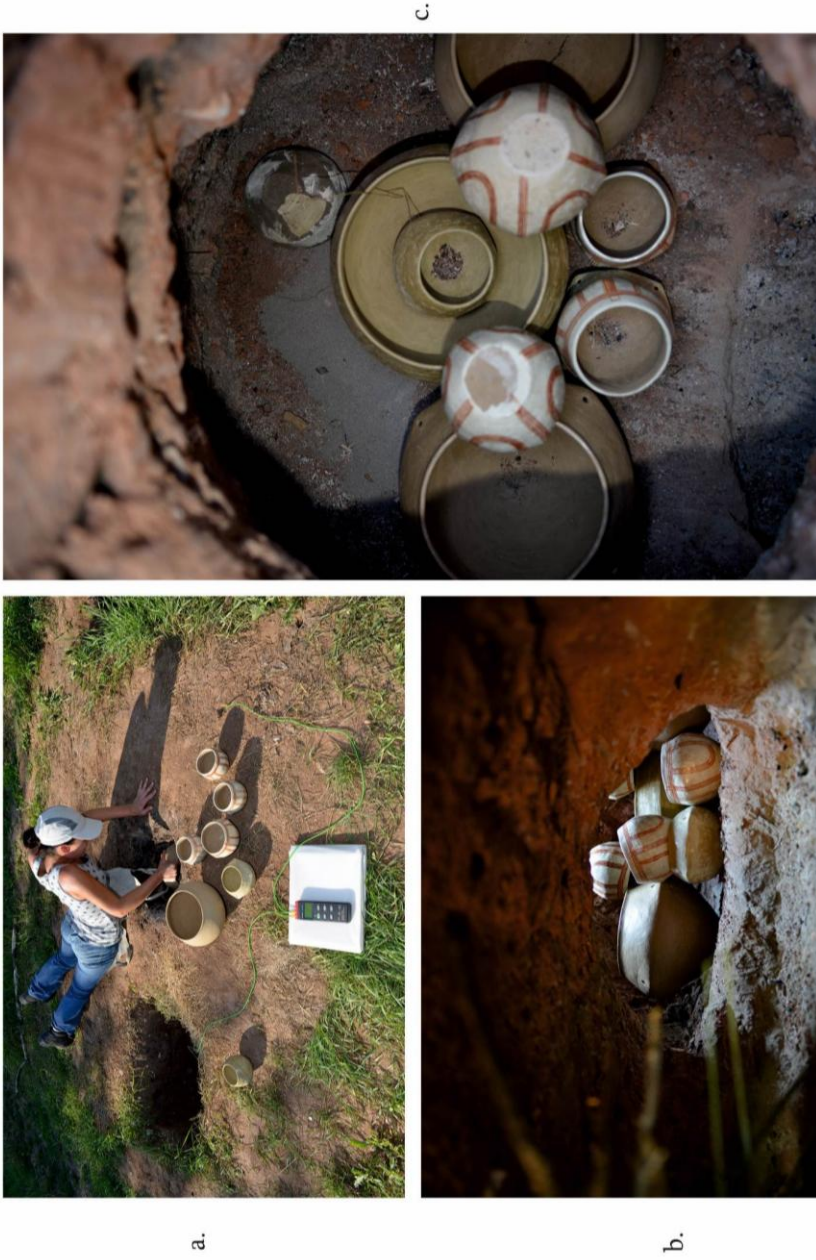


Plate XIII. The experimental firing; [a] – The placement of the pottery in the burning chamber;
[b-c] – Pots in the burning chamber.

Lumea Nouă painted pottery



Plate XIV. Aspects during the experimental firing.



Plate XV. The results of experimental firing;
[a] – Lumea Nouă painted bowl-type vessel (Gligor, “Grupul cultural,” no. 27); [b-c] – Experimental pots.

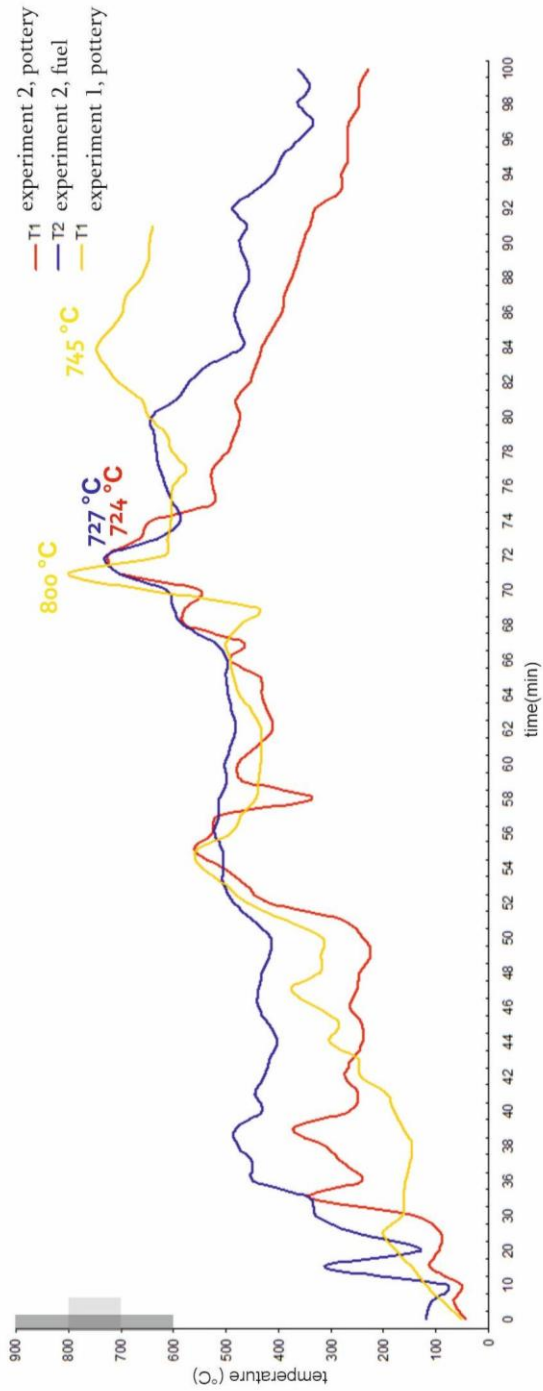


Plate XVI. The graph of the temperatures during experimental firings.



Plate XVII. The results of experimental firings; [a] – Compared section view through the wall of some original artifacts and experimental pots.; [b] – Experimental pottery section view.